Appendix N

Evans and Peck - Operating and Maintenance Costs: Investigation and Benchmarking – Final Report, October 2012

QR Network Pty Ltd

Operating and Maintenance Costs

Investigation and Benchmarking
Final Report

EVANS & PECK

October 2012

Authors

Name	Organisation	Role

Revision

Revision	Date	Description
A	June 2012	Draft for review
B	October 2012	Final Report

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EVANS & PECK

Executive Summary

Objectives

Evans & Peck was appointed by QR Network Pty Ltd ("QR Network") to conduct an independent investigation and benchmarking study into the asset management and maintenance practices of heavy haul freight railways in Australia and overseas. The study was commissioned to provide support to QR Network in their upcoming Access Undertaking (UT4) submission to the Queensland Competition Authority (the QCA). The main objective of the study was to provide an independent assessment on the appropriateness of QR Network's management and maintenance practices, and thus their operating costs to maintain the Central Queensland Coal Network (CQCN), giving due consideration to the unique characteristics of the CQCN and the applicability of industry norms.

Approach

Three work paths, illustrated below, were investigated as part of the study. The scope initially focussed on building upon a previous benchmarking survey conducted by WorleyParsons for the 2008 Access Undertaking submission (UT3). This evolved significantly over the course of the study due to low levels of commitment from benchmark railways to participate fully in the survey, which in turn, impeded some of the analysis that could be undertaken based on the survey responses. Consequently, a greater emphasis was placed on the second investigation work path, which focussed on reviewing and analysing existing publications and other research material. In addition, a third work path, building up independent cost estimates for three key maintenance activities, was added to the scope to ensure a more robust and comprehensive investigation. Each of the three work paths were investigated in parallel to identify all potential contributing factors impacting QR Network's maintenance task and cost.

Work Paths		
SURVEY	**PUBLICATIONS AND RESEARCH**	**INDEPENDENT COST ESTIMATING**

Key Activities

- Identification of comparable rail organisations to benchmark - Contact and discussions with comparable rail organisations regarding survey participation - Preparation and distribution of survey to participating rail organisations - Assessment and analysis of responses by: - Network Characteristics - Supply Chain Management - Maintenance Costs and Profile - Asset Management Organisation - Possession Planning and Management - Strategy and Asset Monitoring Information - Work Practice Engineering - Technical Network Characteristics	- Identification of focus areas for further in-depth investigation and analysis - Desktop review of publicly available documents and sourced research material focussing on: - Asset Management and maintenance practices, conditions and trends - Maintenance Cost Benchmarking Analysis - Analysis of results	- Assessment of suitable cost characteristics - Independent cost build ups for: - Ballast Cleaning - Rail Grinding - Mechanised Resurfacing - Analysis and review of industry account reporting practices and costs against QRN

Basis of Evaluation

- Benchmarking of survey participants by category - Previous benchmarking investigation and analysis (UT3)	- Previous QR National Access Undertakings - Cost Benchmarking Reports - Asset Management Reports - Other published reports on rail industry practice and trends	- Benchmarking and costing reviews - Maintenance and operational standards - Track machinery specifications - Infrastructure and asset management plans - Comparison against QR Network's costs

Assess findings against QR Network's maintenance task and cost

Project Kick-Off   Formal Survey Close   Draft Report   Final Report

March   April   May   June   October

The survey work path primarily focussed on the key factors influencing maintenance by considering the appropriateness of QR Network's practices and methodologies in terms of current industry trends.

The publications and research work path encompassed a wide ranging review of publically available documents and other research material which encompassed asset management and maintenance information and reports, previous benchmarking investigations conducted by external consultants, and other reports on the access undertakings of QR Network and other Australian rail organisations. These publications were reviewed and analysed, in conjunction with Evans & Peck's industry knowledge and experience, to make an informed judgement on the reasonableness of QR Network's asset management and maintenance practices together with the organisational cost efficiency. Where possible, the analysis incorporated normalising to take account of the unique characteristics of the CQCN and the impacts of this on QR Network's maintenance task.

The third work path on independent cost estimating considered a bottom up approach to the cost estimating of three key maintenance activities and comparing those estimates with QR Network's actual maintenance costs for those activities for the 2011/12 financial year. The independent cost estimates were developed based upon current capital costs and market prices in respect of:

1. Rail grinding (mainline);

2. Ballast cleaning (mainline); and

3. Resurfacing (ballast tamping and stone blowing).

Key Findings

Overall the investigation found that QR Network generally has robust engineering and maintenance practices in place to manage the CQCN network which appear to be in line with industry norms. Their unit costs, based on a dollar per track kilometres versus net system tonnage basis, appear to be both prudent and reasonable when compared with similar national heavy haul railways.

The following table summarises the key findings from each of the three work paths that are considered to be influencing QR Network's asset management and maintenance task, and in turn, maintenance cost efficiency. References to the supporting analysis are also provided in the table.

No.	References	Key findings for asset management and maintenance task
1	Sections 4.2.1, 4.2.8, 4.2.9 of Survey Findings. Section 4.3.1 of Publication & Research Findings	*Unique characteristics of the CQCN are key contributors to the maintenance task* Two of the works paths identified that the unique characteristics of the CQCN, such as relatively high annual tonnages, significant temperature ranges, periods of extreme weather, high operating speeds, spillage of coal, poor formation support and narrow gauge track configuration all result in distinctive management and maintenance challenges for QR Network, and consequently contribute significantly to the magnitude of QR Network's maintenance task. A 'one size fits all" maintenance strategy will not always provide the most efficient solution as maintenance strategies need to appropriately account for unique network characteristics and the operating regime.
2	Sections 4.2.1, 4.2.9 of Survey Findings. Section 4.3.1 of Publication & Research Findings. Appendix E	*Ballast fouling significantly impacts the CQCN maintenance task* Two of the work paths confirmed that in railways where coal contamination is present it significantly impacts the degradation of track components and thus the size of the maintenance task, and also presents environmental challenges. The CQCN has many locations where high levels of coal contamination are present. The risks associated with this, such as loss of structural integrity of the track have recently been acknowledged in the industry. QR Network and a number of Class 1 US railways now lead the industry in the research and strategies required to deal with these maintenance issues.
3	Section 4.2.9 of Survey Findings.	*Analysis of the maintenance intervention levels for ballast cleaning, mechanised resurfacing and rail grinding identified areas where intervention periods need to reduce on the CQCN* International research found that for contaminated ballast, intervention periods for ballast cleaning/undercutting, mechanised resurfacing and rail grinding must

