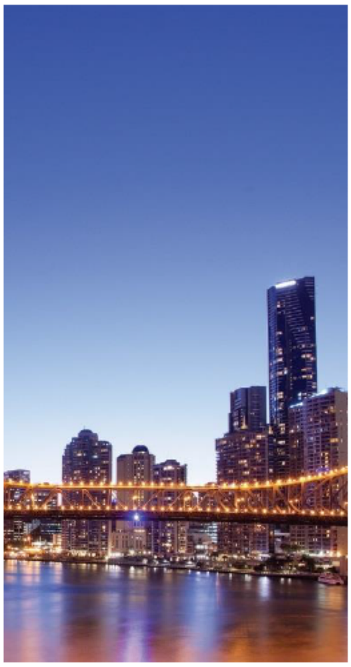
GHD Advisory



Review of Aurizon Network's Baseline Capacity Assessment Report

Queensland Competition Authority

1 March 2018

Contents

Figures

Tables

DISCLAIMER

This report has been prepared by GHD for the QCA, and may only be used and relied on by the QCA for the purpose agreed between GHD and the QCA in this report.

GHD otherwise disclaims responsibility to any person other than the QCA arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report. The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD and other parties described in this report. In particular, GHD wishes to acknowledge the work of Adam Boyle of A.D. Boyle & Associates in assisting GHD prepare this report.

GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by the QCA and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

Glossary of Terms

Term	Description
AATT	Agreed Allotted Time Thresholds. The Agreed Allotted Time Thresholds for On-Time Arrival at destination are: 30 minutes for coal services; 60 minutes for bulk mineral (other than coal) and freight services; and 30 minutes for long-distance passenger services.
Absolute Capacity	The theoretical limit for line capacity. It is the number of Train Service Entitlements that could run over a prescribed route during a specified time interval, in a strictly perfect, mathematically generated environment.
AN	Aurizon Network, monopoly operator of the Central Queensland Coal Network.
ARTC	Australian Rail Track Corporation
Available Capacity	The difference between the Committed Capacity and Capacity. It is an indication of the additional Train Service Entitlements that could be handled under the main line and branch lines.
BCA	Baseline Capacity Assessment. Refers to the throughput that Aurizon Network can reliably maintain on the entirety of the Central Queensland Coal Network.
BCAR	Baseline Capacity Assessment Report. Aurizon Network's report setting out its BCA.
BRTT	Below Rail Transit Time: For a Train Service travelling between its origin and destination, the sum of[1]: (a) The relevant nominated section running times (in the direction of travel) (b) Identified Below Rail Delays for that Train Service (c) The time take in crossing other Trains to the extent such time is not contributed to by Above Rail causes of Force Majeure Events (d) Delays due to Operational Constraints directly caused by Aurizon Network in maintaining the Rail Infrastructure provided such delays are not contributed to by Above Rail causes of Force Majeure Events
Capacity	The sum of Existing Capacity and Planned Capacity
Capacity Utilisation	Existing Capacity/Absolute Capacity
Coal System	Any one of the Newlands System, Goonyella System, Blackwater System, Moura System or Goonyella-to-Abbot-Point System.

[1] System Operating Parameters | Public Release 2016, Aurizon, 2016

Term	Description
Committed Capacity	The portion of Capacity that is required to meet contracted Train Service Entitlements and other obligations (see part 12 of 2016 AU)
Confidence interval	A range of values within which a statistical estimate (i.e. a mean) can be expected to lie.
CQCN	An approximately 2,800 kilometre network of rail used to ferry goods through the Central Queensland Region. Known as the Central Queensland Coal Network. It consists of five divisions for pricing purposes. The five divisions are Blackwater, Moura, Goonyella, Newlands and Goonyella-to-Abbot-Point Systems.
CQSCM	Central Queensland Supply Chain Model
Deterministic	In mathematics and physics, a deterministic system is a system in which no randomness is involved in the development of future states of the system.
DAU	Draft Access Undertaking
Dynamic Modelling	The objective of dynamic modelling is replicating modelled train services so that services reasonably reflect what one would expect from a Daily-Train-Planning perspective, prior to attributing consideration for the factors that contribute to day-of-operation and other losses.
ECP	Electronically controlled pneumatic brakes
Existing Capacity	Absolute Capacity, net of: (a) Aurizon Network's reasonable requirements for the exclusive or partial utilisation of the Rail Infrastructure for the purposes of performing activities associated with the maintenance and repair of the Rail Infrastructure, including the operation of work Trains; and (b) Aurizon Network's allowances for "day of operations" losses, speed restrictions and other operational losses or restrictions applicable to the Rail Infrastructure as set out in the System Operating Parameters.
Force Majeure	Unforeseeable circumstances that prevent someone from fulfilling a contract.
GAP	Goonyella to Abbot Point
Location Utilisation	The number of trains at a given location at a given point in time as a percentage of the maximum number of trains that can occupy that location. For our purposes, the number of trains counted at any given location are broken down into 10-minute increments and calculated throughout the recorded month.

Term	Description
MaTP	Master Train Plan containing the planned time of scheduled traffic
MTPA	Million Tonnes Per Annum
Maintenance and Renewals	Any work involving maintenance or repairs to, or renewal, replacement and associated alterations or removal of, the whole or any part of the Rail Infrastructure (other than Infrastructure Enhancements) and includes any inspections or investigations of the Rail Infrastructure.
Path Utilisation	The actual usage of paths in a given period versus what is practically available for that same period, post consideration of any path losses or robustness allowances, i.e. for Jilalan in the empty direction of travel, if there are 50 paths available for train services in day and 25 paths are utilised by dispatching rail services in this same day, the path utilisation for that day is 50%.
Planned Capacity	The same as Existing Capacity, in principle, relating to infrastructure that does not yet exist, or has not been commissioned, but for which Aurizon Network is contractually required to deliver.
Point of diminishing returns	A phenomenon involved in multiple scientific fields. It refers to the emerging of system-performance decreases (e.g. lower volume of trains can be used on Aurizon Network's below-rail infrastructure over a duration of time) when the magnitude of a variable exceeds a certain point.
QCA	Queensland Competition Authority. Statutory Authority charged with ensuring monopoly providers of infrastructure provide fair and equitable access, in line with the QCA Act's requirements, to declared infrastructure in Queensland.
QCA Act	The Act of parliament, namely the *Queensland Competition Authority Act 1997*, that sets out the rights, powers, limits and responsibilities of the QCA.
RFI	Request for Information
Seasonality	The tendency of a variable to exhibit distinct peaks and troughs at certain times of year.
Section Utilisation	The actual usage of certain track infrastructure (section) by a train service for a given period as a percentage of that period. Each track is considered in isolation and can only allow 1 train to traverse the section of track at any given point in time.
Static Modelling	Static-modelling assumptions (amongst others) are generally fed into Aurizon Network's dynamic capacity model and are, quite simply, a mathematically generated form of determining a starting point in which to commence dynamic modelling

Term	Description
Stochastic	Having a random probability distribution or pattern that may be analysed statistically but may not be predicted precisely.
STP	Strategic Train Plan
Supply Chain	All aspects that affect the transportation of coal from a mine to the end customer, including loading facilities, Rail Infrastructure, Railway Operators, load out facilities and coal export terminal facilities. For clarity, a number of supply chains can exist within a Coal System and can be denoted by reference to the destination coal export terminal.
ToR	Terms of reference. Conditions of engagement under which this report is taken.
Train Paths	The occupation of a specified portion of Rail Infrastructure, which may include multiple sections in sequential order, for a specified time.
TSE	Train Service Entitlement. An Access Holder's entitlement pursuant to an Access Agreement to operate or cause to be operated a specified number and type of Train Services over the Rail Infrastructure including within a specified time period, in accordance with specified scheduling constraints and for the purpose of either carrying a specified commodity or providing a specified transport service.

1. Executive Summary

The Queensland Competition Authority (QCA) has engaged GHD (us) to undertake a review of Aurizon Network's Baseline Capacity Assessment (BCA) as set out in Aurizon Network's Baseline Capacity Assessment Report (BCAR). The objective of this review, in the context of our role and the requirements of Aurizon Network's 2016 Access Undertaking (AU), is to:

- Review Aurizon Network's method and assumptions used to develop the BCA and advise whether they are reasonable and appropriate for the purpose
- Comment on whether the resulting Capacity Analysis and its components (such as Available Capacity) are reasonable
- From the above, recommend whether the QCA should accept/agree with the BCA, with reasons to support the recommendations
- Comment on whether the assessment of system capacity demonstrates that contracted train service entitlements (TSEs) can be met
- Make recommendations of improvements to the BCA process.

A key element of the BCA review is a detailed assessment of the robustness and reliability of Aurizon Network's capacity modelling processes used to assess its ability to meet its contractual obligations for TSEs. Hence, the review includes a reliability assessment of Aurizon Network's determination of its ability to meet contracted TSEs. In undertaking this review, we have taken into account multiple system performance aspects by way of modelled operations, planning, and execution of the freight task across Aurizon Network's Central Queensland Coal Network (CQCN).

Our analysis has focussed on *all* elements of the supply chain, as required by the 2016 AU. In doing so, we have taking into consideration remarks conveyed by relevant stakeholders, in particular CQCN coal miners, which seek to utilise the BCA in their planning processes and to understand the Available Capacity to meet their existing and planned coal haulage requirements.

Our overall assessment of Aurizon Network's BCA on a system-by-system basis is as follows:

1. **Goonyella:** We recommend that Aurizon Network's assessment that there is sufficient capacity to accommodate current TSEs is accepted. However, we consider that Aurizon Network's determination of Available Capacity for the Goonyella system is conservative.

   While we agree on the location of congestion points along track infrastructure and agree as to where material surplus capacity exists, we disagree from analysing the information provided, that these 'bottlenecks' warrant Aurizon Network's position that less than 1% capacity (relative to Absolute Capacity) exists for additional TSEs, or 371 new TSEs, in the Goonyella system.

2. **Blackwater:** We recommend that Aurizon Network's assessment that there is sufficient capacity to accommodate current TSEs is accepted. We also consider that Aurizon Network's determination of

Available Capacity for the Blackwater system is a reasonable reflection of Available Capacity notwithstanding the conservative assumptions that underpin its Available Capacity threshold (statically determined), which in this instance is 59.5% (of Absolute Capacity);

3. **Newlands:** We recommend that Aurizon Network's assessment that there is sufficient capacity to accommodate current TSEs is accepted. However, we consider that Aurizon Network's determination of Available Capacity for the Newlands system is conservative.

   While we agree on the location of congestion points along track infrastructure and agree on a relative stance as to where material surplus capacity exists, we disagree, upon analysing the information provided to us, that these 'bottlenecks' warrant Aurizon Network's assessment that only 2.5% capacity (relative to Absolute Capacity) exists for additional TSEs, or 673 new TSEs, in the Newlands system.

4. **Moura:** We recommend that Aurizon Network's assessment that there is sufficient capacity to accommodate current TSEs is accepted. We also consider Aurizon Network's determination of Available Capacity for the Moura system to be a reasonable reflection of actual Available Capacity that exists notwithstanding the conservative assumptions that underpin its Available Capacity threshold (statically determined), which in this instance is 59.5% (of Absolute Capacity).

Summarising the above:

- We recommend that Aurizon Network's assessment, that there is sufficient capacity in the CQCN to accommodate contracted TSEs be accepted.
- We consider the assessment of Available Capacity for the Blackwater and Moura systems to be reasonable and therefore recommend their acceptance.
- We consider that Aurizon Network's assessment of the Available Capacity of Goonyella and Newlands systems is conservative and hence unrealistically low.

There areas other than the assessment of Available Capacity where we have concerns in relation to the dynamic modelling approach and assumptions adopted by Aurizon Network in undertaking its BCA. These concerns are as follows:

1. **Dynamic modelling is undertaken in discrete one-month periods:** The rail networks which Aurizon Network manages to operate 24 hours a day, 7 days a week. In Aurizon Network's dynamic model, modelling periods are limited to one-month durations and model runs are halted when monthly TSEs are met and train position's re-set. Monthly modelled outputs for 12 runs are then summed together to determine annual network capacity. Therefore, cumulative delays that would naturally extend from one month to another are not captured.

   Due to the nature of Aurizon Network's operated rail network, its performance is affected by different events that are not aligned with month-to-month boundaries. For example, maintenance, system closures, speed restrictions and other events may span from month to month. The complex implications of such events may not be properly addressed in the model when the model is run for a month and with each month's run being isolated from the previous month's run. By modelling discrete monthly periods, the long-term impact of supply chain behavioural patterns such as congestion being compounded from one month to another is not captured. Aurizon Network's dynamic modelling therefore, potentially, allows for more completed journeys on the system than may be achieved in reality. Accordingly, we recommend that Aurizon Network models 12 months of activity as part of its dynamic modelling for future capacity assessments.

2. **Aurizon Network's dynamic modelling (7-day) warm-up period is considered insufficient[2]:** A short warm-up period exposes a level of risk that the system fails to reach a 'steady-state' before the month modelling period commences, and therefore appropriately emulate actual system running conditions, in just a 7-day period.

   The warm-up period is important because it affects the accuracy of the results when undertaking simulation modelling. When a system is modelled which has not reached the steady-state situation, with random train positions on the network, system results vary rapidly for the parameters used and can produce incorrect information. To address this, we recommend that a 30-day warm-up period be adopted instead of a 7-day period. We consider it appropriate for the minimum warm-up period to at least reflect how TSEs are contractually provided (i.e. on a monthly basis) to access holders.

3. **Aurizon Network's dynamic modelling at critical supply chain interfaces should reflect what exists in practice:** Critical supply chain interfaces such as ports and mines, are modelled based on contracted positions which do not always align with existing physical infrastructure or timing for activities experienced in reality. Examples include two trains being located at a coal loadout [redacted] where there is capacity for only one train and time at port being based on maximum times specified in Access Agreements, rather than historic average times. The use of contracted positions rather than existing physical data reduces the value that can be placed on the output of the model. Instances where the supply chain is modelled that ignores real life performance parameters for example where contracted port unloading times are applied in the model that are higher than actual experienced average port unloading times results in the model underestimating the ability of a network to meet contracted TSEs and or Available Capacity. Conversely, where infrastructure is modelled that is in excess of existing infrastructure such as the modelling of two loadouts, [redacted] where only one loadout exists, results in an over estimate of the ability of a network to meet contracted TSEs.

   In this context, one area that we consider important for stakeholder feedback to be provided is whether the Maximum Time at Unloading Facility (UT4 standard access agreement) is captured by the definition of Committed Capacity (via TSEs) or that of Existing Capacity (via Losses). If the concept of maximum times at an unloading facility form part of Committed Capacity, and are significantly above the average for whatever reason, the impact is that Available Capacity would be artificially under-estimated. By contrast, if the average/median times to which these maximum times relate are accounted for in the definition of Losses (when deriving Existing Capacity), then a more appropriate estimate of Available Capacity could emerge. Ultimately, such thinking should be informed by, among other things, how CQCN stakeholders consider port-unloading times should be addressed in the BCA.

[2] Aurizon Network advised that it uses a 7-day warm up period in response to our RFIs. However, in meetings, Aurizon Network has advised that it uses a 14-day warm up period. As the warm up period is not captured in model outputs provided by Aurizon Network, we are unable to confirm the actual warm up period adopted and have taken the written response as being correct.

4. **Aurizon Network's static modelling assumptions are considered conservative and attribute to a comparatively low Existing Capacity determination when compared against industry:** This has a direct impact on Aurizon Network's BCA determination of Available Capacity, given Existing Capacity is calculated by subtracting, from Absolute Capacity, track non-availability that takes into account track possession times for track maintenance and renewal activities (15% of Absolute Capacity) and other losses (between 21.5% and 28.5%) arising from, for example, unplanned maintenance and network reliability factors. This results in a determination of Existing Capacity that is either 63.7% or 59.5% of Absolute Capacity, depending on the CQCN system. This determined percentage is lower than typically planned in other comparable networks. We understand that Queensland Rail assumes 65% for its West Moreton rail corridor, for example.

   Aurizon Network also uses a different estimate for track outages due to maintenance between its dynamic models and its static models. In its dynamic models, Aurizon Network adopts the planned maintenance schedule, whereas in the static models, Aurizon Network assumes a standard 15% outage figure. In this regard, we consider that Aurizon Network should use information from its maintenance plan to inform track outages due to maintenance/renewals rather than applying a more conservative blanket 15%. We also note that the discrepancy in assumptions between static and dynamic modelling adversely impacts the calculation for Existing and Available Capacity.

   The table below outlines Aurizon Network's static modelling assumptions.

Table 1 – Aurizon Network's static modelling assumptions

Source	Maintenance/Renewals	Other Losses	Existing Capacity
Blackwater	15%	25.5%	59.5%
Newlands & GAP	15%	25.5%	59.5%
Goonyella	15%	21.3%	63.7%
Moura	15%	25.5%	59.5%

Source: Aurizon Network, BCAR (2016), (calculations are referenced off Absolute Capacity)

We consider that the aforementioned issues are, in principle, important considerations that warrant further stakeholder consultation. Overall, we recommend that the QCA accepts Aurizon Network's BCA, although we suggest that the issues outlined above be rectified in future capacity assessments.

2. Introduction

2.1 Aurizon Network's regulatory environment

Aurizon Network is a below-rail service provider that is regulated by the Queensland Competition Authority (QCA). Aurizon Network operates and maintains the Central Queensland Coal Network (CQCN), which comprises the Newlands, Goonyella Abbot Point, Goonyella, Blackwater and Moura coal systems.

The QCA administers the economic regulation of Aurizon Network via the 2016 Access Undertaking (2016 AU) and the *Queensland Competition Authority Act 1997* (QCA Act). The 2016 AU requires Aurizon Network to undertake a Baseline Capacity Assessment (BCA) and to prepare a Baseline Capacity Assessment Report (BCAR) (clause 7A.4). The QCA has engaged GHD to assist it with assessing whether Aurizon Network's BCA meets the requirements of the 2016 AU and the QCA Act.

2.2 2016 Access Undertaking (AU)

Clauses 7A.4.1 and 7A.4.4 of the 2016 AU set out, respectively, the BCA-related requirements and the reviewing consultant's role and requirements in the BCA processes. We have summarised the requirements as follows:

- the BCA must include:
  - Operational, maintenance, construction, and planning assumptions in each Coal System
  - Possession Protocols
  - Aurizon Network's methodology for calculating Train Service Entitlements (TSEs) in each Coal System
  - Network Management Principles, System Operating Parameters and System Rules, if applicable, for each Coal System
  - The terms of Access Agreements relating to Train Services in that Coal System
  - The interfaces between the Rail Infrastructure and other facilities forming part of, or affecting, the relevant Supply Chain.
- The BCA must provide:
  - A static or dynamic waterfall analysis of Train Paths or TSEs in relation to Capacity, as appropriate
  - Analysis of the Absolute, Existing, Planned, Committed and Available Capacity in each Coal System
  - The Strategic Train Plan (STP) for each Coal System
  - The number of Train Paths on each Coal System main lines and branch lines
  - Confidence intervals for the capacity estimates that reflect the degree of reliability Aurizon Network ascribes to its capacity modelling outputs. (emphasis added)

In our view, clauses 7A.4.1. and 7A.4.4 together with s138(2) of the QCA Act require Aurizon Network to consider interactions with the entire supply chain and, in doing so, to consult with relevant stakeholders (e.g. to embrace the concept of Supply Chain Groups and the obligations for Aurizon Network to participate in such groups and, where reasonable, action their requests).

2.3 Purpose of the BCA review

Whether Aurizon Network can meet its contractual obligations, whether train paths on existing infrastructure are being delivered efficiently by Aurizon Network and whether there is Available Capacity to enable growth in coal transportation volumes, are all critical issues to access holders. Not only do these factors affect access holders' volumes and operational flexibility, and potentially business planning, they also contribute to a transparent understanding of the need for infrastructure expansion.

We note the following from Volume II of the QCA's final decision on Aurizon Network's 2014 draft access undertaking (2014 DAU):

The QCA noted that stakeholders have long considered the lack of transparency regarding Aurizon Network's capacity to be a major concern. The QCA also noted stakeholders have expressed a lack of faith in the associated processes to date. The QCA considered these issues to be critical because of the impact they have on the effectiveness of a negotiate-arbitrate model:

As access holders and seekers (and their customers) ultimately fund Aurizon Network's maximum allowable revenue (MAR) under the existing regulatory regime, it is reasonable for them to seek to understand and agree with Aurizon Network's approach and inputs for measuring capacity (i.e. forging a common understanding of what baseline capacity means and is).

It is reasonable for CQCN stakeholders to require this information, as they do not have an alternative source to Aurizon Network for below-rail services. Because access holders and their customers cannot switch suppliers, the QCA considers it necessary that Aurizon Network shares robust capacity-related information with those parties.

It is therefore important that relevant stakeholders understand the Committed and Available Capacity of Aurizon Network's below-rail network and its ability to meet contracted TSEs. It is also important that stakeholders understand and have confidence in the BCA and the underlying principles and assumptions used by Aurizon Network for assessing capacity. In undertaking the BCA review, we have considered the needs of access seekers and access providers from the perspective of all affected CQCN supply chain stakeholders. Of particular relevance, in our view, is the identification of below-rail capacity constraints and variations, access impacts, network utilisation, and planned expansions.

The 2016 AU includes protocols and principles to guide interactions between Aurizon Network and relevant stakeholders (e.g. the concept of Supply Chain Groups and the obligations for Aurizon Network to participate in such groups and, where reasonable, action their requests). These protocols, principles and requirements on Aurizon Network seek to support timely and appropriate exchange of information between these parties. In this context, we consider that Aurizon Network must be observed and be perceived to be coordinating with, and accounting for, all CQCN supply-chain stakeholders in undertaking the BCA. Such stakeholders include mines, port terminals, above-rail service providers, and network-connection points with private interfaces (e.g. Queensland Rail's adjoining infrastructure and private connecting infrastructure).

2.4 BCA review objectives

We have determined the objective for our assessment by reviewing the QCA's terms of reference (ToR) for the engagement and Aurizon Network's 2016 AU.

The objective of the BCA review, in the context of the BCA consultant's role, is to:

- Review Aurizon Network's method and assumptions used to develop the BCA and advise whether they are reasonable and appropriate for the purpose

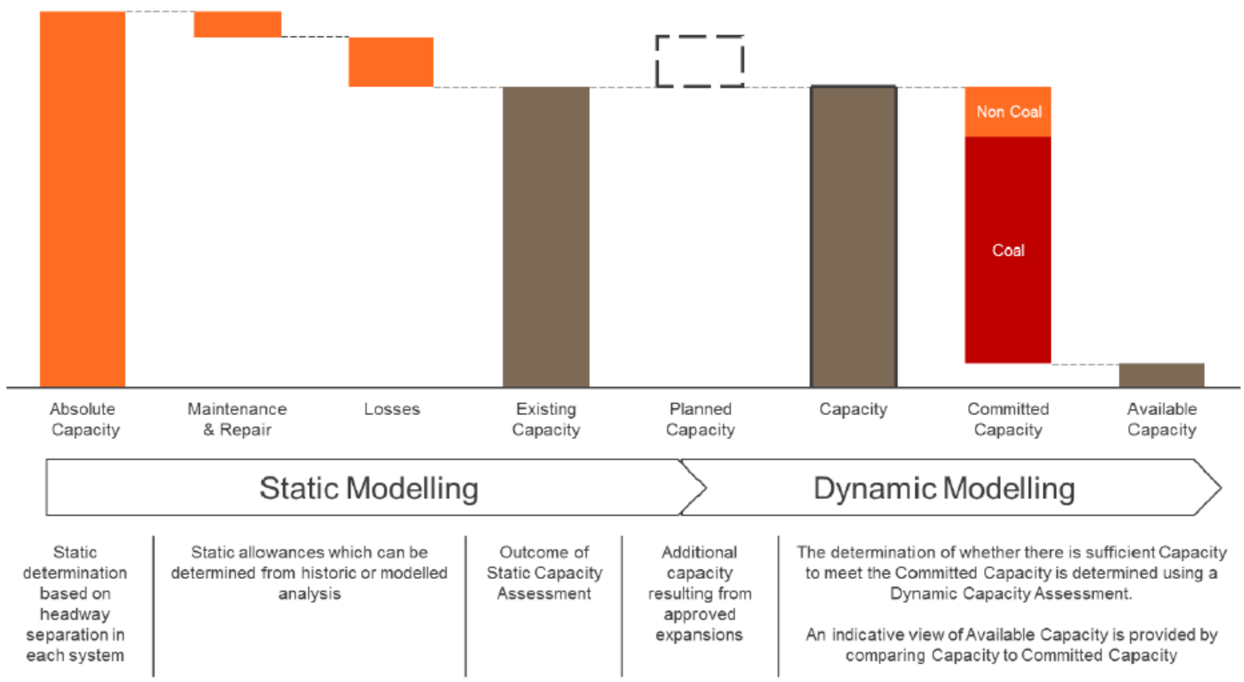
- Comment on whether the resulting Capacity Analysis and its components (such as Available Capacity) are reasonable
- From the above, recommend whether the QCA should accept/agree with the BCA or not, with reasons
- Comment on whether the assessment of system capacity demonstrates that contracted TSEs can be met
- Make recommendations of improvements to the BCA process.

The scope of works is to examine the robustness and accuracy of Aurizon Network's modelling underpinning the BCA and of the below-rail capacity reported. This review provides the basis for providing the QCA and stakeholders with the level of confidence that can be placed in Aurizon Network's capacity estimates, service planning and below-rail network operation. Included in this evaluation is a judgement on whether the approach that Aurizon Network has adopted for undertaking the BCA, is reasonable and whether there is sufficient below-rail capacity to deliver the TSEs that Aurizon Network has contracted for with access holders.

The assessed baseline capacity should, at a minimum, meet the capacity that Aurizon Network is contractually obliged to meet. GHD's engagement for the QCA encompasses both mainline and branch line analysis.