No.	References	Key findings for asset management and maintenance task
	Section 4.3.4 of Publication & Research Findings.	reduce to address the accelerated degradation of the asset. An analysis of QR Network's maintenance intervention frequencies for these maintenance activities indicated that QR Network's ballast cleaning levels should be increased on all four systems. It further highlighted that mechanised resurfacing of the turnouts on the Newlands and Moura systems should be increased, and for these lower trafficked systems it may be more appropriate to consider maintenance intervention and condition in terms of time frequencies rather than tonnages transported. The analysis of intervention periods for rail grinding indicated that QR Network operates a robust program on all four major rail systems.
4	Section 4.2.8 of Survey Findings. Section 4.3.5 of Publication & Research Findings.	***Maintenance task will be impacted in the future by availability of skilled resources to undertake maintenance works in Northern Queensland*** Research highlighted that skilled resources available in the Central Queensland coal area are in short supply due to demand and earnings imposed by the utility sectors in Northern Queensland. This can potentially impact the maintenance task in terms of available skilled resources to undertake work, and also the labour cost proportion required to undertake the works. The survey highlighted that CQCN percentages of labour costs from total maintenance costs were currently in line with industry expectations, but there are significant variations in travel requirements from home base location to depot (thus increased cost) and the CQCN also had comparatively high maximum distances for staff to travel from home base to depot location.

No.	References	Key findings for maintenance cost efficiency
1	Sections 4.2.5, 4.2.7 of Survey Findings. Section 4.3.1 of Publication & Research Findings. Appendix C	***Improved asset management systems would offer QR Network an opportunity to optimise their capital and maintenance investment and achieve greater cost efficiency*** The publication and research work path, combined with the competitor network comparator database developed from the survey work path, identified that QR Network applies an appropriate governance management framework of standards for the management of its assets in conjunction with multiple asset databases and legacy systems. Whilst consistent with some heavy haul railways of similar age, the application of an enterprise asset management system would offer the opportunity for QR Network to optimise capital and maintenance investment, and create an enhanced understanding of the asset performance and condition.
2	Section 4.2.6 of Survey Findings. Section 4.3.2 of Publication & Research Findings. Sections 4.4, 4.4.1, 2 & 3 of Cost Estimating Findings.	***Current possession management practices impact maintenance efficiency however current and future traffic densities may constrain opportunities for extended closures for some maintenance activities*** All three work paths found that current possession management practices are impacting maintenance cost efficiency. There appears to be some room for improvement despite the acknowledgement that future traffic densities on the CQCN may constrain the opportunities for extended closures on highly trafficked sections of the network. Investigations into possession management practices of other rail organisations in Australia and overseas found that those operating with extended closures generally considered that this enabled them to achieve improvements in quality, and reduced costs, whilst providing better, more reliable services to customers.
3	Section 4.3.3 of Publications & Research Findings Appendix F	***Industry cost benchmarking demonstrated that unit maintenance costs on all CQCN systems, in general, were positively placed within the calculated efficiency trend lines*** The industry cost benchmarking analysis identified the ARTC Hunter Valley Coal Network (HVCN) to be the most comparable to the CQCN systems in terms of key network characteristics, freight commodity and traffic hauled. The cost benchmarking analysis that was subsequently conducted clearly indicated that the unit costs of CQCN annual maintenance tasks appeared reasonable when compared with these similar national railways. All CQCN rail systems were positively placed within the calculated efficiency trend lines on a dollar per track kilometre versus net system tonnage basis. Normalising factors associated with the characteristics of each individual rail system were accounted for where this was possible to do, however any additional

No.	References	Key findings for maintenance cost efficiency
		potential cost contributors relating to inherited organisational issues, such as backlog maintenance, legacy asset management processes, or costs relating to varying outsourced maintenance activities were not considered in the analysis.
4	Section 4.2.3 of Survey Findings. Section 4.3.6 of Publication & Research Findings.	*Supply chain management, optimisation, and coordination costs can impact on maintenance efficiencies and costs of operations* The survey work path identified that the majority of benchmarked railways operated under open access regimes similar to the CQCN. Under this type of regime coordination costs can potentially impact on total maintenance efficiencies and the costs of operations. In addition, the Queensland State Government report of 2007 essentially determined that for the CQCN coal supply chain to operate optimally the coal unloaders must operate optimally, and consequently, other elements of the system must be designed to absorb system losses, and these system losses need to be equitably distributed across all components of the supply chain, including the below rail infrastructure. These findings highlight a need for greater transparency and coordination amongst the supply chain parties using the CQCN to ensure common objectives are in place which can in turn realise cost efficiencies on the network.
5	Section 4.37 of Publication & Research Findings.	*Regulatory Framework* The high level review of national regulatory frameworks (QR Network, ARTC, WestNet and Victorian Rail) revealed that they are all reasonably consistent but it is evident from this review that there are areas within the commercial frameworks that could provide incentives for enhanced performance across the supply chain.
6	Section 4.35 of Publication & Research Findings.	*High plant and labour costs impact cost efficiency* Rail is a capital intensive and specialised industry and maintenance providers need high volumes of work to survive. It is therefore recognised these cost components may be high, and consequently, the ratio of "effective" to "non-effective" working periods will be higher, which in turn impact the cost efficiency of maintenance.
7	Sections 4.4, 4.4.1, 2 & 3 of Cost Estimating Findings Appendix G	*QR Network generally maintains competitive per kilometre rates for rail grinding, ballast cleaning and mechanised resurfacing* Due to QR Network maintaining some of their key maintenance activities in-house, the CQCN have maintained reasonably competitive per kilometre rates for rail grinding, ballast cleaning and mechanised resurfacing. Under the assumptions of the estimate in each case, QR Network's actual outputs for the 2011/12 financial year appeared to be reasonably efficient, when taking into account the constraints and limitations associated with achieving productive outputs within the available track access periods. For plain line rail grinding QR Network achieved an efficiency level of ████%, with an average of ████ km of grinding per shift, and ████████ of productive grinding in a shift for the 2011/12 financial year. Optimum production however is achieved when greater than 4 hours of grinding can be achieved in a shift. For ballast cleaning, QR Network achieved, on average, ██ kilometres of ballast cleaning at a unit cost of $██████ per ████ deployment block in the 2011/12 financial year. Optimum production however occurs when ████ blocks achieve around ██ kilometres of ballast cleaning. For plain line mechanised resurfacing, in the 2011/12 financial year, QR Network achieved, on average, █ kilometres of tamping at a unit cost of $██████/km per shift, and ████ kilometres of tamping with stone blowing at a unit cost of $██████/km per shift. Optimum production costs occur in each case when production rates achieve greater than 14 kilometres in a shift.
8	Sections 4.2.1, 4.2.6, 4.2.9 of Survey Findings. Section 4.3.1 of Publication & Research Findings. Sections 4.4.1,2	*Network operating characteristics directly impact unit costs by "forcing" works to be carried out "non-efficiently"* The access constraints of the current operating regime present the single most important factor for optimising maintenance costs on the CQCN as maintenance costs are not considered to be efficient when they are undertaken during short possession times due to the relatively high proportion of set up costs. The growing density of traffic to carry increasing tonnages results in lower opportunities to obtain longer possession periods, and reactive works are sometimes forced to be undertaken during "non-efficient" cost periods, thus

No.	References	Key findings for maintenance cost efficiency
	& 3 of Cost Estimating Findings	increasing the overall unit rate. The only way to minimise this may be to reduce the need for reactive maintenance which requires sophisticated asset management systems and predictive modelling tools.

Recommendations

Based on the findings of the study, Evans & Peck considers that the following initiatives would offer QR Network the scope to enhance both asset management and maintenance practices and maintenance cost efficiency.

Link to Key Finding	Recommendations for asset management and maintenance task
Key Finding 1, Maintenance Cost Efficiency	**Adoption of Enterprise Asset Management System** The adopting of an enterprise asset management system would enable QR Network to optimise the allocation of capital and maintenance investment as well as enhance their understanding of the CQCN asset performance and condition.
Key Finding 2, Maintenance Cost Efficiency	**Investigate policy of Extended Closures on CQCN** QR Network should consider investigating the reasonableness, practicalities and costs of adopting a policy of extended closures on the CQCN through positive collaboration with all parties in the pit, rail and port supply chain, and determine the impacts of such a policy in conjunction with the potential for quality and efficiency gains in the maintenance and reliability of services.
Key Finding 3, Asset Management and Maintenance Task	**Increase ballast cleaning maintenance** It is recommended that ballast cleaning maintenance be increased on all CQCN's four systems in line with industry peers who experience coal contamination.
Key Finding 3, Asset Management and Maintenance Task	**Increase mechanised resurfacing of turnouts on Moura and Newlands systems** The maintenance intervention periods for mechanised resurfacing of turnouts on the Moura and Newlands systems should be decreased in line with industry peers who experience coal contamination.
Key Findings 2 & 3, Asset Management and Maintenance Task	**Continue robust coal loss management programs** To proactively combat the risks associated with coal fouling across the CQCN, QR Network should continue with its various coal loss management work programs.

Link to Key Finding	Recommendations for maintenance cost efficiency
Key Finding 5, Maintenance Cost Efficiency	**Improve the access undertaking framework** Enhanced commercial incentives between QR Network and the operators through the access undertaking framework could enable cost efficiency opportunities to be realised.
Key Finding 3, Maintenance Cost Efficiency	**Conduct a sensitivity analysis to optimise maintenance intervention levels** It is recommended that QR Network conduct a sensitivity analysis on all key maintenance activities and its maintenance intervention periods to ensure that the intervention periods and production levels are optimised across all systems on the CQCN.
Key Finding 4, Asset Management and Maintenance Task	**Undertake labour optimisation investigation** It is recommended that QR Network undertake further investigation and analysis on the impact to maintenance costs arising from the location of depots, with a focus on optimising the demarcation of depot locations and skills to specifically cater for CQCN maintenance activities.
Key Finding 4, Maintenance Cost Efficiency	**Investigate ways to improve coordination and understanding of the supply chain** It is recommended that QR Network review the CQCN supply chain coordination plan with a focus on the formulation of common objectives with other supply chain parties, and establish common indicators to measure how each component of the supply chain is progressing towards the goals that have been set.

1 QR Network's Requirements

1.1 Objective

Evans & Peck was appointed by QR Network Pty Ltd. ("QR Network") to conduct an independent investigation and benchmarking study into the asset management and operational maintenance practices of heavy haul freight railways in Australia and overseas. The objective of the study was to provide an independent assessment of the appropriateness of QR Network's maintenance methodologies and practices, and resulting costs to maintain their network, giving due consideration to the unique elements of the Central Queensland Coal Network (CQCN).

1.2 Context

1.2.1 Central Queensland Coal Network (CQCN)

QR Network owns and manages the CQCN, which currently consists of over 2,600 route kilometres of narrow gauge (1,067 mm) track, which links the coal mines in the Bowen Basin to the major coal ports at Mackay and Gladstone.

The CQCN has four major rail systems, the Moura, Blackwater, Goonyella and Newlands systems, with each forming part of a unique pit-to-port supply chain, as shown in Figure 1. Of special note are network capacity expansions recently completed and those that are planned to be completed within the next five years.

A major project recently completed was the "Northern Missing Link", also known as the Goonyella to Abbot Point Expansion (GAPE) project. This project consisted of approximately 70 km of new track connecting the Goonyella and Newlands systems, together with upgrades of the Newlands system that provided additional passing loops to be able to accommodate additional tonnages.

Among the capacity expansion projects currently under way are the Wiggins Island Rail Projects (WIRP) Stages 1 and 2. Combined, these two programs of work will add a further 60 Mtpa capacity to the Wiggins Island Coal Export Terminal (WICET) at the Port of Gladstone via the Moura and Blackwater systems. There will also be further enhancements to provide additional capacity to service the planned terminal expansions at Abbot Point and Hay Point. These terminal expansions could lead to a requirement for between 30 and 90 Mtpa capacity expansion programs to the Goonyella and Newlands systems.