The relationship and method of capacity assessment, as it relates to Aurizon Network's BCA, is summarised in Figure 1 below.

Figure 1: Waterfall chart showing Aurizon Network's methodology for its capacity assessment[3]



With respect to the static modelling, GHD has been commissioned to assess whether the impact of maintenance requirements and other losses on Existing Capacity are being estimated by Aurizon Network in a manner that encompasses use of credible assumptions and existence of efficient operating practices.

[3] Source: Aurizon Network, BCAR (2016)

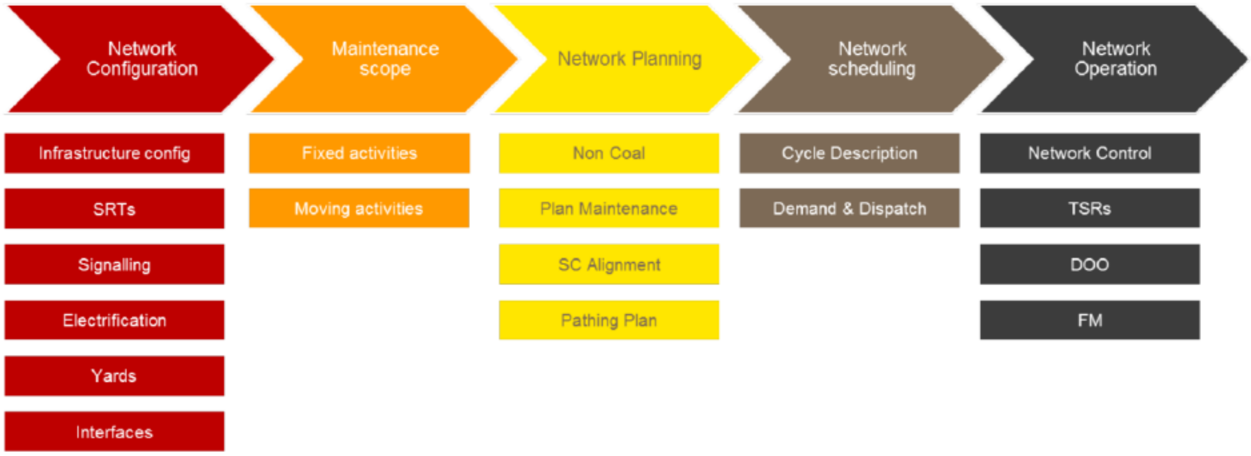
Similarly, for the dynamic modelling, we have been commissioned to assess whether the assumptions underpinning the modelling are robust and whether the results in terms of capacity metrics, that is the BCA as a whole, covering Capacity and Available Capacity, can be accepted by the QCA.

2.5 System Operating Parameters (SOPs)

Aurizon Network has developed system operating parameters (SOPs) for the purpose of conveying defined methodology and input parameters used when undertaking capacity assessments of the CQCN. Aurizon Network has done this to align its capacity requirements with the contractual commitments it has to access holders. Input parameters are taken from Access Agreements, as well as other planning, scheduling, and operating procedures.

The key input parameters reflected in the structure of SOPs are summarised as follows:

Figure 2: Key input parameters from SOPs that relate to the BCA[4]



Metrics recorded in Access Agreements used in the generation of the SOPs and forming a sub-set of these key input parameters include:

- number of TSEs required
- mode of operation (even railings)
- the time taken for trains to traverse sections of the network (Section Run Times or “SRTs”)
- the time at interface locations (load and unload times)
- how above-rail operators will operate on the Aurizon Network’s infrastructure – supported by Operating Plans.

2.6 Timeline of events

We outline below a timeline of important events associated with the development and review of the BCA.

- On 21 March 2017, Aurizon Network released to the QCA its BCAR together with its supporting 2016 SOP document. The SOP sought to be consistent with the assumptions underpinning the BCA.

[4] Source: Aurizon Network, System Operating Procedures (2016)

- On 5 April 2017, the QCA published non-confidential versions of the documents publicly, seeking stakeholder responses.
- Two industry stakeholder responses were received by the QCA. On 5 May 2017, Pacific National submitted a response to the QCA in relation to Aurizon Network's SOP and BCA documents. Likewise, on 5 May 2017, the Queensland Resources Council similarly submitted its response to the QCA.
- In late August 2017, GHD was commissioned to undertake a review of Aurizon Network's BCA and present findings to the QCA.

2.7 BCA stakeholder submissions to the QCA

A summary of the two stakeholder responses received by the QCA is outlined below.

Pacific National

Pacific National's key concerns were divided into views on the SOPs and the BCA. Pacific National made the following comments on the SOPS:

- Aurizon Network's proposed SOPs are static and do not account for the dynamic nature of the supply chain (e.g. port capacity, mine loading capability and interfaces with private/connecting rail infrastructure)
- Aurizon Network's proposed SOPs should include cycle-time assumptions for each coal system
- Aurizon Network's proposed SOPs need to provide sufficient information to allow for independent validation
- Committed Capacity should not be based on trains running 360 days a year, since Aurizon Network has to account for maintenance and renewal activities
- Sectional running times (SRTs) that are reported in the proposed SOPs differ from those in the individual Access Agreements
- Stop times for diesel trains are labelled to be zero, but those for electric trains are positive
- Its own Operator Appendix should be provided by Aurizon Network to account for the movements of trains in yards
- The proposed SOPs state that the capacity assessment does not take into account constraints to the operations outside the CQCN interface points, raising concerns that the proposed SOPs are not consistent with the 2016 AU. Pacific National noted that Section 7A.4.1 b) iii) B) of the 2016 AU states that the BCA must consider interfaces between rail infrastructure and other elements of the supply chain. Pacific National considered this issue to be one of major non-compliance
- The availability diagrams under the section of the proposed SOPs are difficult to interpret in their current format. Pacific National believes that the Available Capacity (and what the Available Capacity represents) is not clear in these diagrams. Pacific National said that Aurizon Network should supply the spreadsheets that underpin these diagrams to stakeholders may assist in addressing this interpretation-related concern
- The proposed SOPs refer to an internal management processes by which Aurizon Network determines the quantum, duration and timing of possessions. Pacific National said there should be a degree of regulatory oversight of these procedures to ensure they are consistent with the network

management principles. Pacific National recommended that these procedures be included in the scope of the QCA's regulatory audit of Aurizon Network

- The modelling of capacity based on assumed rolling stock may not reflect the capability of actual rolling stock. This may in turn result in the over-estimating or under-estimating of the system capacity available
- The proposed SOPs state that payloads differ but they do not outline what payloads have been assumed in Aurizon Network's modelling. Pacific National believes that the modelling should be based on the payloads specified for each network system in Schedule F of the 2016 AU
- In relation to temporary speed restrictions (TSRs), Aurizon Network has used historical TSR data from 1 Feb 2014 to 31 Jan 2015 to inform its proposed SOPs. Pacific National considered that Aurizon Network should explain why that period was appropriate to use, and why other periods should not be used. Pacific National also queried if the graphic shown on page 40 of the proposed SOPs reflect electronically controlled pneumatic brakes (ECP) or pneumatic braking trains, and questioned how Aurizon Network had forecast the number of TSRs known up until mid-2018
- In relation to day-of-operation losses, Aurizon Network assumes that these "losses will incorporate part of the impact of TSRs". While the losses may incorporate part of the impact of TSRs, there are many other factors contributing to these losses, such as weather, train crewing and operational issues at ports and mines. These factors have the potential to obscure the impact of TSRs in day-of-operation losses. Pacific National considers that following the development of the day-of-operation losses, Aurizon Network should clarify how the losses and TSRs affect each other.

Pacific National made the following comments on the BCAR:

- Further detail is required of the capacity losses arising from "Losses" and "Maintenance and Renewals" as shown in the BCAR system waterfall charts
- Clarification is required of the time period that each waterfall chart represents. (Pacific National assumes that the charts represent the two-year forecast of capacity for each system)
- Further detail is required on the demand profile chart. Pacific National considers that the demand profile information should be available by month
- The baseline capacity assessment should extend beyond the two year period currently contained in the BCAR. Operational decisions relating to rail infrastructure and rolling stock often have longer time frames than two years so extending the BCA beyond two years would assist in this decision making. Pacific National believes extending the BCA to four or five years would be sufficient. (If the capacity assessments are intended to be flat beyond the two-year time horizon, then this should be made explicit in the BCAR). Pacific National recognises that extending the timeframe of the capacity assessment will result in capacity assessments in later years being more uncertain
- The System Monthly Variance chart for each of the Aurizon Network coal systems shows a fall in the available train service entitlements in February each year. Pacific National is seeking that Aurizon Network confirms that this fall in the available TSEs is a function of the number of days in the month
- The BCAR should also contain information in relation to: where queues and bottlenecks are forming; the daily range of variation in the results for each system; and information regarding daily capacity peaks and whether these peaks are met
- It was helpful that Aurizon Network had included capacity assessments for branch lines

- In relation to the Newlands/GAPE system, the key operational information outlined for the other Aurizon Network rail systems includes a maximum train speed. However, the key operational information for the Newlands and GAPE System does not include a maximum train speed. Pacific National believes that this section should include a maximum train speed for this system
- In relation to the system monthly variance, there appears to be a possibility in August-to-October 2018 that the target TSEs will not be met. Pacific National said that if this materialises, then Aurizon Network should shift some maintenance to July or December to provide for forecast TSEs to be met.

Queensland Resources Council

The Queensland Resources Council's main points were that:

- Aurizon Network's BCA approach and the proposed SOPs did not align with the 2016 AU's requirements. The QRC said the approach and SOPs had failed to satisfy the requirement to include consideration of the terms of Access Agreements and of interfaces between the rail infrastructure and other supply-chain parts
- Modelling capacity based on actual or planned payloads is likely to lead to a different (and more accurate) capacity outcome. In this context, the QRC said the draft BCAR will necessarily be materially inaccurate because the BCA is based on contracted or planned payloads (and actual payloads are materially different to contracted or planned)
- 'Even railings' is not an appropriate assumption to adopt, particularly in the Goonyella coal chain, where the multi-user Dalrymple Bay Coal Terminal employed a cargo-assembly mode of operation
- The definition of Capacity suggests there is intended to be a distinction between TSEs which are contracted and the train paths used to measure Capacity. Under UT4, Absolute Capacity is defined by reference to Train Paths rather than Train Services Entitlements. Train Paths are defined as "the occupation of a specified portion of Rail Infrastructure, which may include multiple sections in sequential order, for a specified time". No reference is made to contractual commitments. Contrast this with definition of Train Services Entitlements which are defined as "an Access Holder's entitlement pursuant to an Access Agreement to operate or cause to be operating a specified number and type of Train Services"
- SRTs in the proposed SOPs differ from those by which trains are scheduled. Those SRTs have been developed to align with the majority of Access Agreements. In that regard, the QRC questioned the utility of a capacity assessment modelled solely based on contracted commitments
- During consultation on the initial SOPs and BCA, the QRC suggested that Aurizon Network seeks further input from port and rail operators together with input from industry, including, if considered appropriate, by undertaking facilitated workshops. To the QRC's knowledge, no such workshops were undertaken. The QRC believed that collaborative input from all elements of the supply chain would facilitate the development of SOPS that best represent how capacity is actually consumed.

2.8 Central Queensland Coal Network (CQCN)

The CQCN is an integrated and interconnected narrow gauge (1,067 mm) heavy haul (26.5 tonne axle load (TAL)) rail transport network which links more than 40 mines to five export coal terminals, using over 2,800 km of track, as listed in Table 2.

Table 2 – CQCN characteristics

System	Length (km)	Aurizon Network UT5 FY2018 forecast (mtpa)
Blackwater	1,171	70
Goonyella	1,021	120
Moura	315	10
Newlands	242	9
GAPE[5]	69	16
Total[6]	2,818	226

The layout of Aurizon Network's CQCN is shown in Figure **3**.

[5] Goonyella to Abbot Point Expansion (GAPE) is typically coupled with Newlands

[6] Number differs from the sum of throughput across the individual systems due to rounding

Figure 3: CQCN

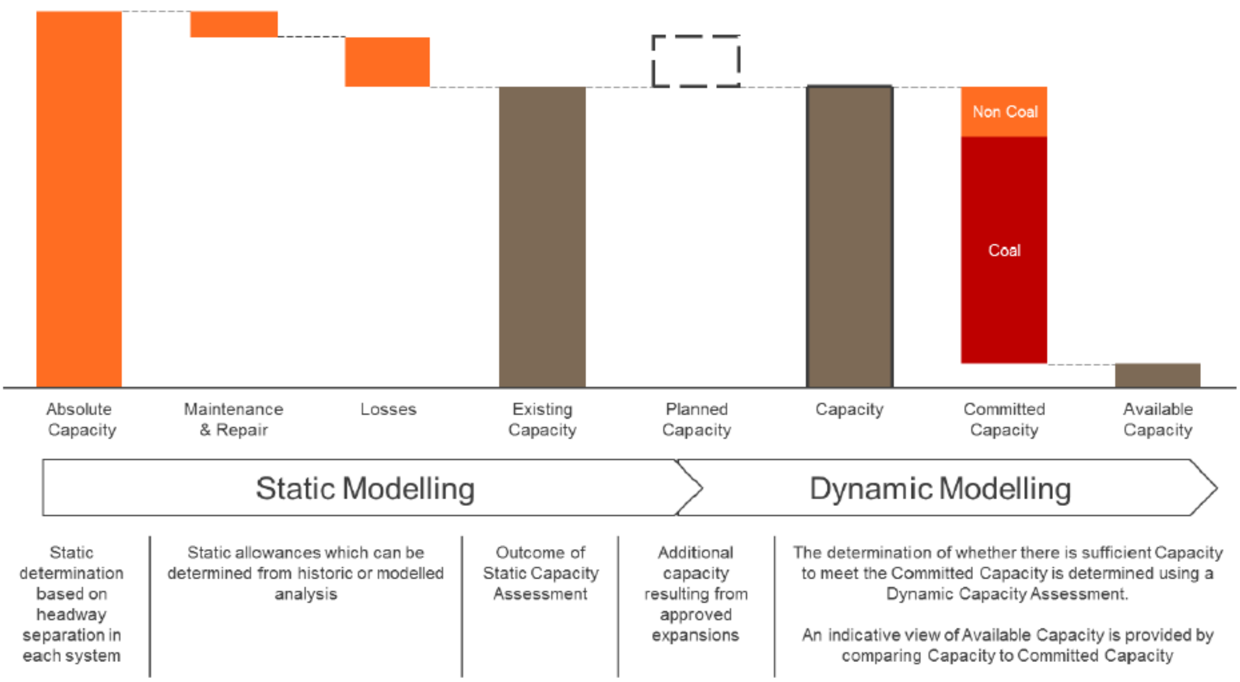
GHD ADVISORY

GHD Report for QCA – BCA Assessment

3. Aurizon Network’s approach to capacity determination

Capacity assessments provide several measures of capacity. The two most important measures being Existing Capacity and Available Capacity. The relationship and method of calculation is summarised in the figure below.

***Figure 4: Rail network capacity components*[7]**



A detailed explanation of each of these components is outlined below.

3.1.1 Absolute Capacity

The number of paths that can be scheduled on an annual basis assuming no reductions/restrictions is referred to as Absolute Capacity. It is calculated by dividing the number of minutes in a year by the scheduled train separation on the longest section of track for a particular network. It represents the upper limit for line capacity.

For the purposes of the BCA, it is the number of TSEs that could run over a mainline route during a specified time interval, in a strictly perfect, mathematically generated environment, with trains running permanently, and with the shortest train path separation achievable as defined by the headway of the route.

Current scheduling constraints necessitate the use of a daily plan. This requires the rounding up of the path separation to a value that is divisible to 1,440 minutes.

[7] Source: Aurizon Network, BCAR (2016)

In the Goonyella system, pathing between Jilalan and Coppabella has a fixed pathing separation of 20 minutes in both the up (empty) and down (loaded) directions, amounting to 72 theoretical paths in a day. Other systems will have different pathing separations. These are outlined in Aurizon Network's System Operating Parameters Public Release 2016, page 31.

It is not possible to actually run the number of trains that can be worked out mathematically. The actual utilisation of paths will be less than this, after taking into consideration network losses and reliability factors, and Access Holder demand for TSEs.

3.1.2 Maintenance and Renewals

Below-rail maintenance and renewals are necessary for maintaining below rail infrastructure to a safe standard for operational use. Maintenance and renewals are factors that therefore reduce Existing Capacity in a railway network.

Examples of maintenance activities include, ballast undercutting, resurfacing, rail grinding, signalling, etc. Renewals are concerned with the replacement of capital equipment and can include replacement of sleepers and rail, amongst other things.

Aurizon Network's maintenance scope requirements together with the required input parameters to scheduling, such as achievable production rates, set up times, track possession requirements, resource type and number are determined in Aurizon Network's PACE software and converted into a Virtual Possession Plan for use in its dynamic model (Central Queensland Supply Chain Model (CQSCM)). Effectively, the Virtual Possession Plan is a schedule that identifies the location and timing of those activities that require track possession time and, therefore, impact on rail services.

3.1.3 Other Losses

Such losses include, amongst other things, the impact of unplanned maintenance on Existing Capacity, and reliability/robustness allowances.

Aurizon Network defines these losses as follows:

Losses result from a number of varying influences, which include (but are not limited to):

- *Adverse weather conditions (excludes those declared as Force Majeure)*
- *Infrastructure faults and failures*
- *Incidents at interfaces (e.g. level crossing incidents, trespassing).*

To represent this, the operating logic in the dynamic model randomly applies cancellations to 12.5% of empty train services scheduled to depart the origin.[8,9] Both static and dynamic models can account for such broader losses. Static models apply a fixed percentage (20-25%), which includes provision for headroom into the losses, to Absolute Capacity net of maintenance activities, while dynamic models simulate a random series of events that introduce losses in the supply chain.

[8] Aurizon Network, System Operating Parameters – 2016 Final, pp 41

[9] In joint meetings with Aurizon Network and QCA staff, Aurizon Network assumes 12.5% train cancellations at origin to reflect that the simulation was optimistic for throughput around closures, rather than 10%, to account for simulation variability. (On this, we note that section 6.1 of Aurizon Network's 2016 SOPs provides that 2.25% of trains are cancelled at origin to reflect that the modelled representation of a system shut is optimistic compared with the actual throughput achieved).

3.1.4 Existing Capacity

Existing Capacity is the practical limit of TSEs that can be moved along a mainline at a reasonable level of reliability. It is derived from realistic network-operation assumptions, which are related to system reliability and interactions with other parts of the supply chain. Locomotive traction and priorities are considered, as is below-rail maintenance and renewals, which all reduce network capacity, and reliability/robustness allowances. It is the capacity that can permanently be provided under normal operating conditions.

3.1.5 Committed Capacity

Committed Capacity is the portion of capacity that is required to meet contracted TSEs and is another important factor for undertaking this BCA. This is what Available Capacity is benchmarked against.

3.1.6 Available Capacity

Available Capacity is the difference between the Committed Capacity and Existing Capacity. It is an indication of the additional TSEs that could be handled on a given mainline route.

3.2 Static modelling

Aurizon Network uses static modelling in the initial stages of its capacity assessments up to and including determination of Existing Capacity. An overview of Aurizon Network's static modelling is outlined below:

1. In the first instance, static modelling is used to determine the number of absolute paths available in a day. Headway is the amount of time that elapses between two trains passing the same location travelling in the same direction on a given route. In essence, the headway equates to the number of paths that can be scheduled on an annual basis assuming no reductions/restrictions are applied to the system. It is calculated by dividing the number of minutes in a year by the scheduled headway (divisible by 1,440 minutes that exists in a 24-hour period).

   The headway will differ depending on the location and certain sections of track (track configuration most importantly, but there are other considerations); and it is broadly a function of:

   - train length
   - signal positioning
   - train speed
   - braking distance, and
   - track configuration

2. Static modelling is then used to determine the impact on capacity of the estimates for system losses. There are two main categories of losses, namely: planned maintenance/renewals, and reliability/robustness/unplanned losses.

   These categories, together with Aurizon Network's static modelling assessment of the losses for each network, are outlined in the table below.

Table 3 – Aurizon Network's static modelling assumptions

Source	Maintenance/Renewals	Other Losses	Existing Capacity
Blackwater	15%	25.5%	59.5%

Source	Maintenance/Renewals	Other Losses	Existing Capacity
Newlands & GAP	15%	25.5%	59.5%
Goonyella	15%	21.3%	63.7%
Moura	15%	25.5%	59.5%

Source: Aurizon Network, BCAR (2016), (calculations are referenced off Absolute Capacity)

3. This static modelling framework then provides a basis in which Aurizon Network can deduce Available Capacity.

3.2.1 Comparison of Aurizon Network's static modelling assumptions with industry

We find that Aurizon Network is conservative when undertaking its static assessment of Existing Capacity in that Aurizon Network assumes a practical utilisation factor (Existing Capacity/Absolute Capacity) that is below the lower threshold of what is deemed reasonable by industry and academic research on rail capacity. The assumptions that influence Existing Capacity ultimately determines the number of paths made available for its customers.

The consequence of assuming a lower practical utilisation of Absolute Capacity than industry benchmark would suggest translates into a lower allocation of paths than otherwise would be the case. *Ceteris paribus*, if the practical utilisation is higher, this equates to a higher availability of paths that can be consumed by rail services.

Aurizon Network determines that Existing Capacity is either 63.7% or 59.5% of Absolute Capacity, (otherwise commonly referred to as 'Theoretical Capacity') depending on the network. The Goonyella system is the only network that applies a 63.7% practical capacity utilisation factor with Aurizon Network applying a 59.5% utilisation factor for all other networks. These percentages are all lower than typically planned in other networks; for example, Queensland Rail plans for a practical utilisation upper threshold of 65% in its West Moreton network.

While we acknowledge that rail networks differ in terms of operating and environmental characteristics, and that Aurizon Network may have a basis for a conservative practical utilisation threshold when determining the availability of paths, Aurizon Network did not provide us with information setting out the reasons for this low assessment of practical utilisation factor. For the most part, Aurizon Network's systems exhibit operational characteristics that are less complicated and to an extent, reasonably homogeneous, compared against other rail networks, with potentially the exception of the Blackwater system (due to the extent of interaction with Queensland Rail's North Coast Line). Aurizon Network is also a related entity of a publicly listed company and therefore, an assumption is made that it aims to operate to achieve 'best practice'. Accordingly, we see no reason aside from environmental implications, why Aurizon Network could reasonably justify a practical utilisation assumption that is below the range provided by industry or academic research.

In conversations with Aurizon Network and the QCA staff during the development of our report, we considered ARTC's capacity assessment of its Hunter Valley Coal Network, given the similarities between ARTC's network and Aurizon Network's. In this regard, we used ARTC (amongst other rail networks) as a benchmark for explaining our position that Aurizon Network's Existing Capacity determination is conservative when contrasted to the determined Existing Capacity as a ratio of Absolute capacity of comparable networks. In responding to our position, Aurizon Network said that ARTC further applies an 'adjustment factor' that further reduces Existing Capacity to ~49% of Absolute Capacity (or theoretical capacity) – below Aurizon Network's capacity determination approach.

While we acknowledge ARTC does in fact apply an 'adjustment factor' in addition to its practical utilisation threshold (65%), we understand that this 'adjustment factor' is a reflection of commercial agreements that differ to Aurizon Network's situation and responsibilities. In particular, we understand that this 'adjustment factor' is a reflection of commercial agreements that concern the entire supply chain – not just the below-rail network. Effectively, when planning rail capacity, ARTC is contractually responsible for supply-chain-related issues that affect capacity elsewhere along the supply chain, including above-rail service providers and terminals. Further, a component of ARTC's capacity determination approach is industry-driven.

For example, in applying this 'adjustment factor', ARTC takes a capacity reduction component that is directly requested by industry, the purpose of which is to reflect, in part, peaking capacity required by industry. This is not led or influenced by ARTC. This is an important difference to Aurizon Network's approach, in the sense that ARTC must plan for performance failures or contractual non-conformance, incurred elsewhere in the supply chain. We therefore maintain our position that ARTC's estimate of practical utilisation (65%), is an appropriate benchmark for comparing Aurizon Network's capacity determination against.

In reviewing GHD's Draft Report, Aurizon Network sought clarification on supporting material used to inform our view on determining Aurizon Network's Existing Capacity determination as being conservative.

While we have suggested an appropriate single-line track utilisation factor of 67.5% and a duplicated track utilisation factor of 75%, these serve merely as estimates used to illustrate an upper threshold for use in the charts in this report. These are used to convey a relationship between modelled section utilisation and an upper threshold being higher than that assumed by Aurizon Network, for use in our own analysis. We therefore place no commitment behind these figures (67.5% and 80% for single and duplicated track respectively), other than that their use in highlighting that a higher utilisation percentage is appropriate than that currently determined by Aurizon Network.

We recommend that a study be undertaken to quantify what this upper threshold could reasonably be, if it is accepted that Aurizon Network's threshold is indeed conservative. We outline 10 examples (non-exhaustive) below supporting our position that Aurizon Network's static assumptions are conservative and, as such, lead to a conservative assessment of Existing Capacity.

ARTC's 2016-2025 Hunter Valley Corridor Capacity Strategy

'the 65% utilisation factor on single track is intended to deal with issues like uncertainty around actual train performance, temporary speed restrictions and manual decision making in the execution of crosses as well as the natural constraints on the efficiency with which train crossings can be enabled' (page 13)

'ARTC uses a capacity methodology that discounts capacity on single lines to 65% to reflect the practical constraints in scheduling trains… This factor is relatively conservative and also provides a degree of latitude to accommodate other issues such as temporary speed restrictions and differences between actual and modelled train performance' (page 16)

'ARTC will be further considering whether on this basis it would be reasonable to increase the single track utilisation factor to something higher than 65%. If it were to be increased, this would flow through to an increase in the available capacity for any given infrastructure configuration' (page 16)

Aurizon Operations' submission to the ACCC: 2017 ARTC Hunter Valley Access Undertaking, dated 3 February 2017

'*Aurizon notes that the capacity planning assumptions for the Hunter Valley currently assume a relatively low utilisation rate of approximately 65%. This is highly conservative compared to utilisation rates applied in other dedicated bulk export supply chains*' (page 11)

Queensland Rail's Submission to Submissions Made to the QCA: Western System Coal Tariffs, dated 2014

'*The West Moreton Network has a reduction factor of 65%, which means there is a reduction in capacity of 35% where it is applied, which results in capacity across the Toowoomba Range of 112 return train paths per week*

…However, QCA's consultant B&H suggested a reduction factor of 79% (a reduction in capacity of 21%

…the theoretical capacity needs to be adjusted to practical capacity using a factor. An adjustment rate of 65% has been adopted for this analysis. That is, it is realistic to expect a section of track to carry 65% of its maximum theoretical capacity'

CRC for Rail Innovation, Corridor Capacity Assessment, dated 2009

'*The International Union of Railways (UIC) considers the practical limit for daily capacity utilisation to be about 60-70 per cent, and the practical limit for peak capacity utilisation to be about 75-85 per cent (UIC, 2004)*' (page 13)

The Australian Rail Track Corporation (ARTC) has used three methods to analyse capacity on their East–West, North–South, and Hunter Valley networks (ARTC 2007a, ARTC 2008, ARTC 2007b):

The ARTC theoretical capacity model calculates the daily capacity of a link by dividing the duration of the day by the section running time on the longest section plus an allowance for safeworking. The practical capacity is assumed to be 65 per cent of the theoretical capacity on single-line track, and 70 per cent of the theoretical capacity on double-line track.' (pages 16-17)

An Assessment of Railway Capacity, M. Abril, (a) F. Barber, L. Ingolotti, M.A. Salido, P. Tormos, (b) A. Lova, Department of Information Systems and Computation, Dept. of Applied Statistics and Operational Research, and Quality Technical University of Valencia Camino de Vera s/n, 46022, Valencia; dated 2007

'Practical Capacity: …It is the capacity that can permanently be provided under normal operating conditions. It is usually around 60%-75% of the theoretical capacity, which has already been concluded by Kraft (1982). Practical Capacity is the most significant measure of track capacity since it relates the ability of a specific combination of infrastructure, traffic, and operations to move the most volume within an expected service level'

'…two tracks usually have around four times more capacity than a single track'

BITRE, 'Adequacy of Transport Infrastructure Rail', dated 1995

'…It is widely accepted that practical capacity is some 60-70 per cent of the theoretical maximum and this represents the level of utilisation at which a line can provide a tolerable level of service' (Kraft 1988)

Analyzing the Theoretical Capacity of Railway Networks with a Radial-Backbone Topology, F. Riejos, E. Barrena, J. Ortiz, G. Laporte

'Traffic flow that can be offered under normal operating conditions, driving on the railway line with an acceptable level of reliability. This typically corresponds to between 60% and 75% of the theoretical capacity since it depends on the priorities established among different kinds of trains, and on the traffic clustering'

Melbourne Metro, 'Better signalling = more trains. How moving block signalling could boost capacity across Melbourne's rail network', dated 2013

'…This has a 'theoretical' capacity of 30 trains per hour, but because running times vary randomly, the 'practical' capacity is about 80% of this, or 24 trains per hour'

'A Delay Estimation Technique for Single and Double-Track Railroads', P. Murali, M. Dessouky, F. Ordonez, K. Palmer, dated 2009

'…This can be thought of as the utilization of the network being ≤ 80%'

Journal of Rail Transport Planning & Management, 'Hybrid Simulation Approach for Improving Railway Capacity and Train Schedules', dated 2015

'…aligns closely with the 70% practical capacity utilization threshold recommended in railway literature (Pouryousef et al., 2013; UIC, June 2004; Pachl, 2002)'

3.3 Dynamic modelling

As previously explained, Aurizon Network undertakes a combination of static and dynamic modelling when undertaking a capacity assessment of its network. The CQSCM is used by Aurizon Network to perform capacity analysis, in particular, to determine if there is sufficient capacity to meet contracted TSEs and, if so, to determine remaining available capacity (for example to meet growth in TSEs). It is a dynamic model that uses discrete event simulation through a Monte Carlo approach. The CQSCM models the entire CQCN. It allows the measurement and assessment of the impact of changes to a range of supply chain elements on overall network capability.

The model simulates each train movement required to deliver Aurizon Network's input TSE profiles. Train cycles are simulated including transit times, train crossing movements, loading and unloading processes, crew changes, provisioning and yard activities. Maintenance requirements of the infrastructure and the rollingstock are driven by appropriate metrics to produce a comprehensive strategic view. Maintenance and renewals delivery is replicated with requisite track possessions and the associated impact on rail traffic.

The combination of supply chain configuration, performance, reliability and planning parameters replicated by the model, provides a means of testing the effect of changes to individual elements of the supply chain on the overall performance. The model produces a Monte Carlo simulation providing results as a statistical output.

Theoretically, Aurizon Network's dynamic modelling assumptions that directly impact network capacity losses should reasonably align with the static modelling assumptions outlined in its static modelling framework. In this instance, dynamically modelled assumptions such as planned maintenance/renewals, and input speed restrictions should equate with the static allowances outlined previously.

Aurizon Network runs its dynamic model multiple times with a number of 'random seeds' which assists with variability in modelled outputs. The aim of its dynamic modelling is to achieve 100% of contracted TSEs. Should TSEs be met within Aurizon Network's in-house assessment criteria framework (i.e. that it achieves contracted TSEs), then contracted TSEs are deducted from the static model's Existing Capacity estimate. This leaves an estimate for Available Capacity. The assessments of Absolute Capacity, Existing Capacity and Available Capacity are then documented in Aurizon Network's BCAR.

We consider the CQSCM to be a suitable tool for undertaking the BCAR.

4. GHD approach to assessment of models and the BCA

4.1 Our approach

In accordance with the requirements of the TOR, we have undertaken the following in our analysis of Aurizon Network's method for developing the BCA and the BCA in itself for this report:

1. Initial project commencement meeting with Aurizon Network and the QCA
2. Observing a demonstration of Aurizon Network's capacity modelling software at Aurizon Network's office (7 September 2017)
3. Undertaken a Request for Information (RFI) process (22 September 2017 to 24 November 2017)
4. Analysis and benchmarking of supporting data and documentation
5. Presented overall conclusions and recommendations in the context of the criteria in clause 7A.4.1 and 7A.4.4 of the 2016 AU.

We commenced our review of Aurizon Network's BCAR in early September 2017. In the first four weeks of the project, we shaped several RFIs in collaboration with QCA staff to request qualitative and quantitative evidence from Aurizon Network about its capacity determination approach and the assumptions used underpinning its BCA. Aurizon Network received these RFIs on 22 September 2017 with an understanding that there was an expectation that responses be received by 20 October 2017.

During the RFI process, it became apparent to QCA staff and GHD that Aurizon Network staff required greater amounts of time than envisaged to respond to the RFIs. Aurizon Network requested, which was subsequently accepted, a revised deadline of 3 November 2017.

We considered that Aurizon Network's initial responses were incomplete. On 17 November 2017, a face-to-face meeting was convened between Aurizon Network, QCA staff and GHD. At this meeting it was agreed that Aurizon Network would have until 24 November 2017 to provide all outstanding information requested earlier, but which had not been received.

5. GHD findings from analysis

5.1 System wide findings

There are areas where we have concern with the modelling approach and assumptions adopted by Aurizon Network in undertaking its BCA. The impact on Available Capacity and ability to meet contracted TSEs is unknown at this stage in the absence of systems being modelled in a manner that addresses these issues.

These issues are explained below.

5.1.1 Background and context

Aurizon Network dynamically models and reports to the QCA on each system comprising runs of one-month intervals. The CQSCM is run to operate enough services in a given month to achieve the month's TSE requirement for each system and nothing more. Upon achieving TSEs, consists are then returned to the originating depot to await further instruction, which by default in this instance, is nil.

For each new month, trains are reset from the main depot and commence assigned tasks throughout the network. The CQSCM allows for a seven-day warm-up period to allow trains to flow through the rail network before the CQSCM records data relevant to the modelled period. This warm-up period is not included and is in addition to the one-month recorded interval. During this 'recorded period', trains are requested to fulfil their TSE requirement. Trains continue to cycle until the TSE quota is fulfilled.

Upon running each month separately in a year, Aurizon Network then aggregates TSE's for each month based on these simulated findings to compute its network capacity throughout each year, based on the achievement of monthly TSEs.

5.1.2 GHD's findings

Modelling 1-month intervals

We do not accept Aurizon Network's modelling practice in this regard. Aurizon Network's CQSCM is capable of modelling for periods of time beyond a one-month period and indeed beyond a one-year period.

The coal systems that Aurizon Network manages and operates are 24/7 operations. The long-term operation of the systems bear little resemblance to what has been dynamically modelled. Modelling a 24/7 coal system using a model that resets itself each month affords no continuity and does not take into account congestion that may and is likely to spill-over from month to month and hence compound. Such congestion can occur from track configuration and layout as well as from other rail network events, such as maintenance, closures and speed restrictions which may span across month boundaries. In the manner in which Aurizon Network operates its dynamic model, such instances are assumed to rectify themselves at the commencement of the warm up period for each one month's run of the model. We consider that restricting the modelling period to one-month intervals does not accurately reflect a 24/7 coal rail system and the limitations of track infrastructure.

As any congestion or delays are resolved at the end of each month of run and the system is renewed afresh, vital information is lost as regards monitoring the continuity of a train beyond a one-month period. This includes data on the whereabouts of trains on the system from the last day of the recorded month to their potential location on the first day of the following month. In the modelling approach adopted by Aurizon Network, there is no continuity: each train is assigned a new ID for each month and more importantly, there is no guarantee that the number of system trains from month to month is consistent. Further, it is not clear, from our review of model input assumptions and outputs how considerations such as track maintenance, speed restrictions, and fleet maintenance are rolled from one month to another, if at all.

The integrity of the data therefore is compromised by the lack of continuity throughout the cycle. We consider that Aurizon Network's modelling approach is inconsistent with what can, and should be, achieved with the modelling tools it has available, that is to run the model over extended periods to appropriately capture build-up of congestion and delays from one month to another.

To further investigate this matter, we sought scenario-related information from Aurizon Network on its rationale for modelling 1-month instead of 12-month intervals. Aurizon Network said:

A key reason for running the BCA for each month separately was to allow for the number of train consists to be optimised for each month. When running a continuous 12 month simulation the number of consists needed to be set based on the maximum required in any one month. This results in some months having more consists than is optimum. This does result in some variation in the 12 month continuous simulation compared to the original BCA in terms of the achieved TSEs per month. Overall achieved capacity for the 12 month period is still aligned to the BCA issued.[10]

We note that a consequence of using a continuous 12-month simulation could be the 'inflating' of the maximum number of consists required in a month. However, we consider that accommodating this consequence to be reasonable when trading it off with the consequence of not addressing the issue of congestion that is likely to spill-over from month to month. We consider the consequence of not capturing the compounding of congestion from month to month, under Aurizon Network's current modelling approach to be more material than the issue of a potential inflation of the number of consists required in a month.

Simulation warm-up period

We also have concerns with respect to the brief warm-up period of 7-days used prior to recording system data for modelled runs. A longer period is preferred to ensure the system reaches a 'steady-state', and therefore mimics the actual system. The warm-up period is important because it affects the accuracy of the results when undertaking simulation modelling. When a system is modelled which has not reached a steady-state situation, system results can potentially vary significantly from one run to another for the parameters used and can produce incorrect information. To address this, we recommend that a 30-day warm-up period be adopted instead of a 7-day period. We consider it appropriate for the minimum warm-up period to at least reflect how TSEs are contractually provided (i.e. on a monthly basis) to access holders.

We acknowledge that Aurizon Network provided us[11] a summary chart (not the raw data) to indicate that applying a range of 7-day to 30-day warm-up periods to a one-month simulation had a negligible impact on the number of available TSEs. However, without seeing the raw data for this simulation and for a 12-month simulation period, we are unable to verify the accuracy of Aurizon Network's analysis. Nevertheless, we consider it good practice for Aurizon Network to adopt a 30-day warm-up period to allow for steady-state operations to be achieved for appropriate modelling to occur; and, assuming sufficient time was available, provide the same data in such a scenario as provided for the Base Case, to make an informed decision.

Port unloading rates (time at port)

There is inconsistency between what Aurizon Network has reported as being its modelling approach at important interfaces such as the port, and what its CQSCM (cycle time) data suggests.

---

[10] Aurizon Network staff e-mail to GHD staff and QCA staff on 5 February 2018

[11] Aurizon Network staff e-mail to GHD staff and QCA staff on 5 February 2018

Aurizon Network has advised that it had adopted time at port assumptions based on maximum conditions expressed in Access Agreements. Our analysis of CQSCM cycle time data suggests that this approach has not been undertaken in all cases.

Nonetheless, we disagree with Aurizon Network's position that it should model the value specified in Access Agreements for time at the port in any event. While Aurizon Network's approach reflects a condition specified in Access Agreements, Access Agreements in this respect, do not reflect what is expected to occur on a day-to-day basis but reflect, commercially, the maximum time threshold in which a train should be at the port (see Standard Access Agreement Definitions, page 10). The act of assuming the worst-case scenario for port times (given that these intrinsically determine the outturn rate of the coal supply chain), while modelling rail components in a more realistic and efficient manner can only serve to make rail operations 'appear' better than perhaps really occurs. It also fails to meet clause 7A.5(b)(iii)(b) of the Access Undertaking.

In our view, a better approach would be to have taken a midpoint of historic time at port, i.e., an average, while ensuring this time is not greater than the maximum quoted in Access Agreements. Such an approach would meet requirements of clause 7A.5(b)(iii) in its entirety, and provide a more reasonable/reliable estimate of rail network capacity. That said, one area that we consider important for stakeholder feedback to be provided on is whether the Maximum Time at Unloading Facility (UT4 standard access agreement) is captured by the definition of Committed Capacity (via TSEs) or that of Existing Capacity (via Losses).

If the concept of maximum times at an unloading facility form part of Committed Capacity, and are significantly above the average for whatever reason, the impact is that Available Capacity would be artificially under-estimated. By contrast, if the average/median times to which these maximum times relate are accounted for in the definition of Losses (when deriving Existing Capacity), then a more appropriate estimate of Available Capacity could emerge Ultimately, such thinking should be informed by, among other things, how CQCN stakeholders consider port-unloading times should be addressed in the BCA.

5.2 System specific findings

This section provides a detailed insight into our analysis of dynamically modelled scenarios that inform Aurizon Network's below-rail capacity assessment for each of its coal network systems.

We sought to analyse dynamic model inputs as well as outputs to assess practical alignment of the modelling with real-world occurrences. We provide our overall findings at the start of each system commentary taking regard of the BCA review objectives, before providing the analysis supporting our respective findings for each system.

For the sake of avoiding unnecessary repetition, we have included more detailed background information common to all systems for Goonyella and omitted it or summarised it to a large extent, for all other systems.

5.2.1 Goonyella

We recommend that Aurizon Network's assessment of there being sufficient capacity to accommodate current TSEs is accepted. However, we consider that Aurizon Network's determination of Available Capacity for the Goonyella system is conservative.

While we agree on the location of congestion points along track infrastructure and agree as to where material surplus capacity exists, we disagree from analysing the information provided, that these 'bottlenecks' warrant Aurizon Network's position that less than 1% of Absolute Capacity exists for additional TSEs, or 371 new TSEs, in the Goonyella system.

Our detailed analysis supporting our findings are provided in the sections below.

5.2.1.1 Train numbers

Aurizon Operations' fleet includes approximately 500 active locomotives and 13,000 wagons, which when combined in configurations suitable for certain mine-port combinations, become full train sets (or consists).

When asked for clarification on actual consist numbers throughout the network, Aurizon Network provided the following response:

"*Actual fleet size is not used in the capacity assessments. Rather, the assessments use a baseline modelled fleet size, which is incrementally increased/decreased to find the fleet size which will meet the capacity assessment requirements*"

Actual fleet modelling was a concern raised by Pacific National in its stakeholder submission to the QCA. The question as to whether Aurizon Network's modelling of trains reflects the true (or reasonable) availability of rolling stock is an important consideration. On the presumption that there is sufficient capacity to meet contracted TSEs, we sought to ensure that the number of modelled trains did not exceed the number of trains suitable and available for the rail network. This is important because the number of average delays increases exponentially when the number of trains exceeds the saturation level for a given rail network. When this occurs, network reliability is lost and above rail operators will not be able to recoup a return on their above rail investment.

Therefore, increasing the number of trains over the saturation level is not useful for stakeholders (and is an unlikely scenario) and should be accounted for in evaluating Aurizon Network's below-rail capacity assessment. Similarly, modelling a greater number of trains than what exist will produce inaccurate results.

We sought to try and understand whether consist numbers dynamically modelled reasonably align with what exists, or should exist, given a specified TSE requirement.

Aurizon Network provided actual consist figures (based on a Calendar Year or Financial Year of 2016). Modelled consist numbers for Goonyella versus 2016 consist numbers are outlined in the below table.

Table 4 – Goonyella fleet assumptions

System	CQSCM Fleet	Actual 2016 Fleet
Goonyella	33	[redacted]

Source: GHD analysis of CQSCM system performance data (dataset: 9_1708_CycleLog_6) and Aurizon Network Response (dataset: consist numbers 2016)

[redacted]

While consist numbers are important, the issue whether consist numbers align or not, does not in itself pose an issue so long as the relationship between certain above rail variables remain reasonable. These variables are outlined below:

- Consist utilisation levels are not excessively high or excessively low, i.e., an acceptable range is approximately 85-90%;
- TSEs (or throughput) are being achieved; and
- Computed BRTTs are below threshold levels.

In circumstances where the relationship between these variables fails, the consequence will differ. For the purpose of the BCA, a scenario whereby: (1) consist utilisation levels are low; (2) TSEs are achieved; and (3) computed BRTTs are above the BRTT Threshold, would be the most concerning. Such a situation would imply an over allocation of consists, the effect of which allows for TSEs to be achieved while placing artificial pressure on the below rail infrastructure. Such congestion could arise anywhere along the supply chain (bottlenecks) if this were to occur.

Our analysis found no evidence of this and therefore, we consider Aurizon Network's fleet size modelling assumptions to be reasonable.

5.2.1.2 Below Rail Transit Time (BRTT)

Access Agreements specify a target below rail transit time (BRTT), which is a value denoting the minimum, annual average operational performance (expressed as a percentage) that each system must meet. BRTT is measured as an annual weighted system average and effectively measures the additional time to the nominated 'greenlight running' cycle time for a service (excluding any above rail planned dwells or delays or Force Majeure Events). This percentage accounts for the dynamic interactions of cyclic traffic such as crossing activities, network caused delays (including speed restrictions), and queueing of trains.

When Aurizon Network undertakes network capacity analysis through its dynamic modelling, the performance of each system against the target BRTT value is monitored. Where excessive BRTT is identified the reason for the excessive BRTT is investigated. If the reason for excessive BRTT is identified as being reasonable and would likely impact actual operations, then further analysis is performed to identify and assess opportunities to reduce the BRTT.

The table below shows that the average BRTT for the Goonyella system for the modelled period of August 2017, is above the modelled threshold of 123%. In essence, this suggests that there are constraints in the below rail infrastructure.

Table 5 – CQSCM, Goonyella system BRTT (August 2017)

System	Cycle Time	BRTT Threshold	BRTT Achieved
Goonyella	18.55	123.00%	131.47%

Source: GHD analysis of CQSCM system performance data (dataset: 9_1708_CycleLog_6)

A simulation run for a track system not meeting its BRTT Threshold suggests that the system is not operating as efficiently as it should. System performance and therefore BRTT, are stipulated in Access Agreements with customers and are therefore a reflection of the minimum quality of service expected by rail users. System performance is particularly important for above rail operators and mining customers when making coal haulage decisions, such as whether to use rail or not, and hence potential investment decisions such as in significant above rail assets such as locomotives and wagons, for example.

While the modelled BRTT is above the applicable threshold, we do not consider this in isolation, represents grounds to deem that insufficient capacity exists to meet contracted TSEs. We consider it to be more a function of the way the system is modelled in the dynamic model rather than a true reflection of actual system BRTT.

5.2.1.3 Jilalan (depot)

Analysis of CQSCM cycle time data identified situations whereby capacity at important supply chain locations is unrealistically unconstrained.

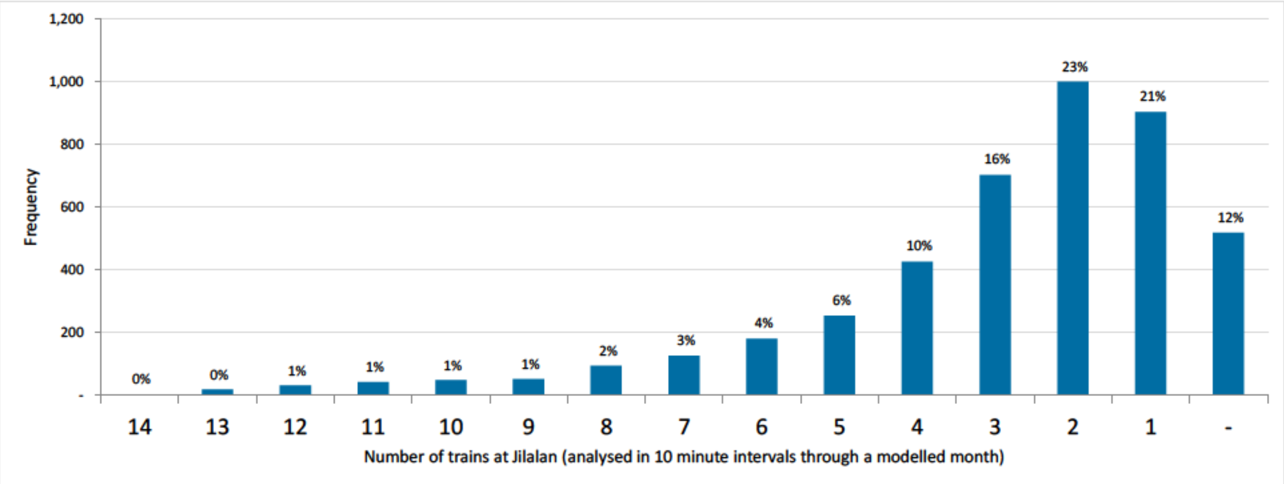
We analysed dynamically-modelled location capacities at both the port and network dispatch locations such as Jilalan. This analysis was undertaken to assess the utilisation of these locations in an attempt to determine the number of holding roads dynamically modelled. Data provided by Aurizon Network was used for this analysis and in the form provided to us, it was limited to examples of 1-month intervals.

Understanding the relationship between modelled holding roads and the resultant utilisation of these holding roads is important, as assuming unconstrained capacity at supply chain interfaces, such as the port and/or rail depots for example, can have the potential to incorrectly overstate available railway capacity. An example of this is where a depot (usually located in proximity to a port) is assumed to be unconstrained in terms of capacity. If this were to occur, trains would unrealistically always find space at the depot (loaded or otherwise). This would free up track capacity and allow better interaction of trains along the rail network in the model than can be achieved in reality. Depending on the utilisation, it may be argued that this track capacity in surrounding areas would otherwise be unavailable, as trains in reality would back up along the rail network.

Depending on the extent of congestion, delays would be exacerbated as the network gradually recovers from the situation. Understandably in this scenario, network capacity is lost and given the likelihood of this scenario, it should be accounted for in the model. Therefore, the inclusion of such capacity constraints at important supply chain interfaces, such as the port and depot, should be taken into consideration.

Aurizon Network advised us that the capacity of the Jilalan depot is 15 trains[12]. From our analysis we found that Aurizon Network's capacity estimations at Jilalan were reasonable, as the maximum number of trains that featured in the modelling was 14; the below chart plots the distribution of utilisation at Jilalan in the 1-month modelled period.

Figure 5: Number of trains at Jilalan at any given time



Source: GHD analysis of CQSCM system performance data (dataset: 9_1708_CycleLog_6)

As previously mentioned, network capacity can be described by reference to the available utilisation of paths to operate trains on. Such paths are based on the constraints from MaTP services, possessions, and moving products.

In terms of the Goonyella system, pathing between Jilalan and Coppabella has a fixed pathing separation of 20 minutes in both the up (empty) and down (loaded) directions, this allows up to 72 theoretical paths in a day. The actual utilisation of paths will be less than this, after taking into consideration network losses and reliability factors, and Access Holder demands for train services (TSEs).

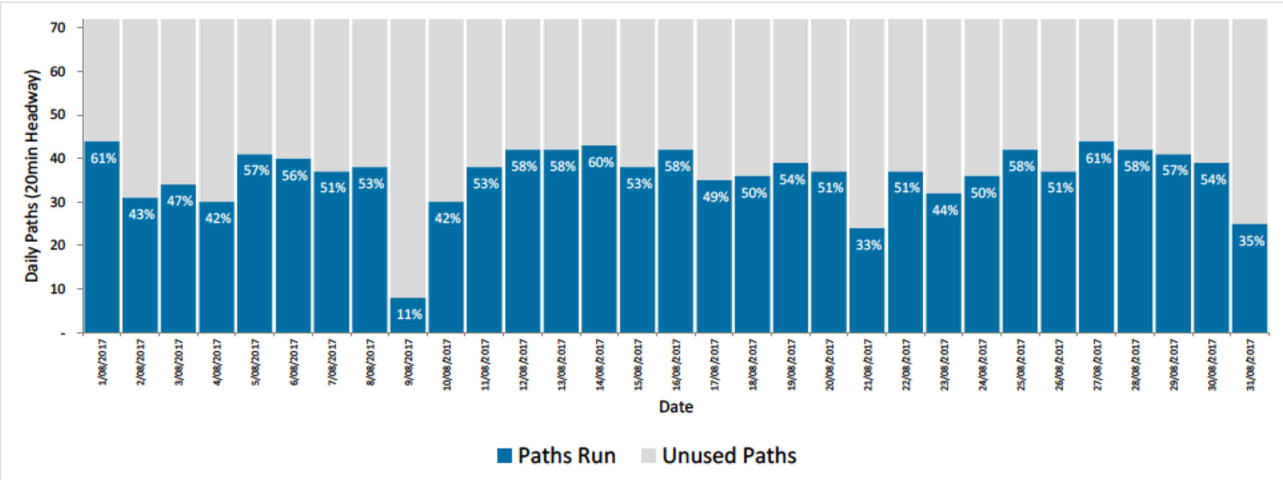
We have sought to understand and validate the modelled utilisation of system paths. We have analysed cycle time data provided by Aurizon Network, which was limited to 1-month intervals. In the example analysed below (dataset: 9_1708_CycleLog_6), we found that throughout this modelled period, network

[12] Aurizon Network provided us this information in a meeting at the QCA's office on 19 January 2018.

pathing utilisation was on average 53% of theoretical daily paths. Compared with industry, we consider this utilisation figure to be low.