These projects provide a context in terms of some of the challenges that the CQCN has in terms of achieving major capacity upgrades in the next five years.

Appendix A provides further details on the four major CQCN systems.

Figure 1:   Central Queensland Coal Network
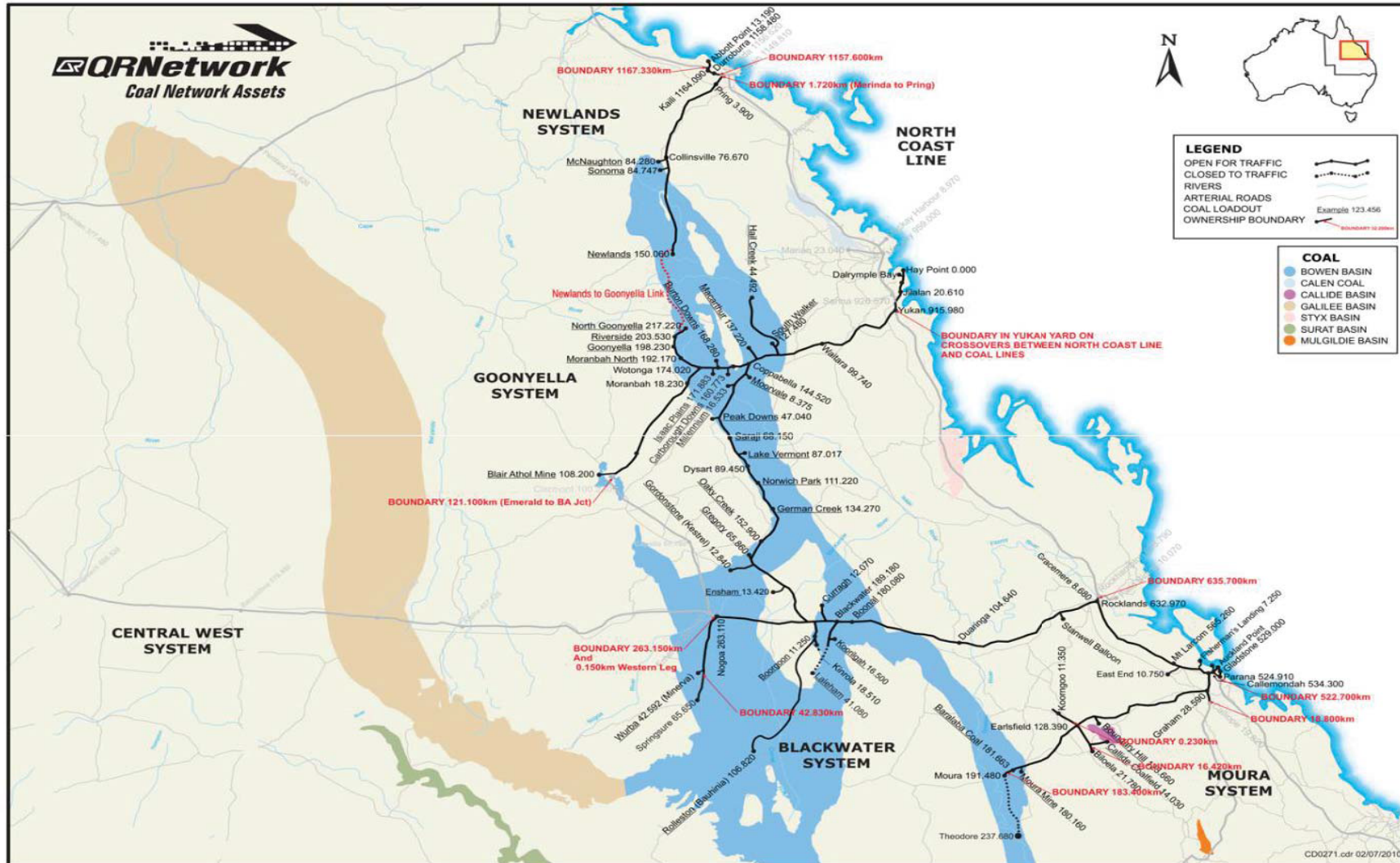
1.2.2 Regulatory regime

The CQCN is a vital element of Central Queensland coal supply chain. As a monopoly organisation, it is regulated by the Queensland Competition Authority ("QCA") to ensure the appropriateness of costs (and subsequent network tariffs) passed on to Operators using the network. The underpinning contractual and commercial conditions are set out in an Access Undertaking (UT) between the respective parties. Each UT, amongst other things, includes a cost structure with a forecast of below rail operational maintenance expenditure (OPEX) for the term of the UT; the QCA uses this cost structure to identify allowances for OPEX budgets.

Three UT submissions for the CQCN have previously been lodged to the QCA. QR Network is due to make another UT submission (UT4) in 2012. Previous submissions (UT1 and UT2) included flaws in the cost structures applied to the infrastructure maintenance. In addition, over the term of these undertakings, Queensland experienced significant growth in the rail network capacity demand due to the mineral boom, which in turn increased the maintenance task.

To address the imbalance QR, at that time, undertook a full review of its maintenance needs and subsequent costs for the UT3 submission to the QCA in 2008. This subsequently provided for a step change in maintenance costs to be applied over the UT3 period. At that stage the QCA did not consider that QR had adequately justified the requested UT3 allowances and as a consequence they were not approved by the QCA.

For the UT4 Access Undertaking submission QR Network are now seeking to ensure their submission clearly demonstrates that their level of maintenance is appropriate to achieve the capacities required and that maintenance is undertaken in a cost efficient and prudent manner, giving due consideration to the current operating environment. To substantiate their reasoning QR Network is drawing on a rigorous study and analysis of Australian and international maintenance practices and benchmarked railway industry costs.

1.3 Evans & Peck's Brief

Evans & Peck was engaged to build upon the previous benchmarking exercise conducted by WorleyParsons for the UT3 submission, to assist QR Network to demonstrate that their maintenance costs are both prudent and reasonable.

The following table summarises Evans & Peck's brief, together with the section of the report where the requirement has been analysed as part of the investigation.