The chart below illustrates the dynamically-modelled path utilisation for trains dispatched from Jilalan in the empty direction of travel for the analysed period. As shown, the utilisation of daily paths remains fairly consistent with little variability oscillating generally between 58% and 49%. This is consistent with running the Goonyella system under an 'even railings' mode of operation (even spacing of train despatch).

Figure 6: CQSCM (Goonyella) path utilisation (dataset: 9_1708_CycleLog_6)



Source: GHD analysis of CQSCM system performance data (dataset: 9_1708_CycleLog_6)

5.2.1.4 [redacted] Loadout

[redacted] loadout has capacity for one train to be loaded with coal at any given time. We have observed, that in Aurizon Network's modelling, [redacted] is assumed to have two loadouts, i.e., can load two trains at the same time. This modelled outcome is impossible to achieve in reality as the infrastructure does not exist.

When we queried Aurizon Network on this, Aurizon Network acknowledged that the modelling of [redacted] loadout incorporates two loadoouts as a specific and unique assumption within the model. Aurizon Network also advised that this was driven by specific contractual arrangements with the respective customer.

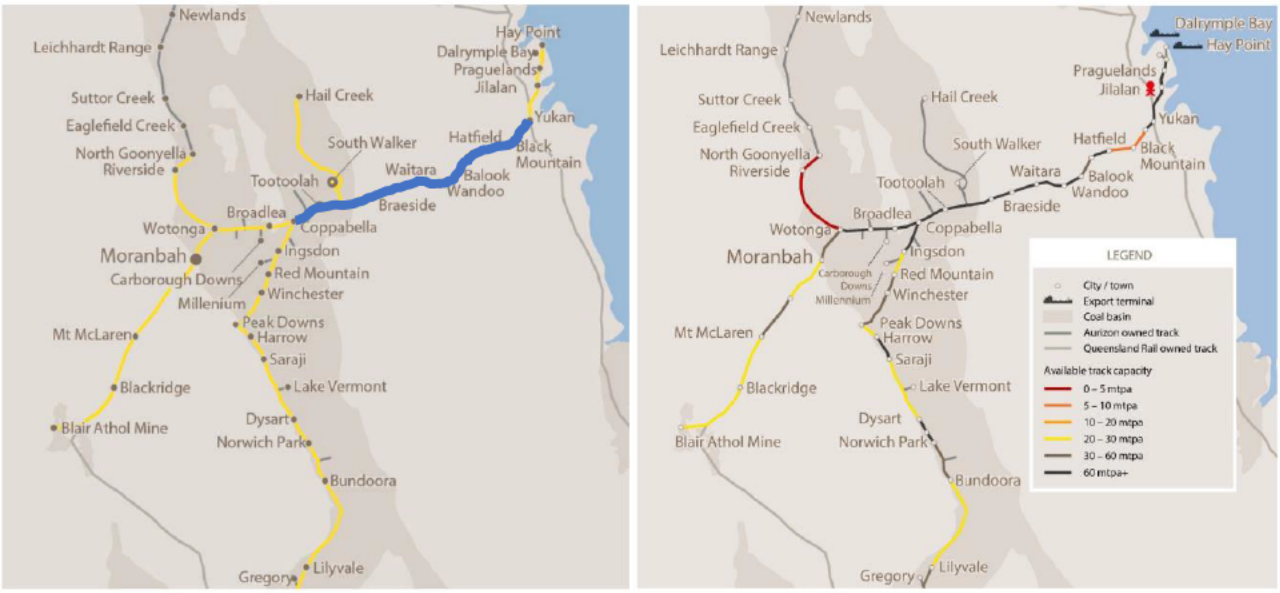
[redacted]

In order to resolve this condition in terms of a model assumption, Aurizon Network therefore modelled the [redacted] loadout as being capable of loading two trains simultaneously. [redacted] We consider it inappropriate for Aurizon Network to model capacity as if two loadouts [redacted] are in place. The consequence of modelling infrastructure that does not exist is an example of modelling a network that is inconsistent with reality. There is therefore, a likelihood that TSEs may be reported as being achieved, when they may not in fact be capable of being achieved.

5.2.1.5 Main corridor utilisation

The main corridor affecting the Goonyella system is defined as the track infrastructure between Jilalan and Coppabella. This corridor has double-tracks. This corridor is highlighted in the below figure.

Figure 7: Goonyella main corridor (left, highlighted in blue) and deemed utilisation (by Aurizon Network, right)



Source: adapted from Aurizon Network, BCAR (2016)

Duplicated tracks usually involve running separate tracks in each direction (up and down direction), compared to a single-track railway, where trains in both directions share the same track.

Duplicated track infrastructure has a higher capacity (*ceteris paribus*) than alternate single-track infrastructure. We estimate that double-track infrastructure can reasonably be expected to cater for up to 75% utilisation (average throughput over a prolonged period of time, typically 12-months). Similarly, single-track infrastructure is limited to perhaps 67.5% utilisation.

These upper utilisation thresholds reflect the practical constraints in scheduling trains on either single-track line with imperfectly spaced loops and variable train speeds, or duplicated track. These utilisation figures provide for a degree of latitude to accommodate other issues such as temporary speed restrictions and differences between actual and modelled train performance.

We have analysed main corridor capacity by way of two metrics, first by way of main corridor path utilisation and second, by track section or location utilisation. In the previous section, we made reference to path utilisation and that our findings indicate a low utilisation of available paths for this network.

For the purpose of the next section and for assisting interpretation of the below charts, we have defined path or pathing utilisation as being:

Path utilisation: is the actual usage of paths in a given period versus what is theoretically available for that same period, before consideration of any path losses or robustness allowances, i.e., for Jilalan in the empty direction of travel, there are 72 theoretical paths in day. If 36 paths are utilised by dispatching rail services in this same day, the path utilisation for that day is 50%.

We note that Aurizon Network defines path utilisation differently from us. Aurizon Network measures this metric as the percentage of available paths of the Existing Capacity estimate (i.e. Absolute Capacity net of

Maintenance & Renewals and Losses). However, we consider that our definition, which is a percentage of Absolute Capacity, to be more appropriate because it is in keeping with how other heavy-haul below-rail operators measure path utilisation.

We have defined section utilisation as being:

Section utilisation: the actual usage of certain track infrastructure (section) by a train service for a given period as a percentage of that period. Each track is considered in isolation and can only allow 1 train to traverse the section of track at any given point in time.

Location utilisation: the number of trains at a given location at a given point in time as a percentage of the maximum number of trains that can occupy that location. For our purposes, the number of trains counted at any given location are broken down into 10-minute increments and calculated throughout the recorded month.

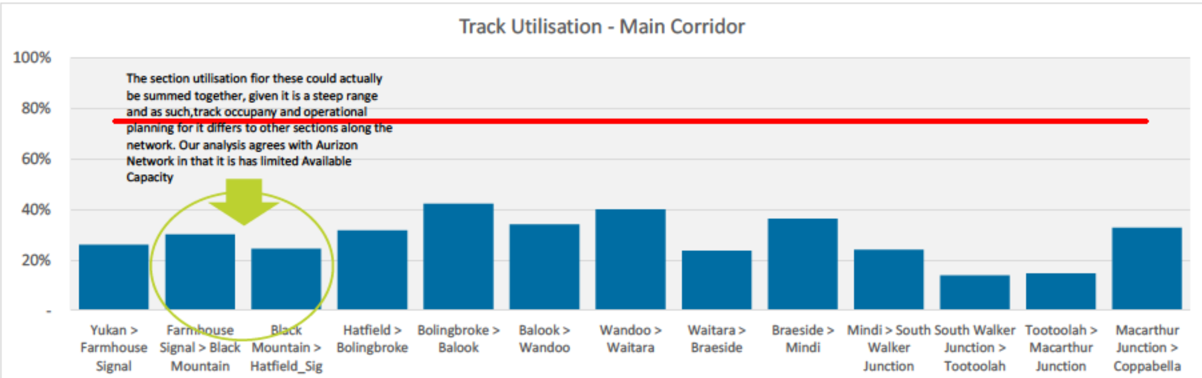
Aurizon Network has made no reference to non-coal train traffic for this network and therefore, non-coal traffic has been ignored in our analysis.

Our analysis of CQSCM track section utilisation between Yukan (near Jilalan) and Coppabella for the modelled period is depicted in Figure 8. The analysis indicates a relatively low and smooth utilisation of track infrastructure. This suggests that (and in the absence of specific location delay data) the corridor has significant surplus capacity.

In the instance that a specific location was to be the cause of continued delays (therefore attributing to increased BRTT), section utilisation in the below figure would be visually higher in the sections modelled below. In this instance, no bottlenecks have been identified.

In light of our analysis of the above, we find that Aurizon Network's determination of main corridor utilisation is reasonable and that surplus capacity exists along this rail infrastructure.

Figure 8: CQSCM (Goonyella) track section utilisation (Yukan to Coppabella)



Source: GHD analysis of CQSCM section performance data (dataset: 2664_9_1708_Sections)

5.2.1.6 Branch line utilisation

We have analysed branch lines as part of our BCA review. For the Goonyella system, three branch lines were considered. These are as follows:

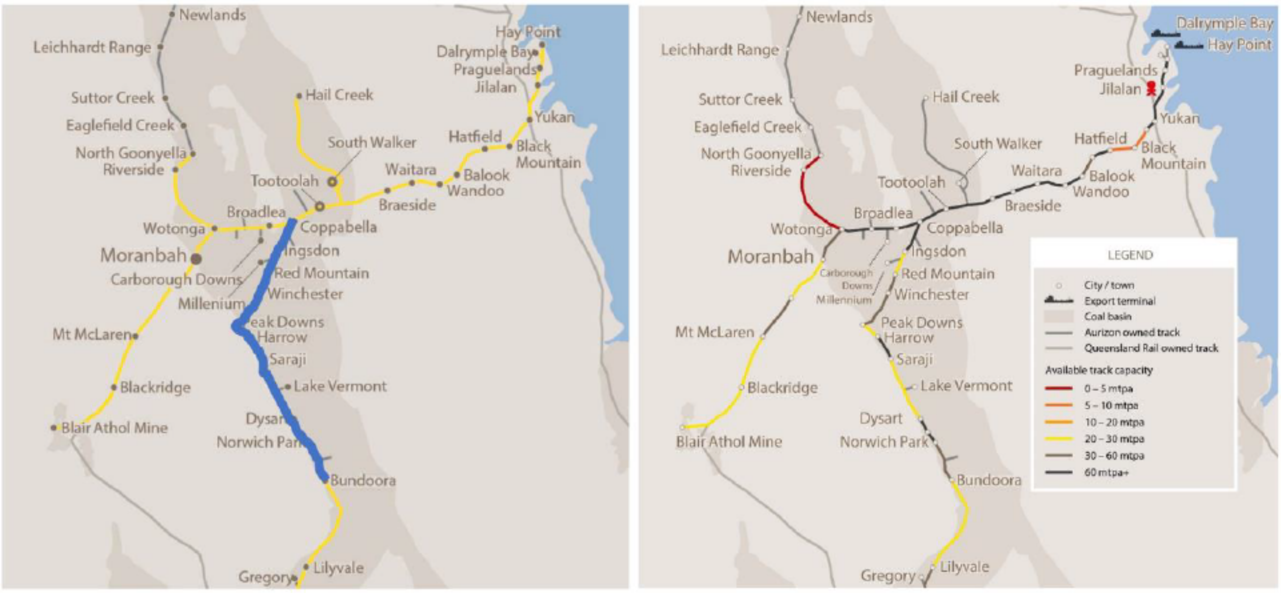
- **Branch line 1:** Coppabella to Bundoora
- **Branch line 2:** Coppabella to Goonyella
- **Branch line 3:** Wotonga to Blair Athol

These branch lines are analysed in turn below.

Branch line 1

Branch line 1 concerns the track infrastructure between Coppabella and Bundoora. The track is predominately single line with the exception of track between Coppabella and Ingsdon. This corridor is highlighted in the below figure.

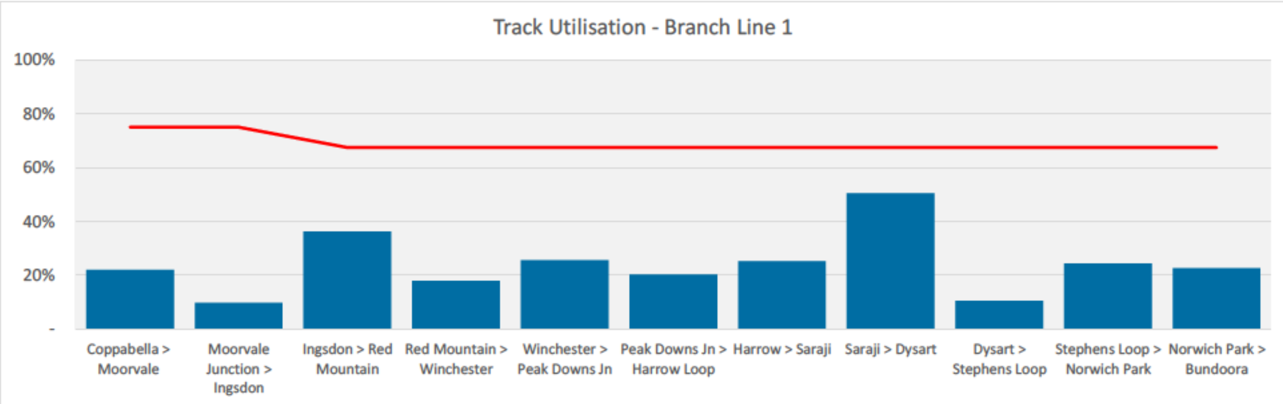
Figure 9: Goonyella branch line 1 (left, highlighted in blue) and deemed utilisation (by Aurizon Network, right)



Source: adapted from Aurizon Network, BCAR (2016)

Our analysis of CQSCM track section utilisation of this corridor for the modelled period is depicted in Figure 10. The analysis indicates an acceptable utilisation of track infrastructure. This suggests that while the corridor has surplus capacity, capacity is more constrained around Saraji and Dysart relative to other sections of track. Our findings align with Aurizon Network's assessment that there remains sufficient capacity for additional TSEs along this branch line.

Figure 10: CQSCM (Goonyella) track section utilisation (Coppabella to Bundoora)

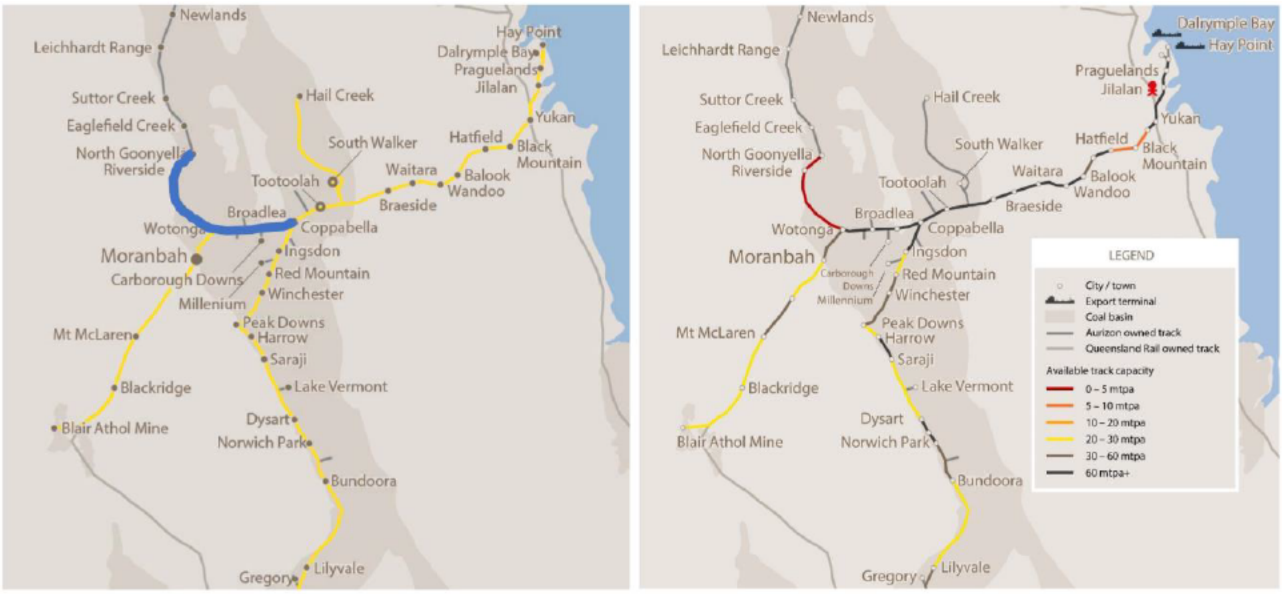


Source: GHD analysis of CQSCM section performance data (dataset: 2664_9_1708_Sections)

Branch line 2

Branch line 2 concerns the track infrastructure between Coppabella and Goonyella. The track is predominately double-track with the exception of track between Wotonga and Goonyella. This corridor is highlighted in the below figure.

Figure 11: Goonyella branch line 2 (left, highlighted in blue) and deemed utilisation (by Aurizon Network, right)

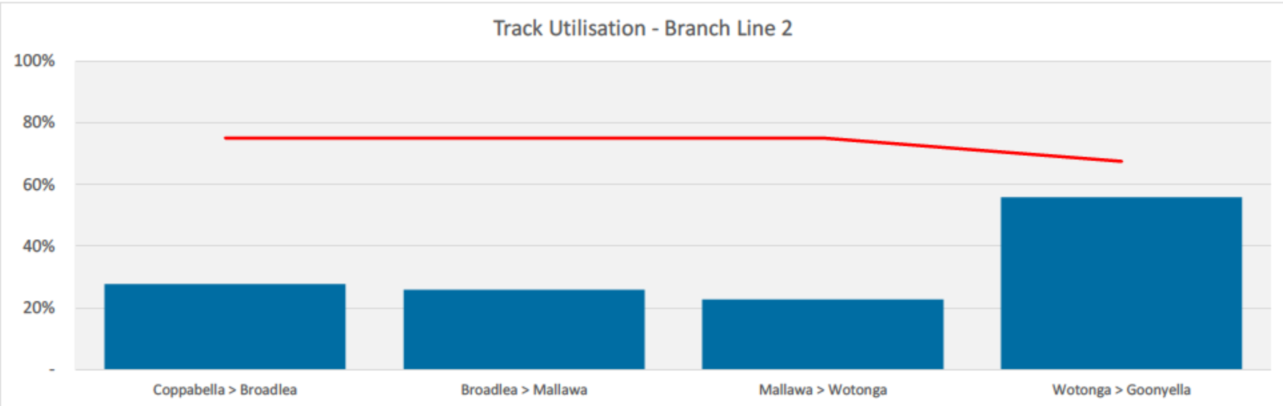


Source: adapted from Aurizon Network, BCAR (2016)

Our analysis of CQSCM track section utilisation of this corridor for the modelled period is depicted in Figure 12. The analysis indicates an acceptable utilisation of track infrastructure to Wotonga. While capacity is limited beyond Wotonga heading north towards the Newlands system, we consider the system has more Available Capacity than determined by Aurizon Network in its BCA.

We note that Aurizon Network's CQSCM results may also show the situation to be worse than in reality, as the dynamic model has certain limitations when taking into consideration junction capacity and the ability for a train to wait for a path at branch lines to mine loadouts.

Figure 12: CQSCM (Goonyella) track section utilisation (Coppabella to Goonyella)

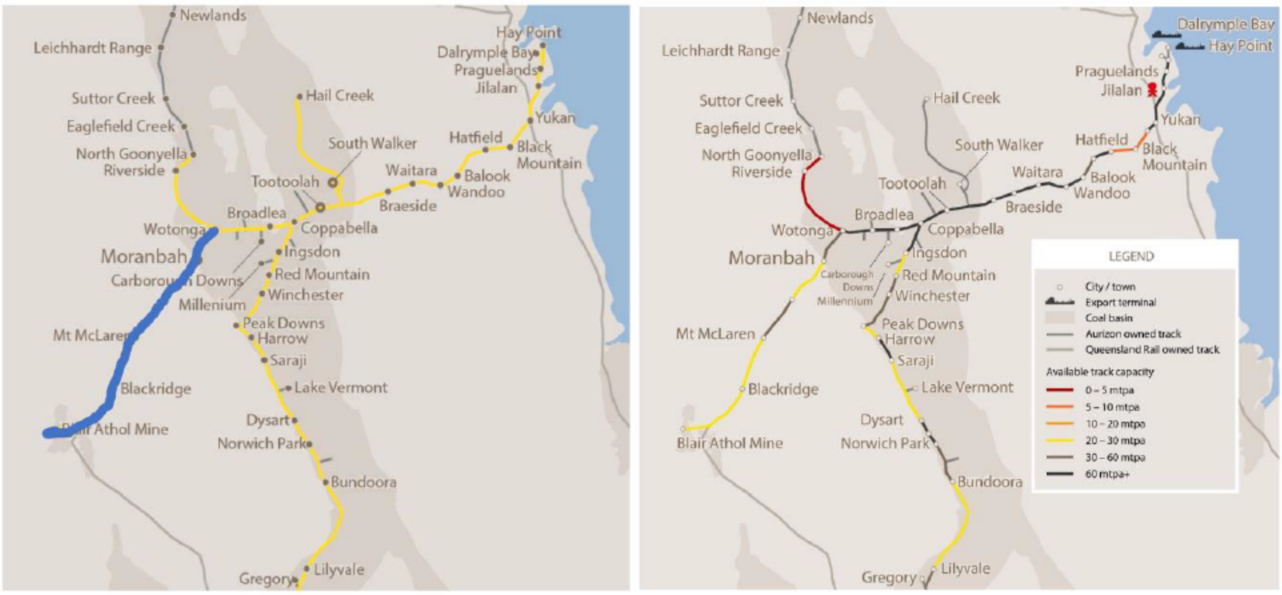


Source: GHD analysis of CQSCM section performance data (dataset: 2664_9_1708_Sections)

Branch line 3

Branch line 3 concerns the track infrastructure between Wotonga and the Blair Athol Mine. The track is single-track. This corridor is highlighted in the below figure.

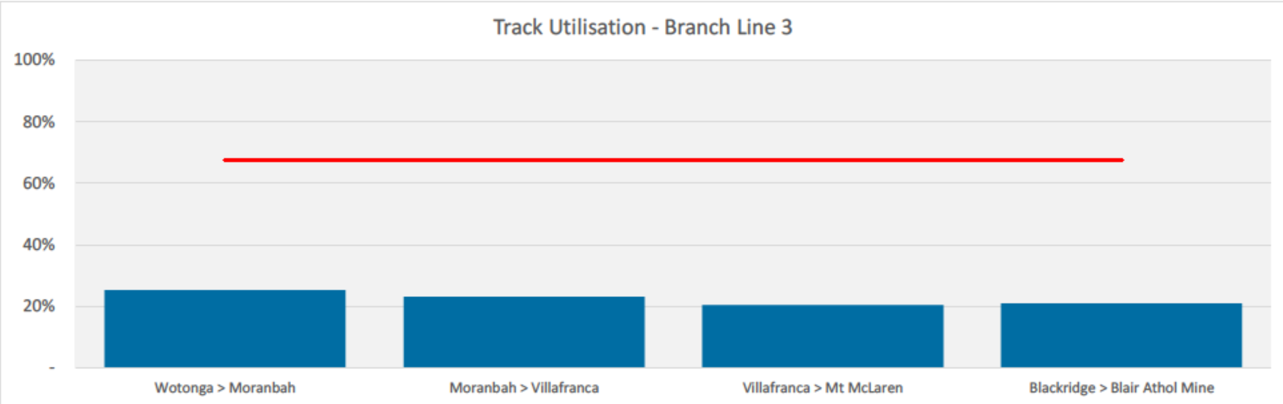
Figure 13: Goonyella branch line 3 (left, highlighted in blue) and deemed utilisation (by Aurizon Network, right)



Source: adapted from Aurizon Network, BCAR (2016)

Our analysis of CQSCM track section utilisation of this corridor for the modelled period is provided in Figure 14. The analysis indicates an acceptable utilisation of track infrastructure. We agree with Aurizon Network findings in its BCA that the corridor has significant surplus capacity.

Figure 14: CQSCM (Goonyella) track section utilisation (Wotonga to Blair Athol)



Source: GHD analysis of CQSCM section performance data (dataset: 2664_9_1708_Sections)

5.2.1.7 Port

The Goonyella system services the Bowen Basin in Central Queensland and carries product to the ports at Hay Point and other destinations by way of connections to the North Coast Line at Yukan and the Central Line via Gregory to Burngrove. Predominately however, coal is exported from the Port of Hay Point.

The Port of Hay Point is the second largest coal export port in the world with two dedicated coal loading terminals, the Dalrymple Bay Coal Terminal (DBCT) and the Hay Point Coal Terminal (HPCT). Dual unloading balloons are located at HPCT and Triple unloading balloons at DBCT.

An overview of each of these terminals is outlined below.

Dalrymple Bay Coal Terminal

- Is a common user terminal, owned by the Queensland Government through DBCT Holdings Pty Ltd
- Has a name plate capacity of 85 MTPA
- Has three rail receivable stations
- An extensive conveyor network transports the coal either directly to the wharf for loading or to the stockyard for storage
- The stockyard covers nearly 67 hectares and provides eight rows of stockpiles with a combined live capacity of over 2.28 million tonnes
- Stacking machines are used to create stockpiles by transferring coal from the conveyors at a rate of up to 7,500 tonnes per hour
- The average stockpile contains about 20,000 tonnes of coal (approximately two train loads)
- When a ship is ready for its cargo, reclaimer machines use a bucket wheel to clear the stockpiles and place the coal back on the conveyor system. These machines reclaim at an average rate of up to 4,200 to 5,800 tonnes per hour
- The 1.66 km wharf features four berths, which can accommodate ships ranging from 20,000 to 220,000 dead weight tonne. Three manually-operated shiploaders are used to transfer coal from the wharf conveyors into the holds of ships at a nominal loading rate of 7,200 tonnes per hour

- While the size and cargo of each ship visiting the terminal can vary greatly, it takes about 22 hours to load the average 80,000 tonne cargo
- Mines Supplying DBCT include Blair Athol, Hail Creek, Goonyella, Riverside,German Creek, Oakey Creek, North Goonyella, Burton, Moranbah North, Millenium, Foxleigh, Moorvale and Coppabella

Source: *http://www.dbct.com.au/what-we-do*

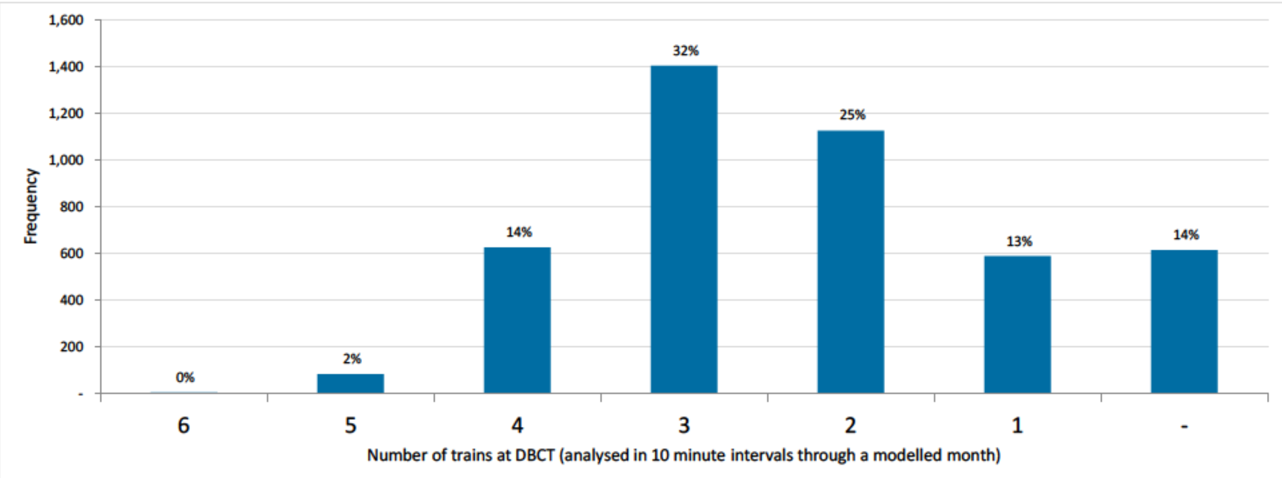
Hay Point Coal Terminal

- Is owned and operated by BHP Billiton/Mitsubishi Alliance (BMA) and only provides coal handling services to mines operated by BMA in the Northern Bowen Basin
- Has a name plate capacity of 55 MTPA
- Total throughput for FY2016 was 48.25 MTPA
- Has two rail receivable stations
- Has three berths, which depending on the berth, can accommodate vessels ranging between 180,000 to 220,000 dead weight tonne
- Two shiploaders are used to transfer coal onto the ships. Nominal loading rates to ships range between 6,000 and 8,400 tonnes per hour
- Mines supplying HPCT include Goonyella, Riverside, Peak Downs, Saraji, Gregory, Norwich Park and South Walker

Source: *https://mining-atlas.com/operation/Hay-Point-Coal-Terminal.php*

We have identified no issues in terms of constraints from our analysis of the capacity at the port and modelled capacity aligns with unloading and holding road capacity. Figure **15** highlights the distribution of rail capacity utilisation at Dalrymple Bay, which has capacity for 6 Goonyella-length trains. As shown below, while the port is heavily utilised (86%), utilisation never exceeds Available Capacity.

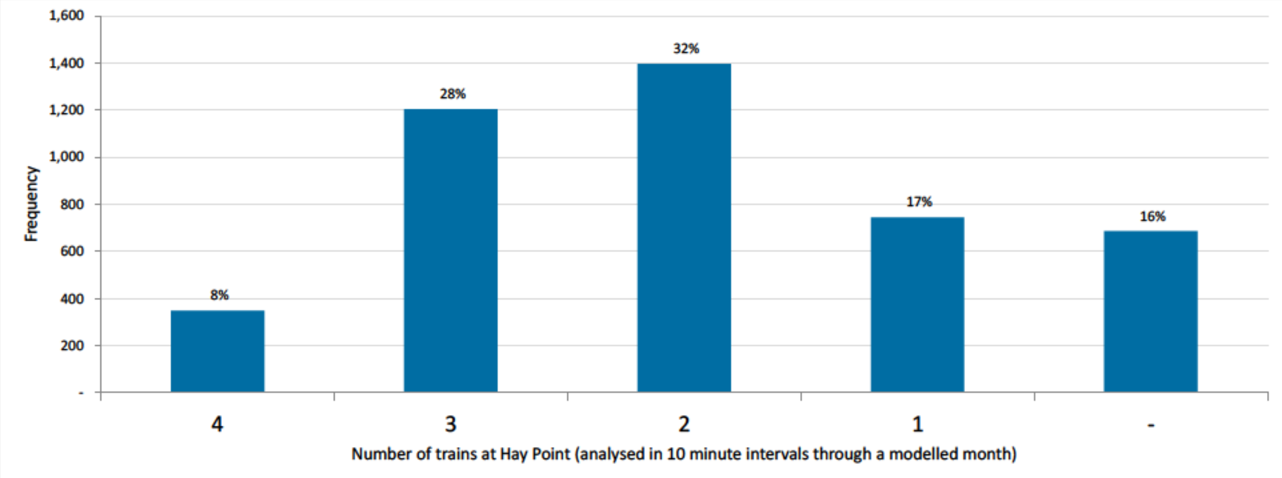
Figure 15: CQSCM, number of trains at Dalrymple Bay at any given time (est. 10-minute increments)



Source: GHD analysis of CQSCM cycle time data (dataset: 9_1708_CycleLog_6)

Figure **16** highlights the distribution of rail capacity utilisation at Hay Point, which has capacity for 4 Goonyella-length trains. As shown below, while the port is heavily utilised (84%), utilisation never exceeds Available Capacity.

Figure 16: CQSCM, number of trains at Hay Point at any given time (est. 10-minute increments)



Source: GHD analysis of CQSCM cycle time data (dataset: 9_1708_CycleLog_6)

The CQSCM is a discrete event simulation model, capable of modelling the entire CQCN supply chain, from port to mine. It creates the ability to measure and assess the impact of changes to the complete range of supply chain elements on overall capability. In response to our questions as to how ports were modelled, Aurizon Network advised that modelling inputs used to undertake the BCA such as true terminal rates and certain factors influencing capacity at the port were outside of its control and influence and therefore, out-of-scope.

In light of this, we sought to compare port interface metrics modelled with historic information. We did this to gain an understanding of the degree of alignment between actual port unloading time and what is dynamically modelled by Aurizon Network in its BCA. The alignment of Aurizon Network's dynamic model (CQSCM) and actual port unloading time was a concern raised by Pacific National in its stakeholder submission to the QCA. The manner in which the modelling of essential supply chain components such as the port, is an important consideration in undertaking a review of Aurizon Network's BCA.

Aurizon Network advised us that that the time at port values populated in its dynamic model scenarios at ports were reflections of maximum time at port allowances as specified in commercial Access Agreements. Aurizon Network provided a sample of Access Agreements for us to cross-check the accuracy of such modelled values with maximum unloading times stated in the agreements. We found no inconsistencies with the maximum unloading times specified in the agreements with the unloading times that Aurizon Network advised that it had dynamically modelled.

However, our analysis of cycle time data as regards time at port, compared against Aurizon Network's approach as advised to us, was difficult to reconcile.

[redacted]

Nonetheless, we find Aurizon Network's approach of specifying a 'time at port' to all trains at port, based on maximum times specified in Access Agreements, as being inconsistent with real world operations.

5.2.1.8 Track Maintenance (Planned OPEX and Renewal Activities)

As a rule of thumb, Aurizon Network plans for 320 days of operations throughout the course of a typical year, assuming 45 days of track non-availability due to planned maintenance and renewal activities. This amounts to a capacity loss of 12%, which is slightly less than Aurizon Network's static modelling assumed capacity loss of 15% for planned maintenance and renewals.

We sought to analyse Aurizon Network's track maintenance assumptions in light of its dynamic modelling. We were able to do this by comparing Aurizon Network's CQSCM Virtual Possession Plan with best practice intervention intervals for maintenance activities, assuming throughput values provided in the BCAR. In our analysis we considered the following activities: resurfacing, ballast, grinding, and other activities. We aligned our understanding of these activities to Aurizon Network's CQSCM Virtual Possession Plan.

For the purpose of reviewing the Virtual Possession Plan for the Goonyella system, the analysis provided below is limited to track infrastructure between Hay Point Junction and Coppabella. We separated the track into two zones, each zone assuming a certain tonnage of throughput. Zone 1 was chosen for the network between Hay Point Junction and Tootolah (the greatest tonnage). Zone 2 was chosen as Tootolah to Coppabella. These zones were selected for the purpose of broadly segmenting tonnage throughput by the most important rail corridors (affecting most of the supply chain).

We found that, in terms of below rail maintenance activities, Aurizon Network's modelling of below rail maintenance activities was reasonable and within 10% of our estimate. The table below highlights the findings.

Table 6 – CQSCM, system maintenance (Hay Point Junction to Coppabella)

Zone	Annual track possession time (hrs)
CQSCM	5,115
GHD Analysis	4,730

Source: GHD's own analysis and CQSCM System Maintenance (dataset: CQSCM BCA Mtce program_ (002))

In total, Aurizon Network has assumed a network capacity loss factor of 7.5% (from Absolute Capacity) for operational maintenance (excluding renewals). From this analysis, we can deduce that Aurizon Network assumes a capacity loss factor of 7.5% (from Absolute Capacity) for renewals. GHD considers these estimates and the calculations underpinning them, to be reasonable with a total network capacity loss of 15% due to planned operational maintenance and renewals. However, we consider a more accurate modelled representation of track availability loss would be to use data derived from the MaTP rather than assuming a flat 15% figure.

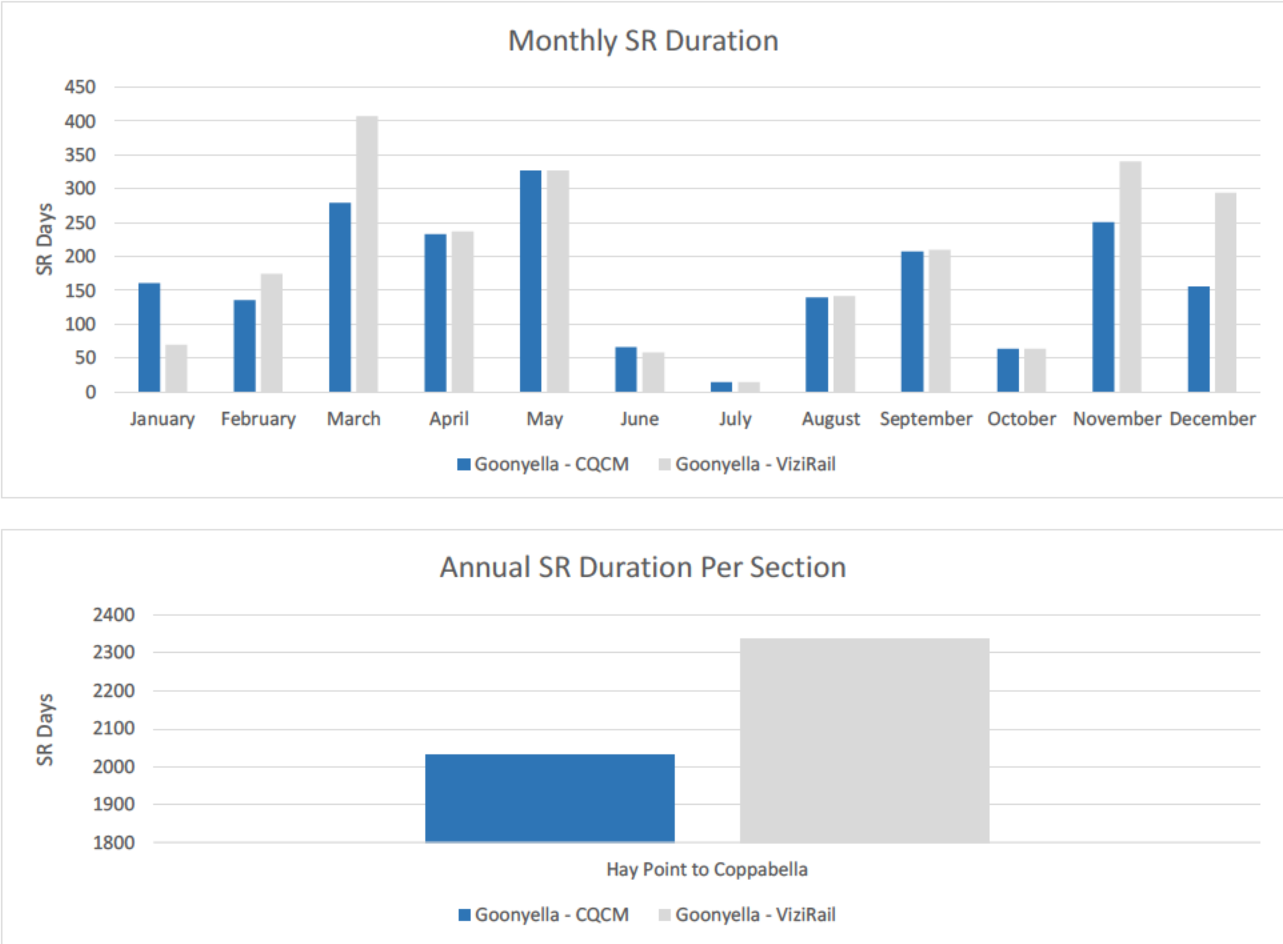
5.2.1.9 Speed Restrictions

Aurizon Network incorporates speed restrictions in its dynamic modelling. The CQSCM takes speed restrictions into consideration by way of an input table which outlines the affected track (up/down), location, purpose, speed reductions, time and duration. Such inputs are based on historical data relating to speed restrictions throughout the network, extracted from Vizirail.

We sought to analyse Aurizon Network's CQSCM speed restriction assumptions to ensure its accuracy. Aurizon Network provided historic data which covered the period between July 2012 and March 2015. The results of the analysis are outlined below. In this instance, analysis is performed separately for each the main corridor (track infrastructure between Jilalan and Coppabella) and branch lines.

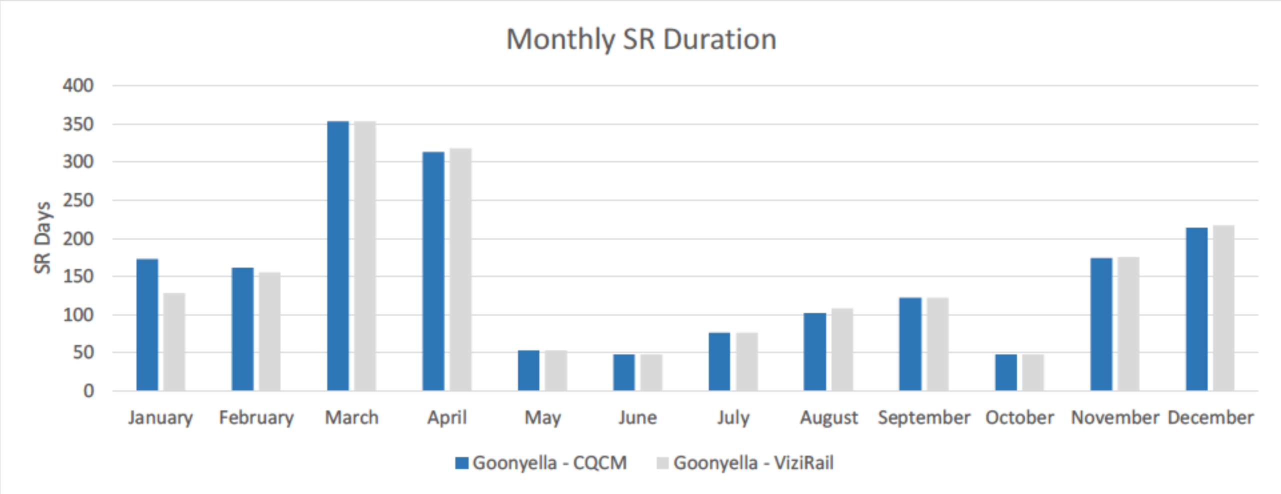
From our analysis of speed restriction inputs into the CQSCM, we found that Aurizon Network's modelling of speed restriction duration for both the main corridor and branch lines closely aligns with historic data. Such inputs for the Goonyella system are therefore considered reasonable.

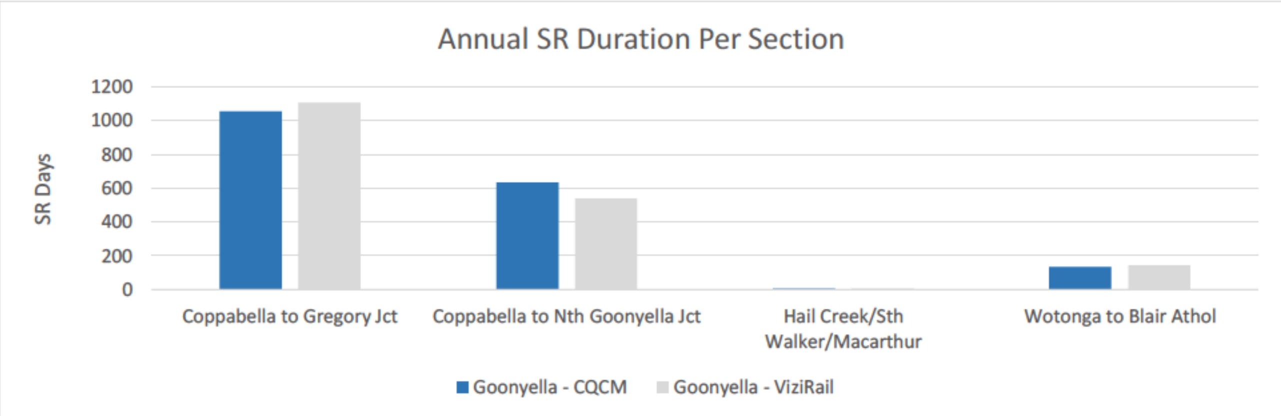
Figure 17: CQSCM, speed restrictions (Hay Point Junction to Coppabella)



Source: CQSCM SRTs (dataset: BCA_SRTs) and historic data supplied by AN (dataset: SpeedRestriction_RAW_Data_and CQSCM input table)

Figure 18: CQSCM, speed restrictions (all branch lines)





Source: CQSCM SRTs (dataset: BCA_SRTs) and historic data supplied by AN (dataset: SpeedRestriction_RAW_Data_and CQSCM input table)

5.2.1.10 Other Losses

Other losses include, amongst other things, the impact of unplanned maintenance on Existing Capacity, and reliability/robustness allowances. It also takes into account the impact of speed restrictions (analysed in the previous section).

In its Static Model, Aurizon Network assumes a capacity of loss (off Absolute Capacity) of 21.3% for the Goonyella system. We consider an assumed loss of 21.3% of capacity for other losses to be unrealistically high. This loss assumption reduces estimates for Existing Capacity for this network, estimated to be 63.7% of Absolute Capacity.

5.2.2 Blackwater

We consider Aurizon Network's determination of Available Capacity for the Blackwater system to be reasonable notwithstanding the conservative assumptions that underpin its Available Capacity threshold (statically determined), which in this instance is 59.5% (of Absolute Capacity).

We set out our detailed analysis in the sections below.

5.2.2.1 Train numbers

Modelled consist numbers for Blackwater versus 2016 consist numbers are outlined in the below table.

Table 7 – Blackwater fleet assumptions

System	CQSCM Fleet	Actual 2016 Fleet
Blackwater	28	[redacted]

Source: GHD analysis of CQSCM system performance data (dataset: 9_1708_CycleLog_6) and Aurizon Network Response (dataset: consist numbers 2016)

[redacted] We therefore consider modelled consist numbers to be reasonable.

5.2.2.2 Below Rail Transit Time

The table below shows that the average BRTT for the Blackwater system for the modelled period of August 2017, is below the modelled threshold of 127%. The annualised modelled Blackwater BRTT is 115% which is close to actual performance data.

The achievement of an average BRTT of 120.14% versus an upper acceptable limit of 127% suggests little evidence of constraints in the below rail infrastructure. We consider Aurizon Network's modelled results for this to be reasonable.

Table 8 – CQSCM, Blackwater system BRTT (August 2017)

System	Cycle Time	BRTT Threshold	BRTT Achieved
Blackwater	23.93	127.00%	120.14%

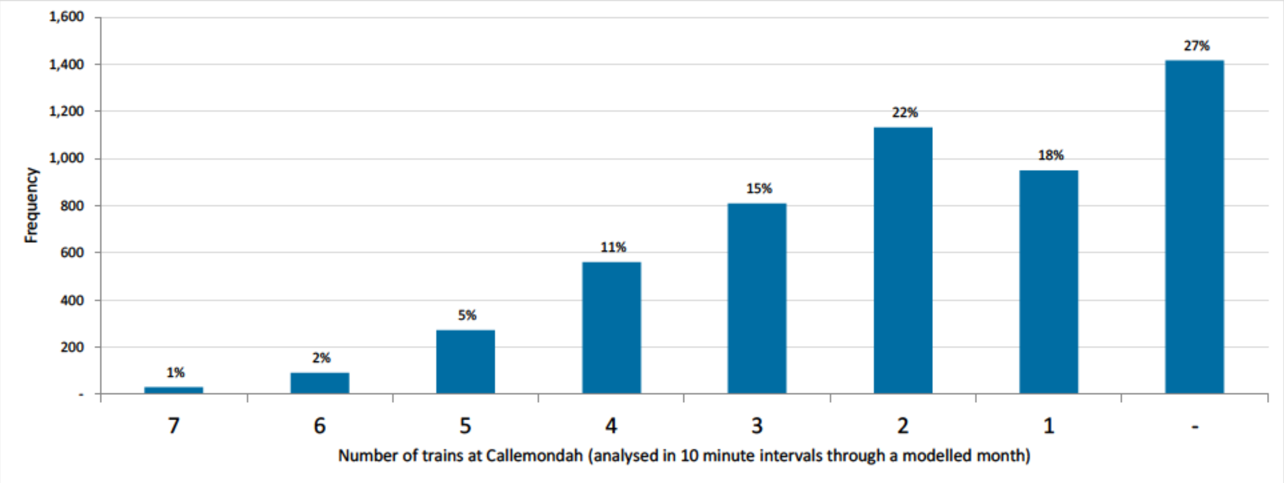
Source: GHD analysis of CQSCM system performance data (dataset: 9_1708_CycleLog_6)

5.2.2.3 Callemondah, Gladstone, and Wiggins Island (depots)

We analysed dynamically-modelled location capacities at Callemondah, Gladstone, and Wiggins Island. This analysis was undertaken to determine the utilisation of holding roads dynamically modelled at these depot locations.

We found that Aurizon Network's capacity estimations at all Blackwater depot locations were reasonable and are an accurate reflection of what can be achieved in practice. The chart below plots the distribution of utilisation at Callemondah in the 1-month modelled period. Charts for Gladstone and Wiggins Island provided no benefit with respect to our analysis given the low utilisation for these locations, and therefore have both been excluded from this report.