Table 1:   Summary of Evans &Peck's Brief

Item	Requirement	Report Reference
1.	Confirm and substantiate the benchmarking results of the UT3 submission by adding further engineering specific questions to the UT4 survey and expanding the list of heavy haul railways which undertook the analysis in 2008.	Sections 3.2.2 and 4.2 Appendix B
2.	Through the benchmark assessment:	
2(a)	review the appropriateness of the engineering standards and design assumptions used for the structure and materials of the infrastructure;	Sections 4.2.9 and 4.3.1

2(b)	assess the reasonableness of the engineering and maintenance strategies adopted considering the constraints and requirements of the network;	Sections 4.2.7 and 4.3.1, 4.3.4
2(c)	review the work programs and their applicability for the traffic task in relation to similar railways;	Sections 4.2.5, 4.2.9 and 4.3.1, 4.3.4
2(d)	establish a greater focus on comparative industry costs for critical maintenance activities and for those critical maintenance activities, establish industry ranges (based on the data received from the benchmarking participants);	Section 4.3.3 Appendix F
2(e)	normalise the underlying cost structure, by focussing on the unique characteristics of QR Network's traffic task, operating environment and commercial structure in comparison with those of other heavy haul railways;	Sections 4.3.3, 4.3.6, 4.3.7 Appendix F
2(f)	assess the efficiency with which the work is performed.	Sections 4.2.6, 4.2.6, 4.2.7, 4.2.8, and 4.3.2, 4.3.3, 4.3.5, 4.3.6 and 4.4.1, 4.4.2, 4.4.3 Appendices F and G
3	Develop the analysis to include an assessment of major cost activities, and using the benchmark data, develop a model of efficiency for the traffic requirement which can then be used to build up a theoretical ideal which can be comparatively benchmarked against actual costs.	Sections 4.4.1, 4.4.2, 4.4.3 Appendix G
4	Include commentary on the consideration of the wider supply chain and asset maintenance aspects that potentially impact interpretation of benchmark data and assessments of cost efficiency.	Sections 4.3.2, 4.3.3, 4.3.5, 4.3.6 Appendix F
5	Conduct, on a case by case basis, cost build-ups of specific maintenance tasks that have a high impact on the total maintenance cost. (**Note:** optional item added to scope)	Sections 4.4.1, 4.4.2, 4.4.3 Appendix G

Evans & Peck's scope evolved over the course of the study due to low levels of formal commitment from rail organisations to participate in the benchmarking survey as a result of corporate policy restrictions and commercial sensitivities, which in turn, impeded some of the analysis that could be undertaken based on survey responses. Consequently, a greater emphasis was placed on the review and analysis of existing publications and other research material. In addition, the independent build-up of cost estimates for selected maintenance activities was added to the study scope.

2 Evans & Peck's Approach

2.1 Parallel Areas of Investigation

To assess the appropriateness of QR Network's maintenance practices and costs, Evans & Peck approached the study by investigating three work paths in parallel to ensure that the information and analysis captured was sufficiently robust to make an informed assessment of QR Network's key maintenance cost drivers, taking into account key considerations such as:

- the CQCN characteristics, limitations and constraints;

- applied governance structures, asset management, maintenance and engineering practices; and

- CQCN traffic task, operating environment, and regulatory compliance requirements.

Figure 2 illustrates the three key work paths investigated, with the main activities conducted under each of these work paths, and the key reference material applied by Evans & Peck as the basis of evaluation for the study findings. This approach allowed Evans & Peck to identify key factors (both internal and external) potentially influencing QR Network's maintenance, whilst giving due regard to the unique elements of the Central Queensland coal network, and the applicability of industry norms.

Figure 2: Study areas investigated
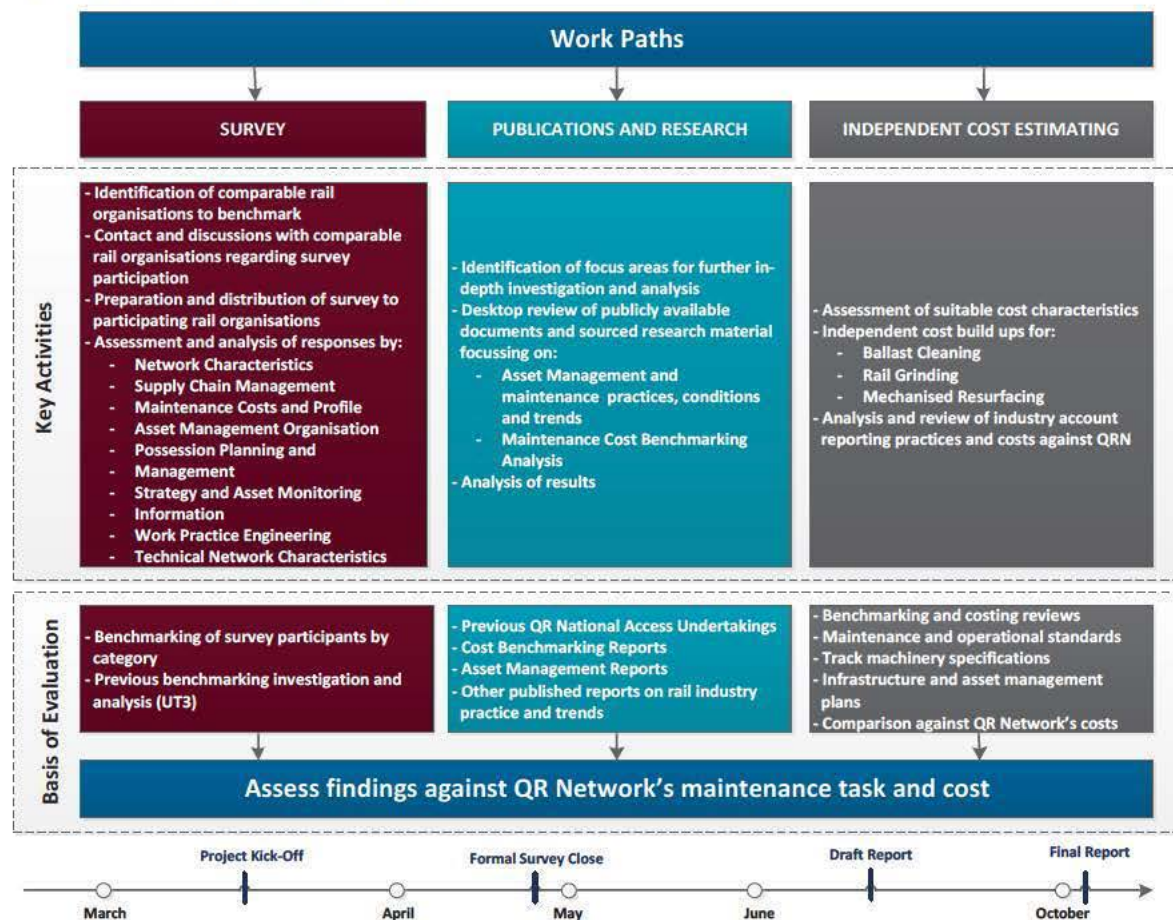
2.2   Evaluation and Reporting

The evaluation and subsequent reporting of the key findings are presented in the following manner in subsequent sections of the report.

Section 3, Basis of Evaluation – this section sets out an overview of Evans & Peck's overall approach to the evaluation process, together with the individual basis of evaluation, and reference material applied, to the discrete areas of investigation under each work path.

Section 4, Key Findings – this section presents a consolidated summary of all the key findings from the study, as well multiple individual findings from each of the discrete areas of investigation carried out under each of the work paths.

Section 5, Recommendations – a recommendations section has been developed based on the key findings of study.

3 Basis of Evaluation

3.1 Overview

In extrapolating relevant information from the reference sources, Evans & Peck applied best endeavours to ensure the accuracy of the information used. Where any conflicts in data existed, the analysis was based on the most up to date data available, and validated with QR Network as far as possible within the timescales available for the assignment.

A consolidated database of all the reference material used for each of the three areas investigated, to analyse and subsequently benchmark QR Network with other heavy haul railways in respect of maintenance task and cost is provided in Appendix D of the report.

The following sections provide an overview of the methodology applied to each individual area of investigation, including the key reference material used for the particular type of analysis.

In accordance with the approach set out in figure 2, each work path considers the investigations and subsequent findings in the context of the report in terms of potential impacts and considerations for QR Network in respect of:

1. asset management and maintenance scope

2. maintenance cost efficiency

All key findings are set out in section 4 of the report.

3.2 Survey

The focus of the survey benchmarking work path was to identify any key factors which potentially influence QR Network's' maintenance, whilst providing justification that the methodologies adopted by QR Network to address these factors are reasonable in terms of cost and standard by comparison to industry benchmarks.

One of the greatest issues in interpreting the results from benchmarking exercises to use in a comparative analysis is that there are numerous factors which will impact the result. To enable effective comparison inherent environmental elements such as underlying foundations, topography, weather, as well as operational elements such as traffic, age and type of infrastructure need to be considered when selecting appropriate benchmarking participants.

In addition, to add further rigour to the results it is beneficial to have as many survey participants as possible in order that sufficient data can be collated from which to identify trends and make reliable conclusions.

Northern Queensland conditions are fairly unique, which makes finding comparable operations difficult, due to a combination of 'local' factors experienced on the CQCN such as:

- relatively high annual tonnages;

- high temperature ranges;

- high concentrated rainfall periods;

- corridor contamination due to spillage of coal;

- narrow gauge; and

- large sections of electrified track.

In addition, different accounting treatments, cultures and history can create a significant impact on how results from benchmarking are interpreted and presented.

To counteract these difficulties and minimise the distortions in benchmark interpretation, a number of considerations were adopted in the survey development, selection of participants and analysis of survey data. These included:

▪ incorporation of previous survey results, both to confirm and substantiate the data received in the current survey;

▪ criteria for selection of relevant participants in the survey;

▪ survey structure adopted;

▪ use of research and published documentation to support the findings and key factors identified in the survey responses;

▪ normalisation methods within the analysis; and

▪ amalgamation of the survey findings with other key work streams to develop an informed and "three dimensional" assessment of key maintenance cost drivers.

The following sections detail how these considerations were incorporated into the survey and how they counteract some of the issues associated with the benchmarking analysis.

3.2.1   Previous Benchmarking Survey

In July 2005 QCA issued a draft decision on QR's second undertaking (UT2), rejecting the report and recommending that an independent review of the appropriateness of the strategy and measures within the Draft Access Undertaking be undertaken for the UT3 submission. As part of this independent review QR commissioned WorleyParsons to conduct a review of the UT3 submission, the scope of the review included a benchmarking of maintenance methodologies, outputs and engineering assumptions against comparable international railways.

This benchmark report was completed in August 2008 and was "regarded highly" by the QCA consultant[1]. The desktop analysis "provided the theoretical base to incorporate field audit and application of practices used elsewhere in the world"[1] as such, the previous benchmarking data was considered to be a robust and comprehensive building block of data upon which to build upon for this study. The previous benchmarking data provided invaluable insight into the appropriateness of QR's maintenance methodologies and strategies benchmarked against several comparable railways around the world which are as relevant today as they were in the 2008 study.

This inclusion of previous benchmarking data was used as a part of the analysis to ensure greater reliability of conclusions through:

▪ Increased data assessment; and

▪ "confirmation" of the results in the 2012 survey, including any relevant changes in methods or systems applied since 2008.

The comparison of the previous benchmarking with the 2012 survey data was also focused on the reasonableness of the 2008 conclusion that, "QR is operating proficiently and plans for the future will improve that performance" and whether those stated "plans" have been incorporated successfully into the business.

Although sufficiently robust in its engineering findings the previous work demonstrated that while QR was not at the lowest level of maintenance cost, compared to other railways, insufficient cost data was obtained in 2008 to be able to make direct comparisons. Hence one of the major

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[1] Report for QR Network Access Undertaking Assessment of Operating and Maintenance Costs of UT3, September 2009, GHD for Queensland Competition Authority

objects of this study was to substantiate this area with a wider range of cost data results, both through the 2012 survey and through the other two work paths.