Figure 19: CQSCM, number of trains at Callemondah at any given time (est. 10-minute increments)



Source: GHD analysis of CQSCM cycle time data (dataset: 9_1708_CycleLog_6)

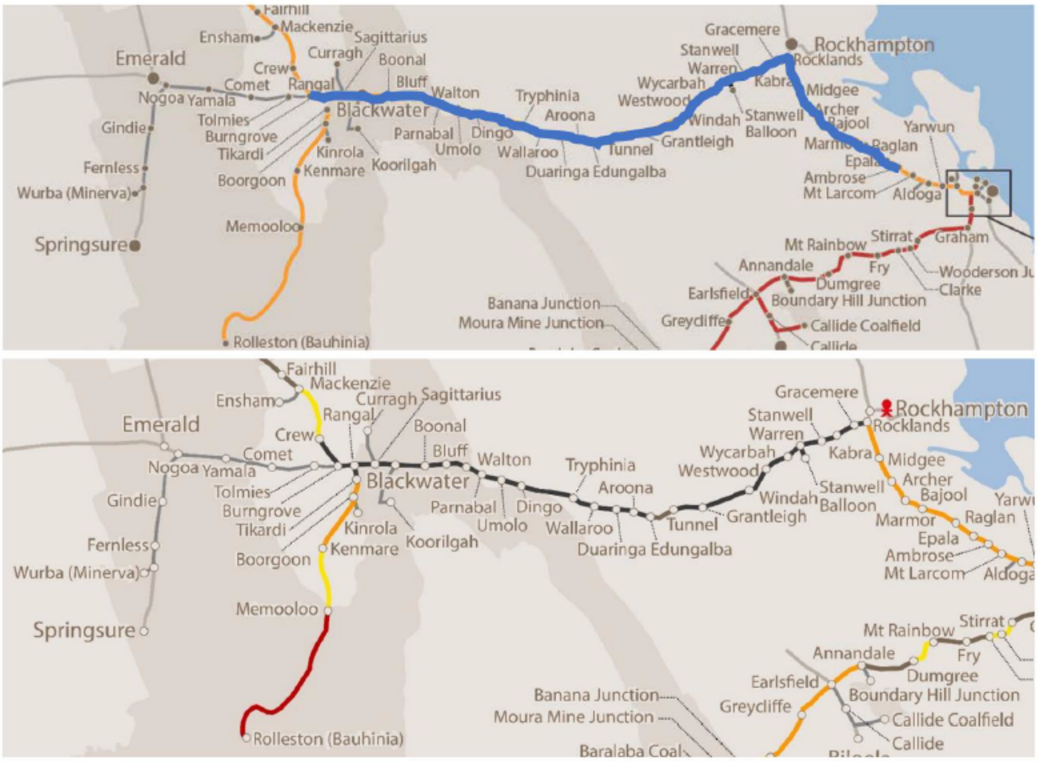
5.2.2.4 Main corridor utilisation

The Blackwater system differs to the other systems in terms of traffic due to the mixed use of its main corridor between Gladstone and Rockhampton, whereby non-coal traffic (general freight, other minerals and grains, and passenger transport) contributes to a large portion of path utilisation.

Aurizon Network estimates that 18,301 TSEs are committed to non-coal traffic. This represents 26.1% of Absolute Capacity, equivalent to 44% of Existing Capacity for this network along the main corridor impacting the section of track between Gladstone and Rocklands (near Rockhampton). Such levels of non-coal traffic materially impacts the availability of path utilisation for use for coal traffic.

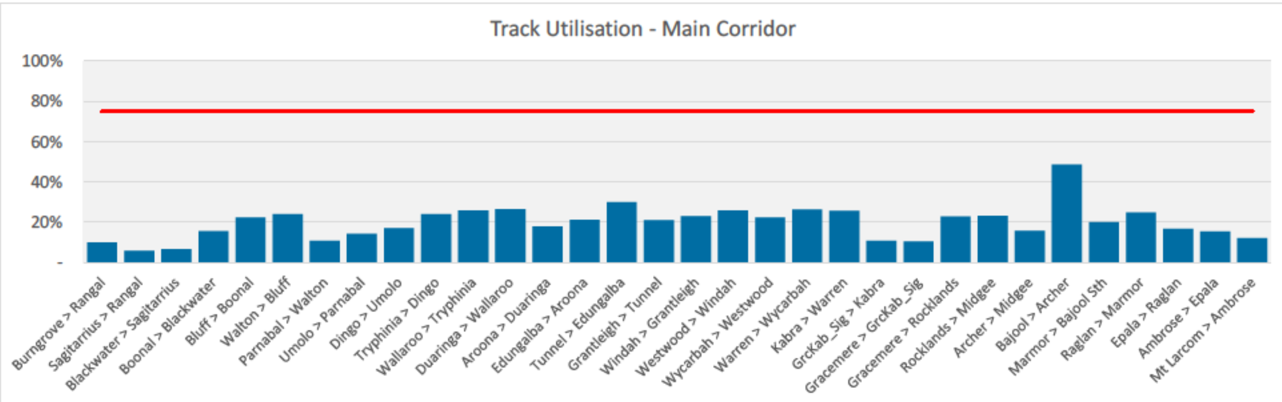
We have not investigated the amount of non-coal traffic further as such research is beyond the scope of this report. Although, given the estimate of Available Capacity provided by Aurizon Network comfortably exceeds the committed TSEs, our analysis agrees with Aurizon Network's findings in that, for the most part, meaningful surplus capacity exists for this system.

Figure 20: Blackwater main corridor (top, highlighted in blue) and deemed utilisation (by Aurizon Network, bottom)



Source: adapted from Aurizon Network, BCAR (2016)

Figure 21: CQSCM (Blackwater) track section utilisation (Mt Larcom to Burngrove)



Source: GHD analysis of CQSCM section performance data (dataset: 2664_9_1708_Sections) – ignores non-coal traffic impacting utilisation between Mt Larcom and Rocklands)

5.2.2.5 Branch line utilisation

We also undertook an analysis of branch line capacity as part of the BCA review. For the Blackwater system, three branch lines were considered. These are as follows:

- **Branch line 1:** Burngrove to Dysart
- **Branch line 2:** Rangal to Rolleston

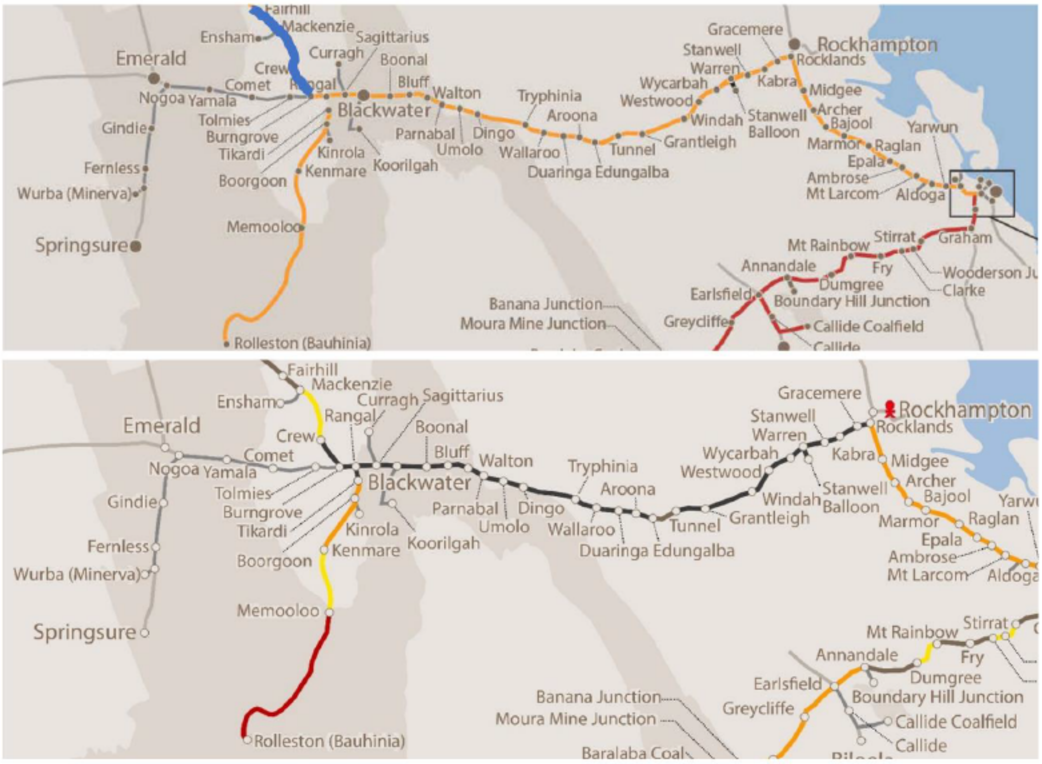
- **Branch line 3:** Burngrove to Nogoa

These branch lines are analysed in turn below.

Branch line 1

Branch line 1 concerns the track infrastructure between Burngrove and Dysart. The track is single-line. This corridor is highlighted in the below figure (highlighted in blue).

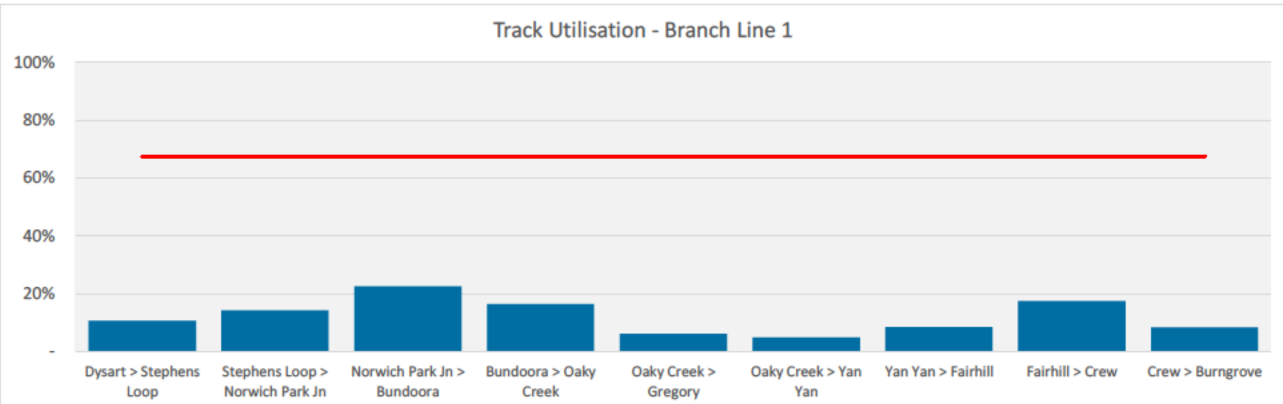
Figure 22: Blackwater branch line 1 (top, highlighted in blue) and deemed utilisation (by Aurizon Network, bottom)



Source: adapted from Aurizon Network, BCAR (2016)

Our analysis of CQSCM track section utilisation of this branch line for the modelled period is depicted in Figure 23. Our analysis indicates an acceptable utilisation of track infrastructure and that the corridor has significant surplus capacity.

Figure 23: CQSCM (Blackwater) track section utilisation (Burngrove to Dysart)

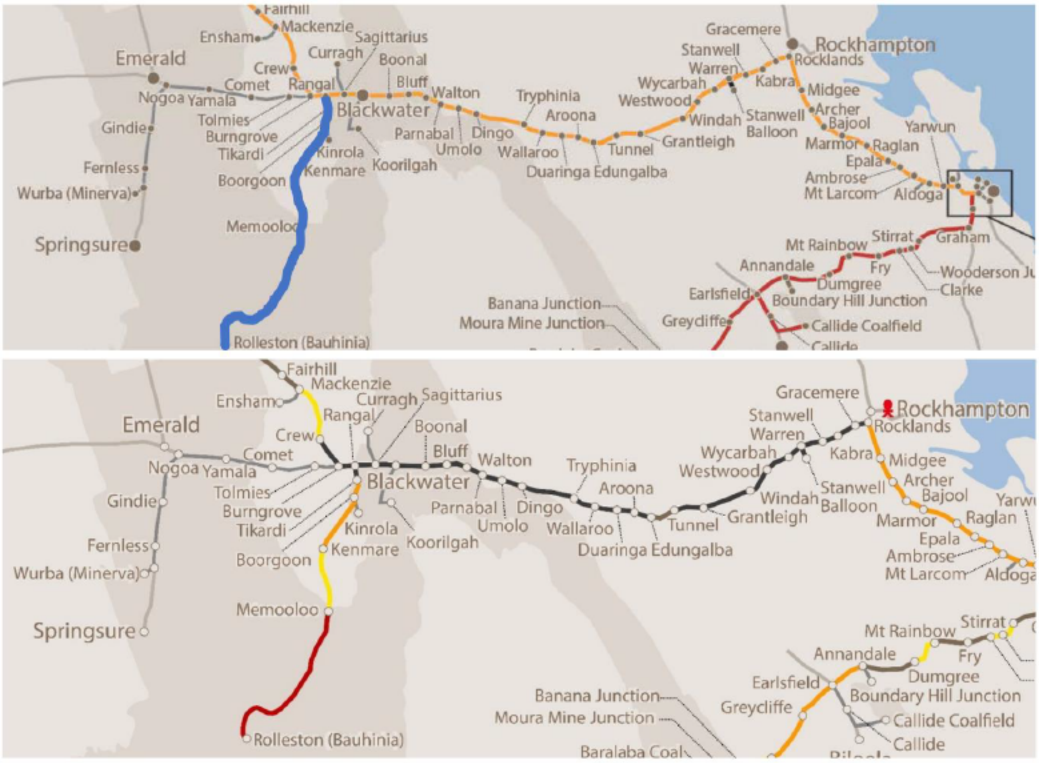


Source: GHD analysis of CQSCM section performance data (dataset: 2664_9_1708_Sections)

Branch line 2

Branch line 2 concerns the track infrastructure between Rangal and Rolleston. The track is single-line. This corridor is highlighted in the below figure (highlighted in blue).

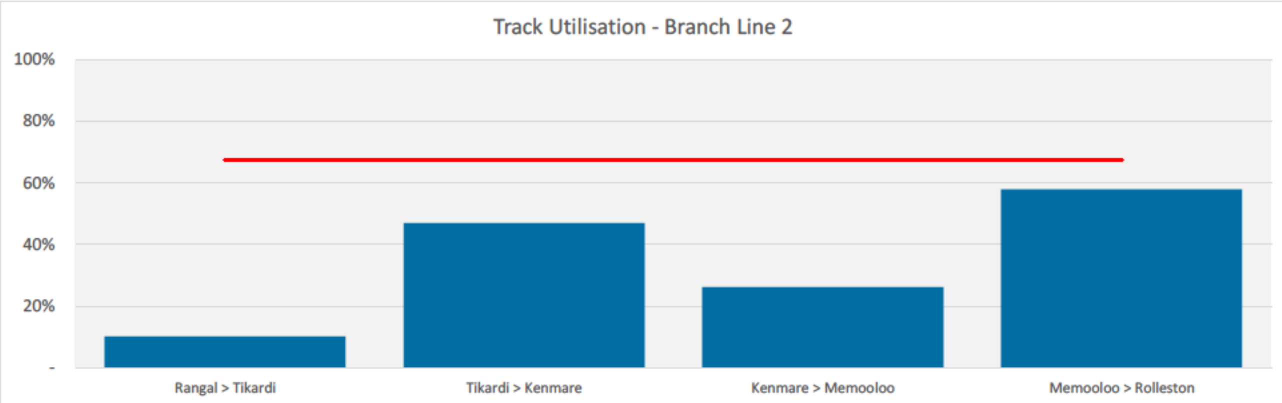
Figure 24: Blackwater branch line 2 (top, highlighted in blue) and deemed utilisation (by Aurizon Network, bottom)



Source: adapted from Aurizon Network, BCAR (2016)

Our analysis of CQSCM track section utilisation of this corridor for the modelled period is depicted in Figure 25. While the corridor has surplus capacity, capacity is constrained around Memooloo and Rolleston relative to other sections of track. This is as a result of Aurizon Network's application of maintenance and other losses resulting in determined Existing Capacity of 59.5% of Absolute Capacity. However, if Aurizon Network were to adopt a higher Existing Capacity as a percentage of Absolute Capacity in line with other similar below rail operators (shown by the red line in Figure 25), then this constraint would be alleviated. Our findings align with Aurizon Network's assessment that there remains capacity along this branch line, with the exception of the section of track between Memooloo and Rolleston which is being operated at or near capacity.

Figure 25: CQSCM (Blackwater) track section utilisation (Rangal to Rolleston)

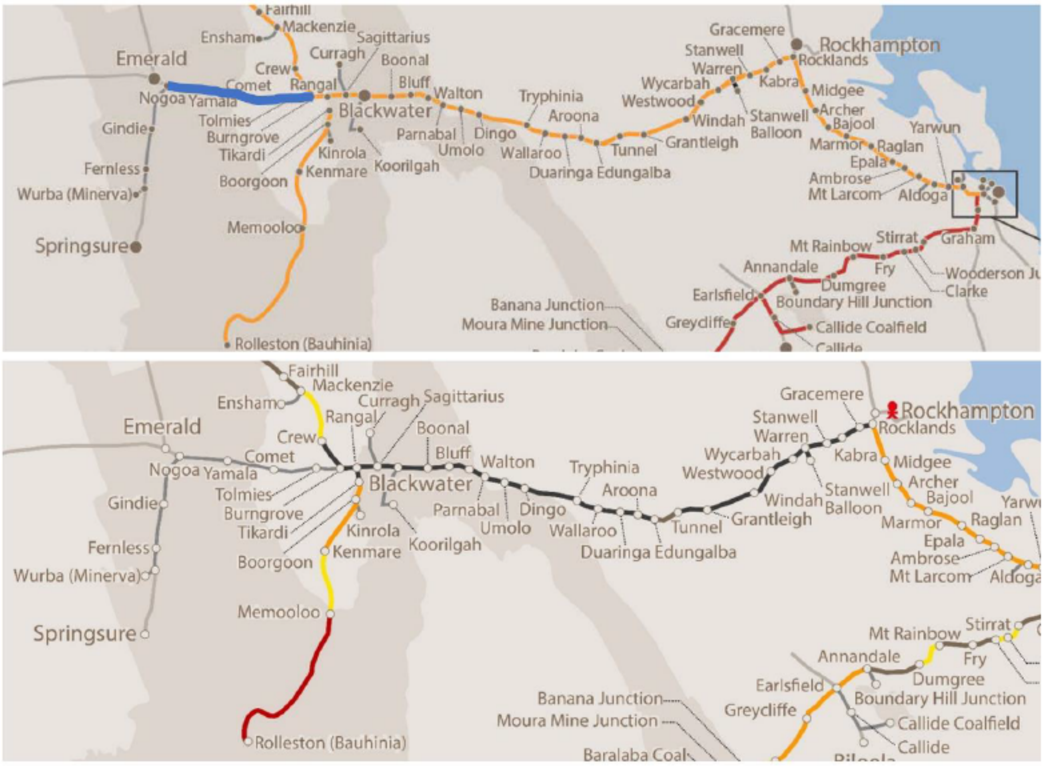


Source: GHD analysis of CQSCM section performance data (dataset: 2664_9_1708_Sections)

Branch line 3

Branch line 3 concerns the track infrastructure between Burngrove and Nogoa. The track is single-line. This corridor is highlighted in the below figure (highlighted in blue).

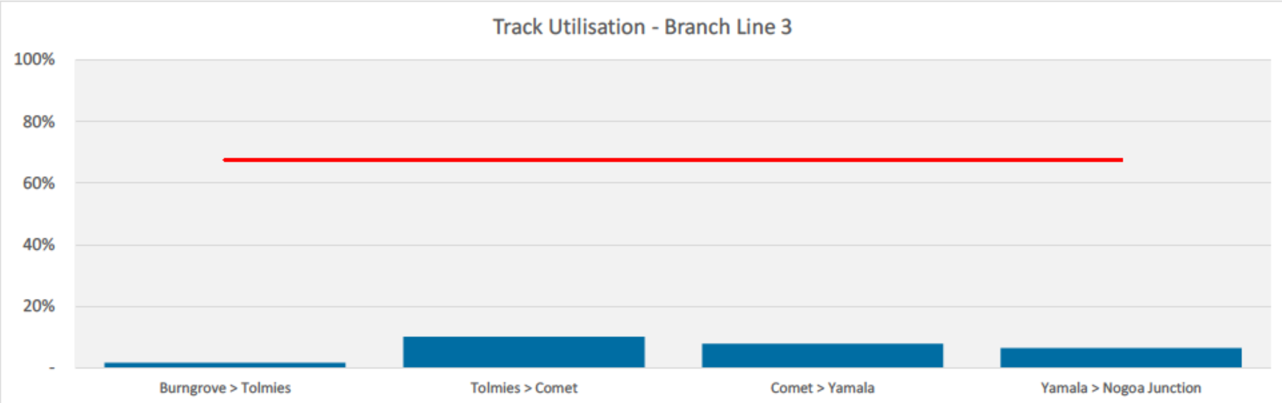
Figure 26: Blackwater branch line 3 (top, highlighted in blue) and deemed utilisation (by Aurizon Network, bottom)



Source: adapted from Aurizon Network, BCAR (2016)

Our analysis of CQSCM track section utilisation of this branch line for the modelled period is depicted in Figure 27. The analysis indicates an acceptable utilisation of track infrastructure. With reference to this data, it is clear that the corridor has significant surplus capacity.

Figure 27: CQSCM (Blackwater) track section utilisation (Burngrove to Nogoa)



Source: GHD analysis of CQSCM section performance data (dataset: 2664_9_1708_Sections)

5.2.2.6 Port

The Blackwater system links mines to export terminals at the port of Gladstone, RG Tanna Coal Terminal, and Wiggins Island Coal Export Terminal (WICET). We provide an overview of each of these terminals below.

RG Tanna Coal Terminal

Originally known as Clinton Coal facility, RG Tanna Coal Terminal started to operate in 1980. Today, RG Tanna Coal terminal is the port's major coal export terminal, with a current throughput capacity in excess of 60 Mt annually.

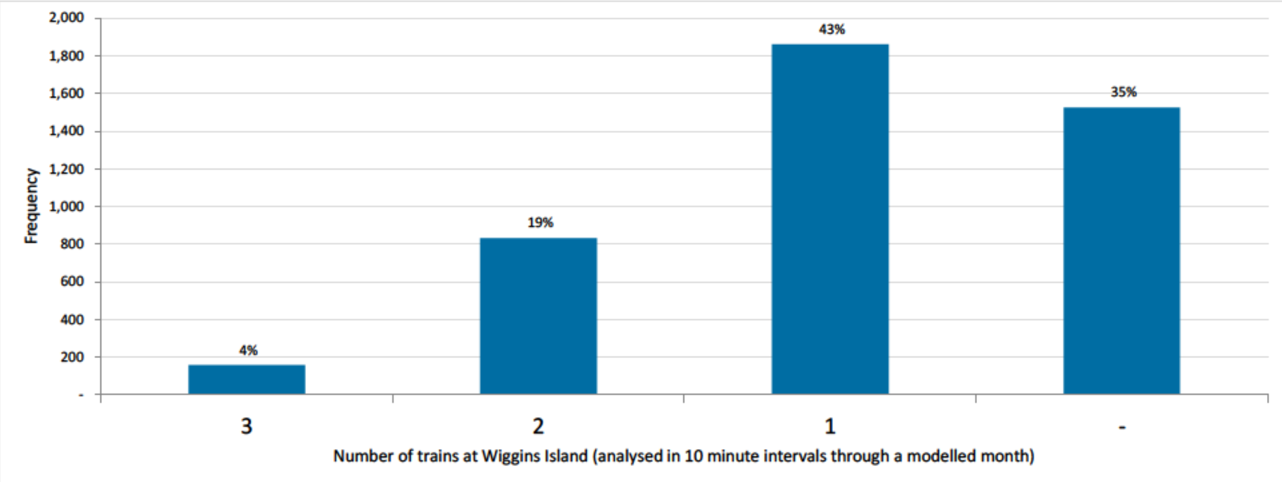
Wiggins Island Coal Export Terminal (WICET)

- Ownership of WICET comprises five coal producers being Aquila Resources, Glencore, New Hope Group, Wesfarmers Curragh and Yancoal
- Has a name plate capacity of 27 MTPA. Potential capacity of 120 MTPA when fully developed
- Rail unloading facilities are located immediately south of the North Coast Line (NCL) and are connected to the Golding Point stockyard via a 5.6 km long overland conveyor
- Rail and train unloader
  - Train consists – Max 2,500 m
  - Discharge Rate – 9,200 m^3/h or 6,900 tph (at 750 kg/m^3) to 8,250 tph (at 900 kg/m^3)
  - Feeder belts – 3,200 mm wide
  - Overland conveyor – 5.6 km, belt width 1,800 mm, belt speed 6.9 m/s
- Stockyard
  - 12 notional stockpiles in two piles
  - Stockpiles max height 18 m high
  - Total on ground storage capacity – 1.85 Mt based on the eight shippers requirements
  - Stockyard footprint average 920 m long x 240 m wide
  - Reclaim conveyors - 6,900 tph with a 2,000 mm belt running at 5.9 m/s.

- Port and Shiploader
    - 2 x reclaim conveyors – 6,900 tph reclaim rate
    - Loading rate - 8,250 tph after the 1200 tonne surge bin
    - Outloading blending with components down to 10%
    - The wharf is located approximately 2 km offshore
    - Shiploader - 8,500 tph to cater for 8,250 tph loading rate plus a surge capacity

We have analysed capacity at the port and found that modelled capacity at all ports aligns with unloading and holding road capacity. The chart below highlights the distribution of rail capacity utilisation at Wiggins Island, which has capacity for 3 trains. As shown below, utilisation never exceeds Available Capacity.

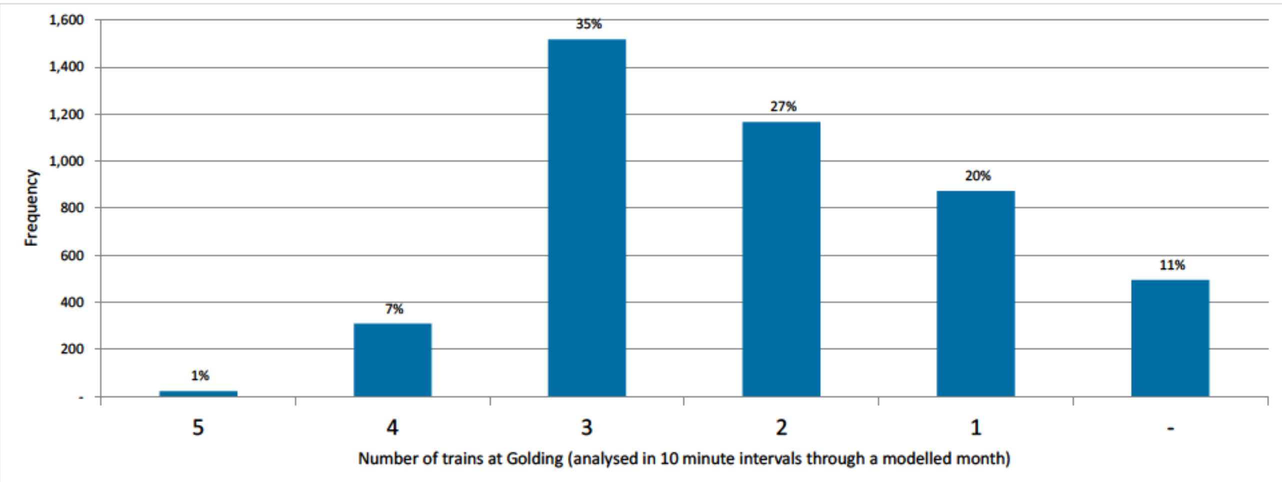
Figure 28: CQSCM, number of trains at Wiggins Island at any given time (est. 10-minute increments)



Source: GHD analysis of CQSCM cycle time data (dataset: 9_1708_CycleLog_6)

The chart below highlights the distribution of rail capacity utilisation at Golding. As shown below, utilisation never exceeds Available Capacity.