3.2.2   Survey participants

Participants were selected mainly on the basis that they were considered to be heavy haul freight systems. The criteria used were adapted from the definition given by the International Heavy Haul Association (IHHA) which are:

- Regularly operates or is contemplating the operation of unit or combined trains of at least 5,000 [metric tons];

- Hauls or is contemplating the hauling of revenue freight of at least 20 million gross [metric tons] per year over a given line haul segment comprising at least 150 km in length; and

- Regularly operates or is contemplating the operation of equipment with axle loadings of 25 [metric tons] or more."

Through consideration of the above, a list of possible participants was selected which included railways from Australia, Scandinavia, Europe and America.

The following table provides a summary of the participants invited to respond to the questionnaires in 2008 and 2012.

Table 2:   Organisations invited to participate in survey

Organisation	Location	Invited 2012	Invited 2008

3.2.3   Survey Structure

Primarily all the railways were sent a letter introducing the questionnaires. The letter detailed the conditions under which the survey was being conducted and assured complete confidentially of the participants. As a reward for participating, the railways were offered a summarised copy of the survey benchmarking report. A copy of the survey questionnaire used for this 2012 study is included in Appendix B.

The survey questions were structured under the following general headings:

General details – which included general information on the railway such as length of line, types of freight transported on the line, average speed, construction date and type, etc.;

Supply chain – which asked for details on the operating environment;

Maintenance costs – which was asked to build up maintenance cost profiles for each organisation;

Asset management organisation – which included information on the asset management processes and systems;

Possession management – which included questions on closure management and maintenance task planning;

Strategy and monitoring – which included questions on the categorisation of assets and recording of asset maintenance works and requirements;

Work practices – which included questions on general labour force, gangs and labour costs;

Track and structures – which included questions on track structure details and major structures on the railway; and

Systems – which included questions on the trackside systems used to support train operations.

The survey structure was developed in line with the criteria considered to be key factors necessary to conduct both qualitative and quantitative analyses of QR Network in terms of other heavy haul railways.

3.3   Publication and Research Investigations

The publications and research work path encompassed a wide ranging review of publically available documents and other research material available to Evans & Peck which was broadly classified into:

1.   Asset Management and Maintenance Information and Reports;

2.   Previous Benchmarking Investigations and Reports; and

3.   Previous Access Undertakings (both QR and other rail organisations).

These publications were reviewed and analysed, in conjunction with Evans & Peck's wealth of industry knowledge and experience, to make an informed judgement on the reasonableness of QR Network's asset management and maintenance practices and their cost efficiency, in light of internal and external factors emerging from the analysis which appeared to impact the magnitude of the task and the costs to undertake maintenance.

The following sets out the specific source material used and methodology applied to each area investigated as part of this work path.

3.3.1 CQCN Configuration and Network Management

To set the CQCN network in context with other heavy haul railways, Evans & Peck conducted a review of the key characteristics of the CQCN, in conjunction with QR Network's governing structure and asset management systems, to consider any key contributing factors of the network that could be impacting the maintenance load and cost efficiency. Consequently, the following key source documents were used to set out the context of operation and management of the CQCN for comparison with other heavy haul railways.

Table 3: Source material for CQCN configuration and management review

Item	Title	Author or Source	Date
1.	QR Network Access Undertaking Assessment of Operating and Maintenance Costs for UT3 – Final Draft	GHD	September 2009
2.	Support tonnage information provided by QR Network for the preparation of the UT4 Access Undertaking	QR Network	May 2012
3.	QR National Sale: Asset Condition Report: Below Rail	WorleyParsons	August 2010
4.	Competitor Network Analysis Database	Evans & Peck	May 2012
5.	Coal Dust Investigation and Management Reports	Internet	-
6	Coal Dust Management Plan, Coal Loss Management Project	QR Network	February 2010
7.	Transitional Environmental Program 2	QR Network	19 April 2010
8.	Working Paper 4.3, Rationale for Coal Loss Project, A Coal Rail Infrastructure Master Plan Work Paper	QR Network	2008
9.	Arkansas Electric Corporation versus BNSF Railway, Petition for Declaration Order	Surface Transportation Board	3 March 2011
10.	Open Access for Heavy Haul Railroads: A questionable strategy for Social Welfare Gains	Harvard Kennedy School, Fagen et al	2010
11.	Xstrata trains shunt Asciano, Chambers, Matt	The Australian, Business News	25 September 2009
12.	Industry Commission Black Coal Industry Enquiry	Queensland Rail	2002
13.	BNSF Railways, Customers FAQ, "What can I ship – coal"	BNSF Railway	March 2011

3.3.2 Possession Management Practices

The possession management practices of QR Network in comparison to other heavy haul railways in Australia and overseas was considered through a review of the WorleyParsons' report, New Closure Model – Business Case Support and Review of World Practices, dated November 2011.

This investigation focussed on how the problem of providing workable access to track for maintainers to carry out essential works was being managed by various rail organisations, whilst enabling the required number of trains to operate. The investigation benchmarked the practices of

QR Network against other railways in terms of philosophies and approaches applied to possession planning and management. In addition, a further comparison was made with the refinery processing industry.

QR Network's possession planning and management practices were benchmarked against a mix of suburban and heavy haul systems, given that the same principles are equally applicable to each type of system. The following ten railway systems were considered as part of the possession management benchmarking exercise.

Table 4:   **Railways used to benchmark possession management practices**

No.	Railway	Location
1.		Australia
2.		Australia
3.		Australia
4.		Australia
5.		Australia
6.		United Kingdom
7.		United Kingdom
8.		USA
9.		Brazil
10.		South Africa

3.3.3   Industry Cost Benchmarking

An industry cost benchmarking analysis was conducted to consider the appropriateness, range and comparability of QR Network's below rail infrastructure maintenance costs in terms of other railway organisations. This analysis used published industry benchmarking reports, in conjunction with additional benchmarking data that Evans & Peck sourced through further research. Consequently, the basis of evaluation for the benchmarking of QR Network's maintenance costs was based on the following documents and information sources.