Figure 29: CQSCM, number of trains at Golding at any given time (est. 10-minute increments)



Source: GHD analysis of CQSCM cycle time data (dataset: 9_1708_CycleLog_6)

5.2.2.7 Track Maintenance (Planned OPEX and Renewal Activities)

Aurizon Network assumes a network capacity loss of 15% (from Absolute Capacity) for planned operational maintenance and renewal activities.

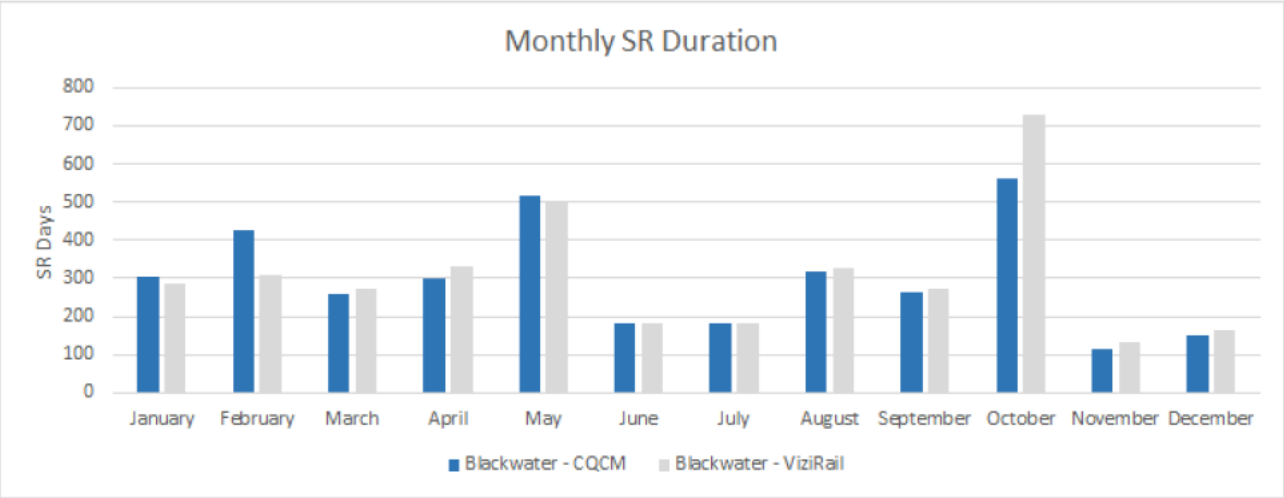
5.2.2.8 Speed Restrictions

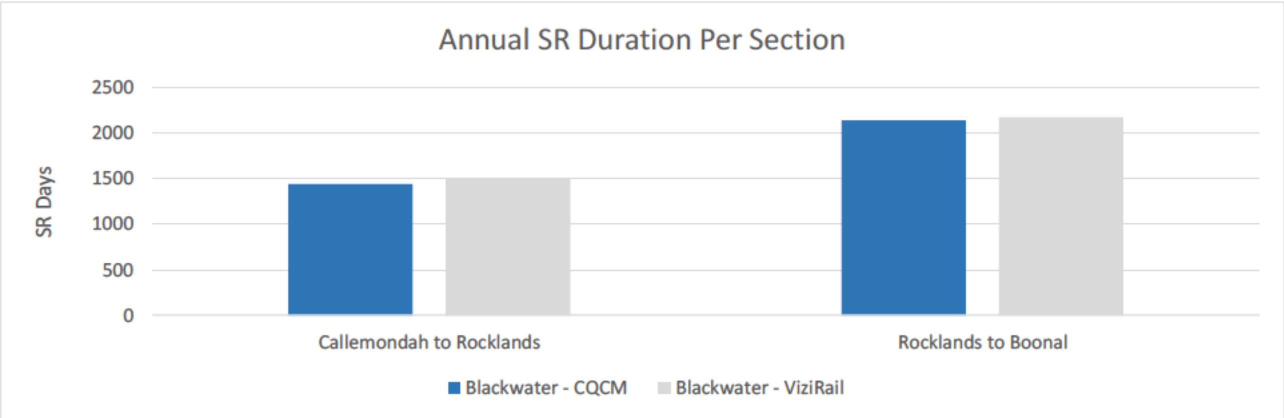
We have reviewed Aurizon Network's CQSCM speed restriction assumptions to assess their accuracy. The results of the analysis are outlined below. In this instance, analysis is performed separately for each of the main corridor (track infrastructure between Callemondah and Boonal) and branch lines.

We found that, in terms of speed restriction inputs into the CQSCM, Aurizon Network's modelling of speed restriction duration for both the main corridor and branch lines closely aligns with historic data. Such inputs for the Blackwater system are therefore considered reasonable.

The figures below detail the findings of this analysis.

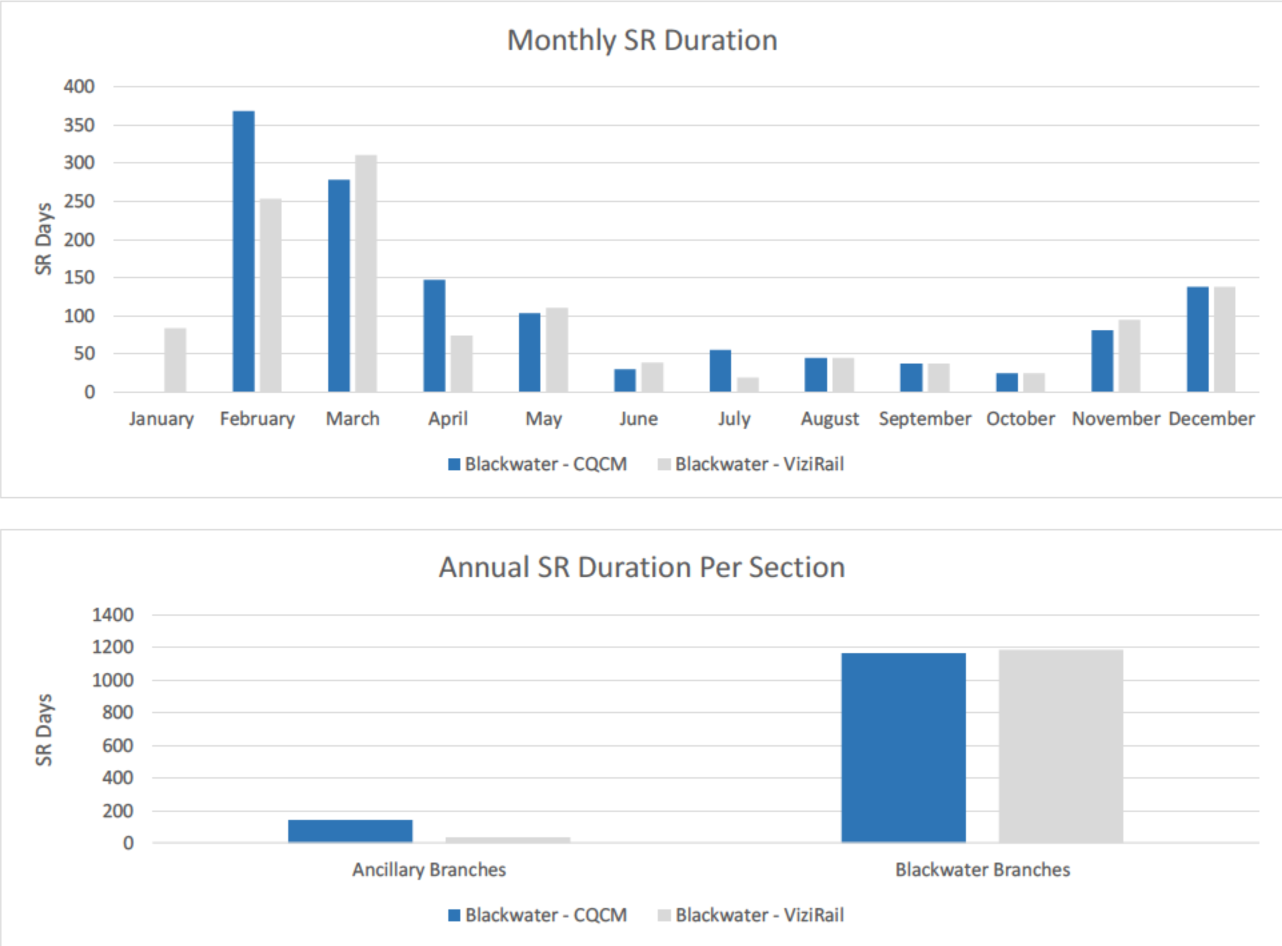
Figure 30: CQSCM, speed restrictions (Callemondah to Boonal)





Source: CQSCM SRTs (dataset: BCA_SRTs) and historic data supplied by AN (dataset: SpeedRestriction_RAW_Data_and CQSCM input table)

__Figure 31: CQSCM, speed restrictions (all branch lines)__



Source: CQSCM SRTs (dataset: BCA_SRTs) and historic data supplied by AN (dataset: SpeedRestriction_RAW_Data_and CQSCM input table)

5.2.2.9 Other Losses

Aurizon Network assumes a loss of capacity due to other losses (off Absolute Capacity) of 25.5% for the Blackwater system. We consider this to be high. It is an influencing factor which materially reduces estimates for Existing Capacity for this network, estimated to be 59.5%.

In light of the extent of surplus capacity that exists for this system, a change to Available Capacity estimates arising from assuming lower other losses is unlikely to materially impact the determination of significant Available Capacity as projected by the track section utilisation data and as such, the impact of a high other loss assumption is not considered material perhaps with the exception of services between Memooloo to Rolleston.

5.2.3 Newlands/GAP

We recommend that Aurizon Network's assessment that there is sufficient capacity to accommodate current TSEs is accepted. However, we consider that Aurizon Network's determination of Available Capacity for the Newlands system is unrealistically conservative.

While we agree on the location of congestion points along track infrastructure and agree on a relative stance as to where material surplus capacity exists, we disagree upon analysing the information provided to us, that these 'bottlenecks' support an assessed Available Capacity of only 2.5% (relative to Absolute Capacity) exists for additional TSEs, or 673 new TSEs, in the Newlands system. We set out the detail of our analysis and findings in the sections below.

5.2.3.1 Train numbers

We have assessed whether consist numbers dynamically modelled reasonably align with what exists, or should exist, given a specified TSE requirement. Modelled consist numbers for Newlands versus 2016 consist numbers are outlined in the table below.

Table 9 – Newlands fleet assumptions

System	CQSCM Fleet	Actual 2016 Fleet
Newlands / GAPE	19	[redacted]

Source: GHD analysis of CQSCM system performance data (dataset: 9_1708_CycleLog_6) and Aurizon Network Response (dataset: consist numbers 2016)

While the number of trains modelled in the Newlands network is greater than available in practice, the rationale in adding more consists to achieve contracted TSEs to determine if the contracted TSEs can be accommodated is justified.

However, we have sought to ensure that the utilisation of these trains was appropriate taking into consideration the target average utilisation range of 85%-90%. Aurizon Network provided average consist utilisation figures for each configuration/operator as being circa 93% or higher for the Newlands. We consider these utilisation figures to be reasonable.

5.2.3.2 Below Rail Transit Time

The table below shows that the average BRTT for the Newlands system for the modelled period of August 2017 is below the modelled threshold of 160%.

In its Access Undertaking (2010), Aurizon Network made mention that existing Newlands customers agreed to a network BRTT of 160%, accepting that BRTTs achieved below this threshold were still considered efficient, given the trade-off between a reduction in below rail capital versus an increase in above rail capital (Total Cost of Ownership).

The achievement of an average BRTT of 134.47% (annualised average BRTT is 237%) versus an upper acceptable limit of 160% suggests little evidence of constraints in the below rail infrastructure.

Table 10 – CQSCM, Newlands system BRTT (August 2017)

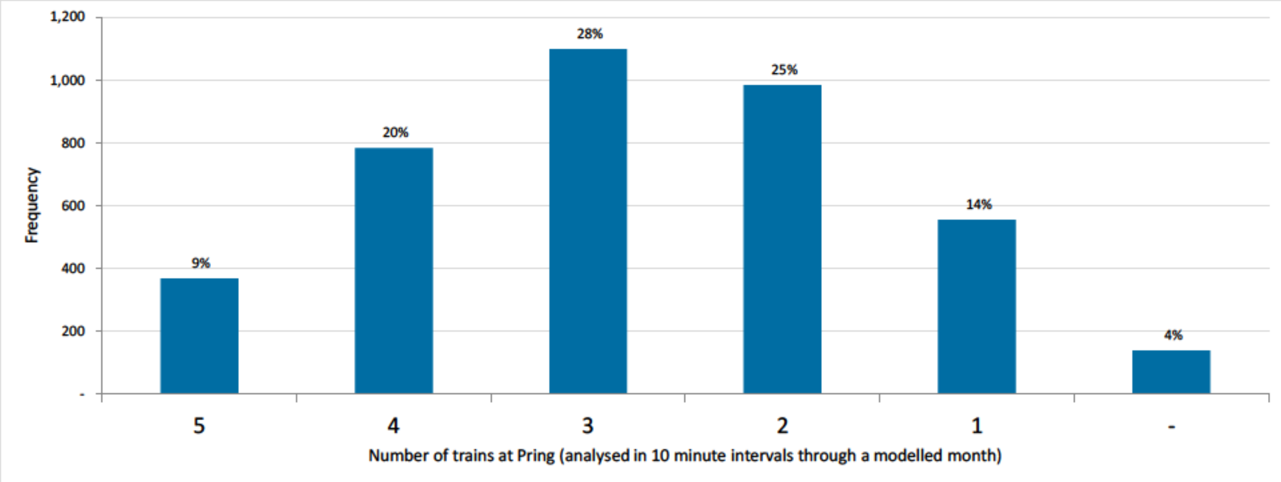
System	Cycle Time	BRTT Threshold	BRTT Achieved
Newlands / GAPE	19.83	160.00%	134.47%

Source: GHD analysis of CQSCM system performance data (dataset: 9_1708_CycleLog_6)

5.2.3.3 Pring (Depot)

We have reviewed the dynamically-modelled location capacities at Pring. From our analysis of the utilisation of holding roads dynamically modelled, we found that Aurizon Network's capacity estimations at Pring were reasonable and are an accurate reflection of what can be achieved in practice. The chart below plots the distribution of utilisation at Pring in the 1-month modelled period.

Figure 32: CQSCM, Number of trains at Pring at any given time (est. 10-minute increments)



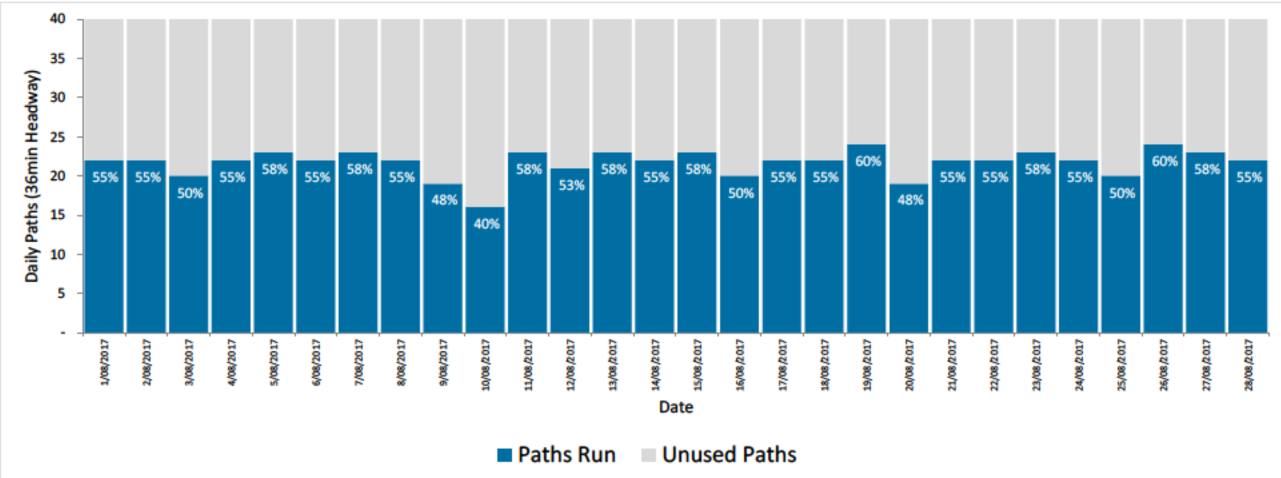
Source: GHD analysis of CQSCM system performance data (dataset: 9_1708_CycleLog_6)

In terms of the Newlands system, pathing between Pring and Birralee has a fixed pathing separation of 36 minutes in both the up (empty) and down (loaded) directions, amounting to 40 theoretical paths in a day.

We have sought to understand and validate modelled utilisation of system paths. In the example analysed below (dataset: 9_1708_CycleLog_6), we found that throughout this modelled period, network pathing utilisation was on average 54% of theoretical daily paths. We do not consider an average pathing utilisation of 54% to be excessively high. Notwithstanding other variables that impact network capacity, it is our view that it is reasonable to assume an average path utilisation closer to 65% in line with that achieved by other operators of below rail coal systems.

The chart below illustrates the dynamically-modelled path utilisation for trains dispatched from Pring in the empty direction of travel for the analysed period. As shown, the utilisation of daily paths remains fairly consistent with little variability oscillating generally between 55% and 60%.

Figure 33: CQSCM (Newlands) path utilisation (dataset: 9_1708_CycleLog_6)

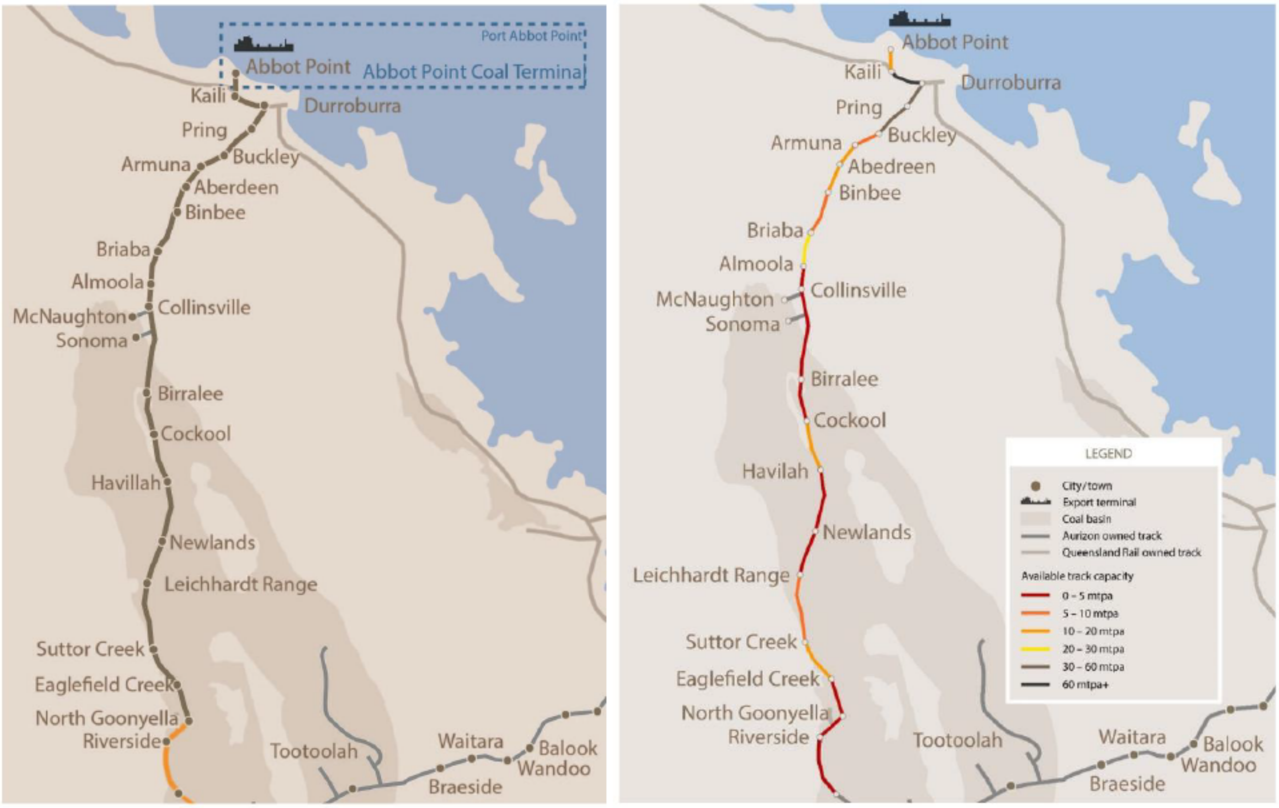


Source: GHD analysis of CQSCM system performance data (dataset: 9_1708_CycleLog_6)

5.2.3.4 Main corridor utilisation

The Newlands system is predominately single-track infrastructure that connects Abbot Point Coal Terminal with the Goonyella system in the south. This system is shown in the below figure.

Figure 34: Newlands and GAPE systems (left) and deemed utilisation (by Aurizon Network, right)



Source: Aurizon Network, BCAR (2016)

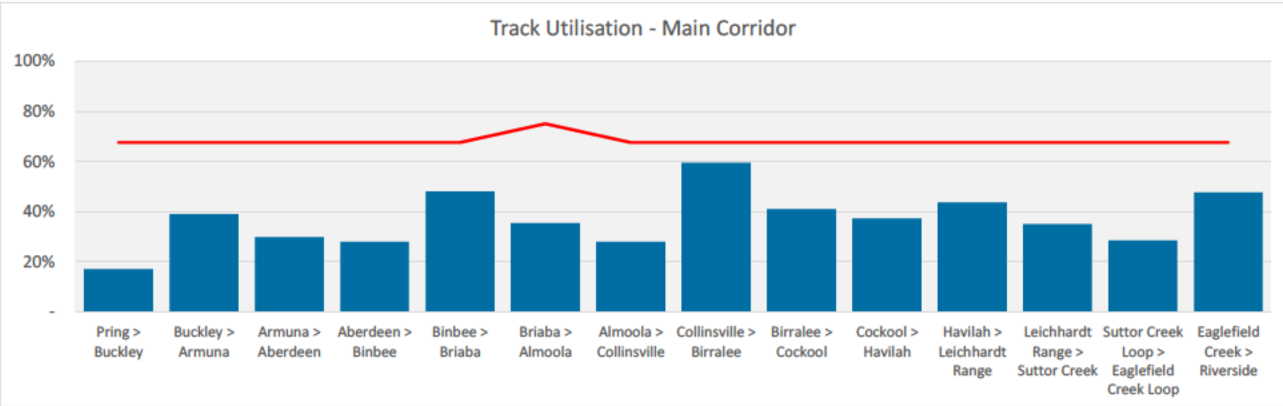
We estimate that single-track infrastructure is limited to around 67.5% track section utilisation.

This upper utilisation threshold reflects the practical constraints in scheduling trains on a single-track line with imperfectly spaced loops and variable train speeds. This upper threshold provides for a degree of latitude to accommodate other issues such as temporary speed restrictions and differences between actual and modelled train performance.

Aurizon Network has made no reference to non-coal train traffic for this network and therefore, non-coal traffic has been ignored in our analysis.

We present our analysis of CQSCM track section utilisation between Pring and Riverside for the modelled period in Figure 35. The analysis indicates a level of utilisation of track infrastructure which is nearing the upper end of capacity at locations such as Collinsville and Birralee.

Figure 35: CQSCM (Newlands) track section utilisation (Pring to Riverside)



Source: GHD analysis of CQSCM section performance data (dataset: 2664_9_1708_Sections)

While we agree with Aurizon Network that track infrastructure between Collinsville and Birralee is heavily utilised and approaching its full capacity, we disagree that track infrastructure south of Birralee is as close to capacity as interpreted by Aurizon Network in its BCAR. Importantly, we disagree that this network has an Available Capacity of only 5 MTPA because of the natural tendency of the dynamic model to overestimate utilisation as the dynamic model has certain limitations when taking into consideration junction capacity and the ability for a train to wait for a path at branch lines to mine loadouts.

5.2.3.5 Port

Abbot Point Coal Terminal (Adani Abbot Point Terminal)

- Has a name plate capacity of 50 MTPA
- Has two rail receivable stations and stockpile areas (2 Mt live capacity)
- There are 5 operating stacking machines (6 installed) used to create stockpiles by transferring coal from the conveyors at a rate of up to 6,000-7,200 tonnes per hour
- Stockpiles are more than 1 km in length

***Source:** https://nqbp.com.au/__data/assets/pdf_file/0020/3278/Port-of-Abbot-Point-Operations-Manual-2016-2017.pdf*

5.2.3.6 Track Maintenance (Planned OPEX and Renewal Activities)

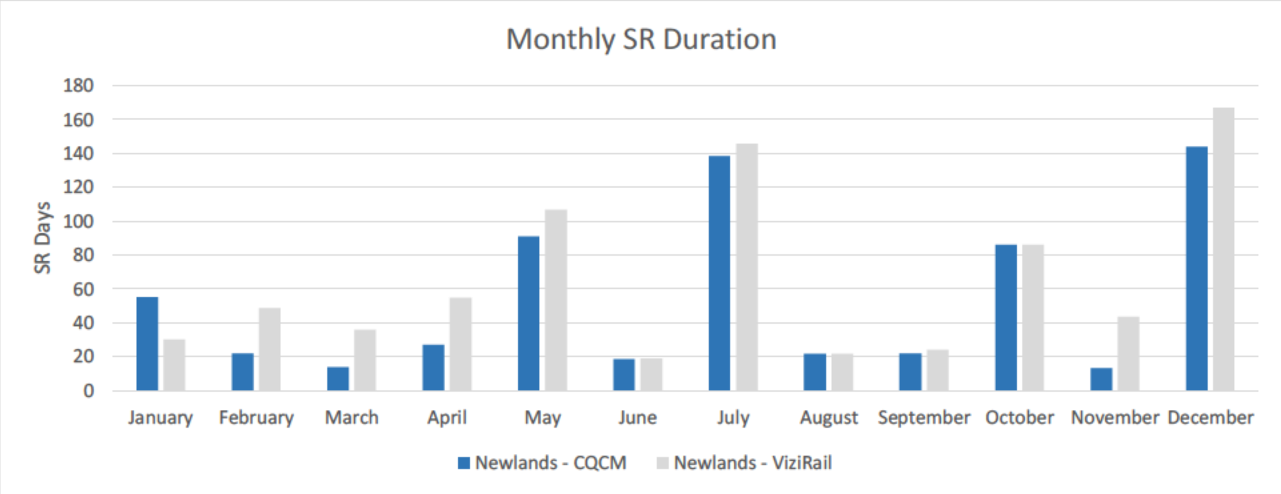
Aurizon Network assumes a network capacity loss of 15% (from Absolute Capacity) for planned operational maintenance and renewal activities.

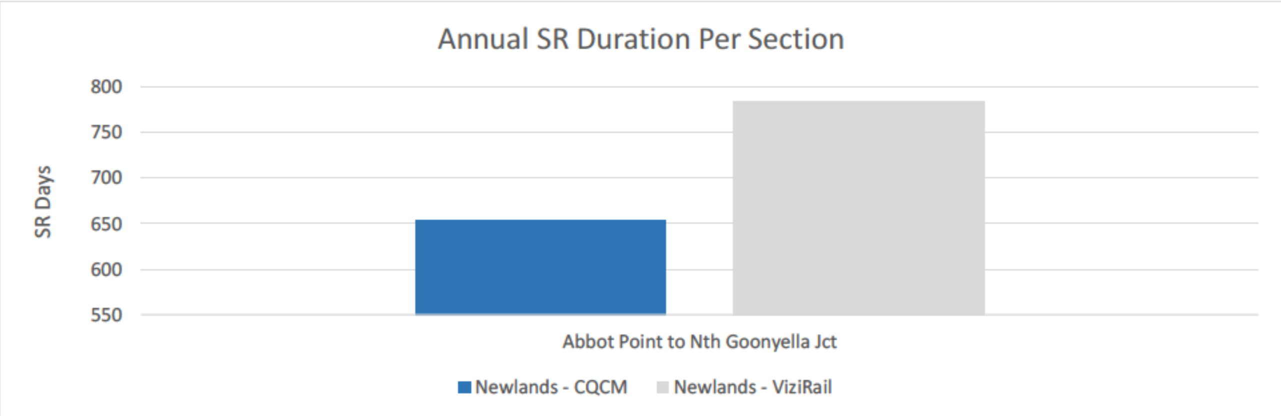
5.2.3.7 Speed Restrictions

We have sought to analyse Aurizon Network's CQSCM speed restriction assumptions to ensure their accuracy. The results of the analysis are outlined below. In this instance, analysis is performed for the track infrastructure between Abbot Point and North Goonyella Junction.

We found that, in terms of speed restriction inputs into the CQSCM, Aurizon Network's modelling of speed restriction duration for the main corridor closely aligns with historic data. Such inputs for the Newlands system are therefore considered reasonable.

Figure 36: CQSCM, speed restrictions (Abbot Point to North Goonyella Junction)





Source: CQSCM SRTs (dataset: BCA_SRTs) and historic data supplied by AN (dataset: SpeedRestriction_RAW_Data_and CQSCM input table)

5.2.3.8 Other Losses

Aurizon Network assumes a capacity of loss (off Absolute Capacity) of 25.5% for the Newlands system. We consider this to be high. It is an influencing factor which materially reduces estimates for Existing Capacity for this network, estimated to be 59.5%.

5.2.4 Moura

We consider Aurizon Network's determination of Available Capacity for the Moura system to be a reasonable reflection of the Available Capacity that actually exists notwithstanding the conservative assumptions that underpin its Available Capacity threshold (statically determined), which in this instance is 59.5% (of Absolute Capacity).

We provide our detailed analysis and findings in the sections below.

5.2.4.1 Train numbers

We sought to try and understand whether consist numbers dynamically modelled reasonably align with what exists, or should exist, given a specified TSE requirement. Modelled consist numbers for Moura versus 2016 consist numbers are outlined in the below table.

Table 11 – Moura fleet assumptions

System	CQSCM Fleet	Actual 2016 Fleet
Moura	3	[redacted]

Source: GHD analysis of CQSCM system performance data (dataset: 9_1708_CycleLog_6) and Aurizon Network Response (dataset: consist numbers 2016)

While the modelled number of trains in the Moura network are less than what exists in practice, we consider Aurizon Network's approach to be reasonable given that the modelled number of trains is sufficient to meet contracted TSEs.

We sought to ensure that the utilisation of these trains was appropriate taking into consideration the target average utilisation range of 85%-90%. Aurizon Network provided average consist utilisation figures for each configuration/operator, being circa 70% for the Moura system. Despite being lower than the target threshold, we consider these utilisation figures to be reasonable given the low demand TSE profile and significant Available Capacity of the rail network.

5.2.4.2 Below Rail Transit Time

The table below shows that the average BRTT for the Moura system for the modelled period of August 2017, is below the modelled threshold of 130%.

The achievement of an average BRTT of 110.85% (annualised average BRTT is 108%) versus an upper acceptable limit of 130% suggests little evidence of constraints in the below rail infrastructure. GHD finds Aurizon Network's modelled results for this to be reasonable.

Table 12 – CQSCM, Moura system BRTT (August 2017)

System	Cycle Time	BRTT Threshold	BRTT Achieved
Moura	14.46	130.00%	110.85%

Source: GHD analysis of CQSCM system performance data (dataset: 9_1708_CycleLog_6)

5.2.4.3 Callemondah and Gladstone (Depots)

These depots have been discussed in section 5.2.2.3 and as such, will not be discussed in greater detail in this section.

5.2.4.4 Main corridor utilisation

The Moura system is predominately single-track infrastructure that connects Golding and QAL ports with mines in the south. This system is highlighted in the following figure.

Figure 37: Moura system (main corridor in blue)

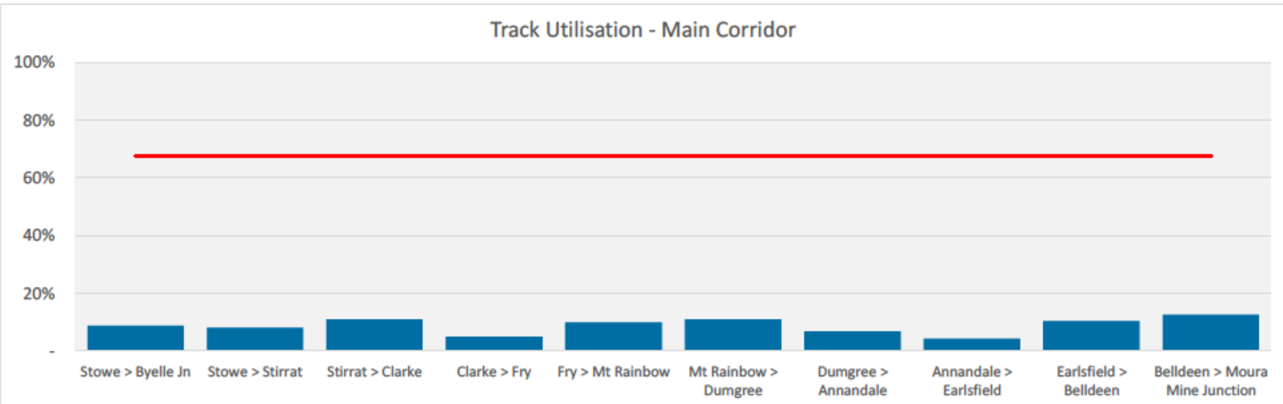
Source: Aurizon Network, BCAR (2016)

We estimate that single-track infrastructure is limited to perhaps 67.5% utilisation. This upper utilisation threshold reflects the practical constraints in scheduling trains on a single-track line with imperfectly spaced loops and variable train speeds. This upper threshold provides for a degree of latitude to accommodate other issues such as temporary speed restrictions and differences between actual and modelled train performance.

Aurizon Network has made no reference to non-coal train traffic for this network and therefore, non-coal traffic has been ignored in our analysis.

The following figure presents our analysis of CQSCM track section utilisation between Stowe and Moura Mine for the modelled period. Our analysis indicates a very low utilisation of track infrastructure, which is in line with Aurizon Network's own estimation.

Figure 38: CQSCM (Moura) track section utilisation (Stowe to Moura Mine)



Source: GHD analysis of CQSCM section performance data (dataset: 2664_9_1708_Sections)

We consider Aurizon Network's assessment of Available Capacity in this network to be reasonable.

5.2.4.5 Port

As the Moura systems shares port terminals with the Blackwater system (already discussed), Golding and QAL, these won't be repeated in this section. Refer to section 5.2.2 for details.

5.2.4.6 Track Maintenance (Planned OPEX and Renewal Activities)

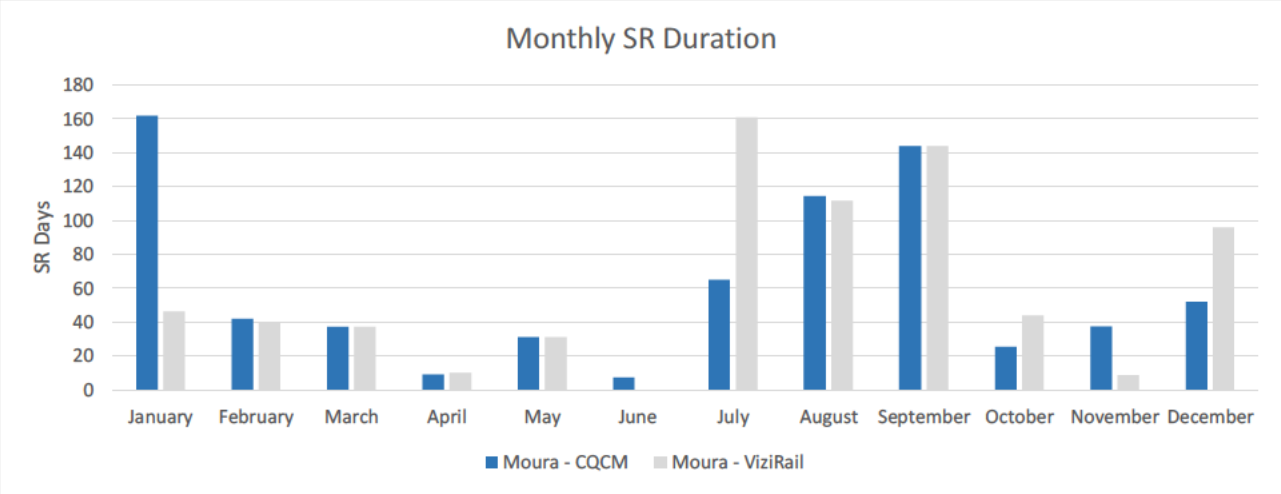
Aurizon Network assumes a network capacity loss of 15% (from Absolute Capacity) for planned operational maintenance and renewal activities.

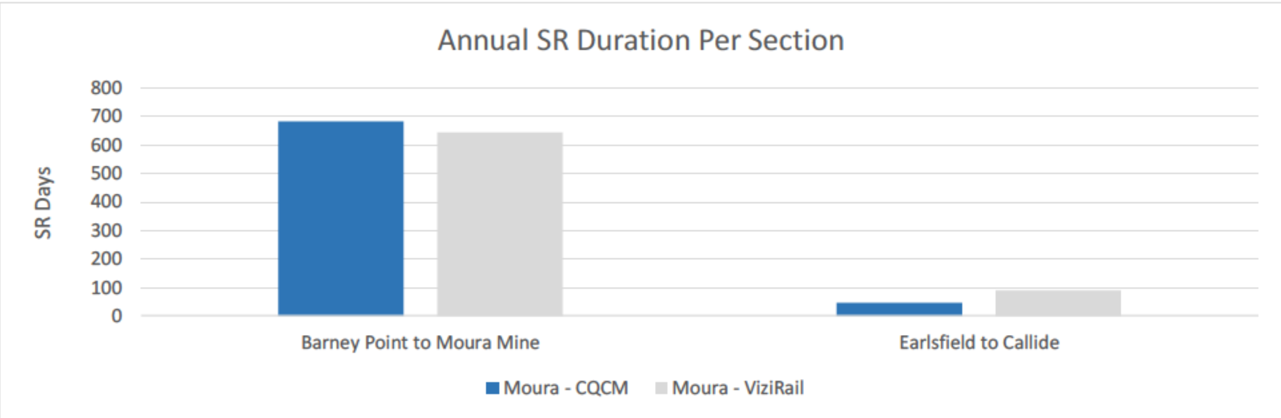
5.2.4.7 Speed Restrictions

We sought to analyse Aurizon Network's CQSCM speed restriction assumptions to ensure their accuracy. The results of the analysis are outlined below. In this instance, analysis was performed for the track infrastructure between Gladstone and Moura.

We found that, in terms of speed restriction inputs into the CQSCM, Aurizon Network's modelling of speed restriction duration for the corridor closely aligns with historic data. Such inputs for the Moura system are therefore considered reasonable.

Figure 39: CQSCM, speed restrictions (main line corridor)





Source: CQSCM SRTs (dataset: BCA_SRTs) and historic data supplied by AN (dataset: SpeedRestriction_RAW_Data_and CQSCM input table)

5.2.4.8 Other Losses

Aurizon Network assumes a capacity of loss (off Absolute Capacity) of 25.5% for the Moura system for all other losses. We consider this to be high and is an influencing factor which materially reduces estimates for Existing Capacity for this network, estimated to be 59.5%.

However, in light of the extent of surplus capacity that exists for this system, we have taken the view that, despite the conservative other loss assumptions presumed by Aurizon Network, a change to Available Capacity estimates arising from assuming a lower level of other losses was unlikely to provide any benefit and as such, the impact of a high other loss assumption was thought to be immaterial.

6. GHD conclusions and recommendations

Whether Aurizon Network can meet its contractual obligations and whether train paths on existing infrastructure are used efficiently, are both critical to access holders. Not only do these factors affect access holders' volumes and operational flexibility, but they also contribute to a transparent understanding of the need for infrastructure expansion.

The objective of the BCA review, is to:

- Review Aurizon Network's method and assumptions used to develop the BCA and advise whether they are reasonable and appropriate for the purpose
- Comment on whether the resulting capacity analysis and its components (such as Available Capacity) are reasonable
- From the above, recommend whether the QCA should accept/agree with the BCA or not, with reasons
- Comment on whether the assessment of system capacity demonstrates that contracted TSEs can be met
- Make recommendations of improvements to the BCA process.

Pursuant to the public release of the BCAR, two industry stakeholder responses were received by the QCA. On 5 May 2017, Pacific National submitted a response to the QCA in relation to Aurizon Network's SOP and BCAR documents. Likewise, on 5 May 2017, the Queensland Resources Council similarly submitted its response to the QCA. Both submissions expressed concerns, paying particular attention to the matters listed below. It was expressed that the BCAR:

- lacked transparency as regards modelled assumptions, including above rail considerations, i.e., payload and the number of trains
- insufficiently considered supply chain interfaces such as the port and mine and in particular, that Aurizon Network sought no collaborative input from other elements of the supply chain to ensure these interfaces were appropriately modelled; thereby being uncompliant with clause 7A.5(b)(iii) of the 2016 AU, and
- adopted a flawed approach to its modelling whereby it failed to model for an appropriate period of time, amongst other concerns

We were commissioned by the QCA to undertake a review of Aurizon Network's BCA and BCAR. Our review provides the basis for providing the QCA and stakeholders with confidence in Aurizon Network's capacity estimates, service planning and below-rail network operation and in particular, whether the QCA should accept the BCA as set out in the BCAR.

In undertaking our analysis, we sought to take into consideration the complex issues raised by stakeholders, and to also ensure that this report addresses the objectives/scope of the BCA review. We summarise our findings below. We start with commentary on Aurizon Network's BCA modelling approach, followed by judgements on each of the four rail systems managed by Aurizon Network; prioritised by those systems where our findings differ greatest against those interpreted and conveyed by Aurizon Network. We then set out our recommendations.

Analysis of modelling approach underpinning BCA

We find that Aurizon Network's dynamic modelling approach does not adequately model the CQCN for the following reasons:

1) **Dynamic modelling is undertaken in discrete one-month periods**
   a) Dynamic modelling periods are limited to isolated one-month periods and monthly modelled outputs are summed together to determine annual network capacity.
   b) The rail networks in which Aurizon Networks manages, operate 24 hours a day, 7 days a week. Therefore, cumulative delays that would naturally extend from one month to another are not adequately captured.
   c) In modelling discrete monthly periods, the long-term impact of supply chain behavioural patterns is not captured. Aurizon Network's dynamic modelling therefore potentially, allows for more completed journeys on the system than could be achieved in reality.
   d) Further, as each month is modelled anew, there is no continuity in train data. This extends to the location of trains from the last day of an earlier month to the first day of the next. Neither can data be reconciled in following a train's cycle over a twelve-month period
   e) The impact of tack closures and other events spanning across monthly boundaries is not adequately captured.
2) **Aurizon Network's dynamic modelling approach commences each new modelled run with a seven-day warm-up period prior to recording system data for modelled runs. As mentioned earlier, Aurizon Network models a new run for each month of the year, thereby attributing 12 warm-up periods for each annual period.**
   a) A warm-up period commences by assuming all trains are situated at the depot and, under an even-railings mode of operation, trains are systemically throughout the network – where before commencement of the warm up period, the rail network has zero trains running on it.
   b) A short warm-up period exposes a level of risk that the system fails to reach a 'steady-state', and therefore the model does not appropriately emulate the actual system under normal running conditions, in just a seven-day period.
   c) The warm-up period is important because it affects the accuracy of the results when undertaking simulation modelling. When a system is modelled which has not reached the steady-state situation, system results vary rapidly for the parameters used between model runes which can lead to incorrect information being derived as to system outputs.
3) **Aurizon Network's dynamic modelling approach at critical supply chain interfaces is modelled without considering real life performance parameters.**
   a) Time-at-port values populated in Aurizon Network's dynamic model are reflections of maximum time at port allowances specified in commercial Access Agreements.
   b) Specifying a 'time at port' to all trains at port, based on maximum times specified in Access Agreements, is inconsistent with real world operations.
   c) [redacted]l loadout has physical capacity for one train to be loaded with coal at any given time but is assumed to have two load-outs in the BCA (i.e. it can load two trains at the same time). This modelled outcome is impossible to achieve in reality as the infrastructure does not exist. [redacted]

[redacted] we consider it inappropriate for the BCA to model capacity as if two loadouts [redacted] are in place.

d) Modelling critical supply chain interfaces such as ports and mines, based on assumptions that do not align with reality undermines the value one would reasonably expect to benefit in reading such an assessment. In circumstances where the supply chain is modelled without considering real life performance parameters, i.e. actual experienced average loading/unloading times, the results have diminished validity and potentially, result in an over estimate of the ability of a network to meet contracted TSEs.

4) **Aurizon Network's static modelling assumptions are considered conservative and attribute to a comparatively low Existing Capacity determination when compared against industry.**

a) Aurizon Network assumes an Existing Capacity (or upper practical utilisation threshold) of either 63.7% or 59.5% of Absolute Capacity, depending on the network.

b) This determined percentage is lower than typically planned in other comparable networks, for example ARTC plans for a ratio of Existing Capacity to Absolute Capacity of 65% in its Hunter Valley Coal Network and publicly acknowledges this percentage could be revised upward to ~75% (with efficient signalling). We understand that Queensland Rail assumes 70% for its Mt Isa to Townsville rail corridor and 65% for its West Moreton rail corridor.

c) This has a direct impact on Aurizon Network's BCA determination of Available Capacity. The assumptions that influence Existing Capacity ultimately determines the quantum of paths made available for its customers. The consequence of assuming a lower practical utilisation upper threshold of Absolute Capacity translates into a lower allocation of paths. Ceteris paribus, if the practical utilisation threshold is higher, this equates to a higher availability of paths that can be consumed by rail services.

System-Specific Conclusions

Goonyella

1) **GHD finds Aurizon Network's dynamic modelling of the Goonyella system to be reasonable**

We recommend that Aurizon Network's assessment that there is sufficient capacity to accommodate current TSEs is accepted. However, we consider that Aurizon Network's determination of Available Capacity for the Goonyella system is conservative.

While we agree on the location of congestion points along track infrastructure and agree as to where material surplus capacity exists, we disagree from analysing the information provided, that these 'bottlenecks' warrant Aurizon Network's position that less than 1% capacity (relative to Absolute Capacity) exists for additional TSEs, or 371 new TSEs, in the Goonyella system. We note that the modelling for Goonyella results in excessively high levels of BRTT. As modelled, the Goonyella system on time performance (BRTT) falls behind the Blackwater on time performance (BRTT). This contradicts actual system BRTT as reported in system KPIs where the Goonyella system has the best on time performance amongst all other Aurizon Network operated coal systems. This is in keeping with what would be expected from a system such as Goonyella which comprises mainly double track sections.

Newlands

1) **GHD finds Aurizon Network's dynamic modelling of the Newlands system to be reasonable**

We recommend that Aurizon Network's assessment that there is sufficient capacity to accommodate current TSEs is accepted. However, we consider that Aurizon Network's determination of Available Capacity for the Newlands system is conservative.

While we agree on the location of congestion points along track infrastructure and agree on a relative stance as to where material surplus capacity exists, we disagree upon analysing the information provided to us, that these 'bottlenecks' warrant the view that only 2.5% capacity (relative to Absolute Capacity) exists for additional TSEs, or 673 new TSEs, in the Newlands system.

Blackwater

1) GHD finds Aurizon Network's dynamic modelling of the Blackwater system to be reasonable

We recommend that Aurizon Network's assessment that there is sufficient capacity to accommodate current TSEs is accepted. We also consider that Aurizon Network's determination of Available Capacity for the Blackwater system is a reasonable reflection of Available Capacity notwithstanding the conservative assumptions that underpin its Available Capacity threshold (statically determined), which in this instance is 59.5% (of Absolute Capacity).

Moura

1) GHD finds Aurizon Network's dynamic modelling of the Moura system to be reasonable

We recommend that Aurizon Network's assessment that there is sufficient capacity to accommodate current TSEs is accepted. We also consider Aurizon Network's determination of Available Capacity for the Moura system to be a reasonable reflection of actual Available Capacity that exists notwithstanding the conservative assumptions that underpin its Available Capacity threshold (statically determined), which in this instance is 59.5% (of Absolute Capacity).

Overall conclusions:

Aurizon Network takes the difference between the static model and the contracted TSEs to determine the Available Capacity. However, the assumptions in the static model, particularly around system losses due to unplanned maintenance activities and robustness factors are conservative. We have come to this view by benchmarking Aurizon Network's system losses with those of other below rail network operators and academic research. This results in the projected Available Capacity estimate being lower than in reality is the case.

We also have concerns with respect to the approach and assumptions Aurizon Network uses in its dynamic modelling:

- Aurizon Network models each system in discrete monthly intervals which results in an underestimate of the compounding impact of delays and hence potentially results in an over estimate of the ability of a network to meet contracted TSEs.
- Aurizon Network only uses a seven-day warm up period which may not allow the network to reach a stead state.
- Aurizon Network models critical supply chain interfaces such as ports and mines, based on assumptions that do not align with reality, e.g. the modelling of two trains being located at coal loadouts [redacted] where there is capacity for only one train and time at port being based on maximum times specified in Access Agreements. The modelling of two loadouts where only one exists potentially results in an over estimate of the ability of a network to meet contracted TSEs. The modelling of maximum unloading times at ports rather than average actual unloading times potentially results in an under estimate of the ability of the network to meet contracted TSEs and or of Available Capacity.

The above issues may result in an inaccurate determination as to whether contracted TSEs can be met. In that they may result in the dynamic model achieving TSEs with less of an adverse impact to operational performance than may be the case. Should Aurizon Network change its dynamic modelling method to a 12 month continuous basis, the results of the simulation may result in capacities for train services being different from application of the current, one month at time, modelling method due to compounding of delays.

Recommendations

Notwithstanding the above, we consider that the issues identified are unlikely to materially impact on the modelled number of TSEs that can be achieved. We therefore recommend that the QCA accepts Aurizon Network's BCA, although we recomend that the issues identified in this report be addressed in future capacity assessments.

GHD
Advisory

Level 9 145 Ann Street Brisbane QLD 4000 Australia
GPO Box 668 Brisbane QLD 4001 Australia

61 7 3316 3000
advisory@ghd.com

G:\91\10446\Deliverables\Final Report\9110446 - GHD Assessment of AN Baseline Capacity Assessment - Final.docx

Rev.No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Draft	Val Lavrukhin Adam Boyle	Stephen Hinchliffe		Stephen Hinchliffe		18/11/2017
Final	Adam Boyle	Hiresh Devaser & Stephen Hinchliffe		Stephen Hinchliffe		01/03/2018

GHD Advisory

GHD

ghd.com/advisory