Table 5: **Source material used for industry cost benchmarking analysis**

Item	Title	Author or Source	Date
1.	Report for QR Network Access Undertaking Assessment of Operating and Maintenance Costs for UT3 - Final Draft	GHD	September 2009
2.	Review of ARTC Operations and Maintenance Costs and Cost Allocation	PricewaterhouseCoopers	April 2008
3.	An assessment of ARTC Maintenance Cost Relative to efficient industry practice	ARTC	June 2007
4.	Maintenance Cost Benchmarking for the Victorian Freight Network	WorleyParsons	January 2006
5.	WestNet Rail's Floor and Ceiling Costs Review	Economic Regulation Authority	June 2009
6.	Review of WestNet Rail's 2009 Floor and Ceiling Costs for Certain Rail Lines	PricewaterhouseCoopers	June 2009
7.	Report for Review of Unit Prices for Clause 9 Ceiling Price Review	GHD	October 2008
8.	WestNet Rail's Floor and Ceiling Costs Review	Economic Regulation Authority	July 2007
9.	Annual Maintenance Cost Report 2010/2011	Internet	October 2011
10.	QR National Annual Report 2010/11	Internet	September 2011
11.	Blackwater, Goonyella, Moura and Newlands Coal System Fact Sheet	Internet	October 2011
12.	ARTC Annual Reports	Internet	2006/07 - 2010/11
13.	ARTC Annual Compliance Reports to IPART	Internet	2006/07 – 2010/11
14.	A Ceiling Test Protocol for RailCorp prepared for IPART,	Sapere Research Group	November 2011
15.	Supporting QR Network supplied tonnage and maintenance cost information as at May 2012	QR Network	May 2012

For each of the source documents reviewed, where there was tonnage or maintenance cost information, this was extracted from the documents to extrapolate and build a database from which a detailed analysis could then be undertaken to determine whether the comparison was valid, and suitable as a benchmark to QR Network, given due regard to the sensitivities of the various systems in terms of key network characteristics, such as size and configuration, traffic haulage and freight commodity.

3.3.4   Maintenance and Renewal Asset Management Policy

A review of QR Network's Draft Asset Policy Maintenance and Renewal document, dated 30 January 2012, was carried out to identify and evaluate impacts and issues for maintenance load and cost associated with QR Network's approach to asset management planning for maintenance and renewals work. The policy documents QR Network's time based estimates for asset lives and the required intervention levels to mitigate asset deterioration arising from traffic haulage and other major sources of asset deterioration over and above those arising directly from the traffic haulage. Based on this, appropriate units in net tonnes for coal spillage and gross tonnes for most other

wearing components are determined and applied by QR Network to the cost estimating of maintenance and renewals scope.

3.3.5 Plant and Labour Costs

The research conducted for this project highlighted that there is a paucity of railway cost information publicly available and an apparent reluctance of the railway industry in general to share cost information amongst its peers, to investigate the issues and considerations in relation to the impact of plant and labour costs on QR Network's maintenance efficiency. Given this, Evans & Peck applied their local and industry knowledge to provide some current industry views on current trends in working gang practices, appropriate rates, and plant considerations in relation to increasing efficiencies in maintenance operations.

3.3.6 Supply Chain Optimisation

To investigate the issues and considerations of the CQCN coal supply chain and the potential impacts of this to the maintenance efficiency of QR Network, Evans & Peck applied their local and industry knowledge to assess this, in conjunction with a review of the "Goonyella Coal Supply Chain Capacity Review" report, issued by the Queensland Department of Transport in 2007 discussing the issues associated with optimising the CQCN coal supply chain.

3.3.7 Regulatory Framework

A high level review of QR Network's access undertaking commercial framework and service level specification was carried out to consider any potential issues associated with the contractual arrangements for maintaining the CQCN network that are negatively impacting QR Network. This analysis was carried out by comparing the access undertaking contractual arrangements of the various rail organisations, where documents could be sourced by Evans & Peck for this investigation.

The following key reference documents were used for this area of investigation.

Table 6:   Source material used to compare commercial access arrangements

Item	Title	Author or Source	Date
1	Hunter Valley Coal Network Access Undertaking	ARTC	23 June 2011
2	Access Agreement Coal	QR National	N/A
3	QR Sale: Asset Condition Report Below Rail (Annexure B – Asset Condition Report Track & Level Crossings)	WorleyParsons	30 July 2010
4	UT3 Parallel Active Comparison Exercise – Comments on Service Level Specification for Rail Infrastructure Maintenance: Central Queensland Coal Region	WorleyParsons	2 June 2008
5	Queensland Competition Authority – Report for QR Network Access Undertaking – Assessment of Operating and Maintenance Costs for UT3	GHD	September 2009

3.4 Independent Cost Estimating

The third work path investigated by Evans & Peck considered a bottom up approach to cost estimating the key maintenance activities conducted on the CQCN, and comparing those estimates

with QR Network's actual maintenance costs for those maintenance activities in the 2011/12 financial year.

For this exercise, comparable first principles estimates were developed based upon current capital costs and market prices in respect of the follow activities:

1. rail grinding (mainline);

2. ballast cleaning (mainline); and

3. resurfacing (ballast tamping and stone blowing).

Table 7 below presents a high level summary of the underlying assumptions applied to the cost estimating build-up, with further details provided in Appendix G.

Table 7: **Key assumptions applied to the cost estimating build-ups**

Item	Aspect	Assumptions
1	Major equipment	Ownership costs, maintenance costs, service life and depreciation were all allowed for. These varied with equipment and the details are included in Appendix G.
2	Other plant	Current industry rates were obtained and used in the cost estimates.
3	Crews	Crew sizes were based on equipment manufacturer literature and cross checked with actual crew employed.
4	Consumables	Consumables were included. Detailed costs and consumption rates are described in Appendix G.
5	Mobilisation and travel	Actual historical mobilisation and travel patterns were used in the cost build up.
6	Production rates	Costs were calculated for a range of productivities. These were generally related to access constraints.
7	Possession and site access	Actual historical access and possession regimes were used. These varied for each activity.
8	Overheads and margin	No allowance for offsite overheads and margins has been allowed for.

4 Key Findings

The key findings in terms of impacts and considerations for QR Network in respect of asset management and maintenance task and maintenance cost efficiency are presented, for ease of reference, as consolidated summary findings at the outset of this section of the report in accordance with Evans & Peck's approach outlined in section 2.1 (figure 2).

Subsequent sections of the Key Findings present all of the detailed outcomes and findings from each of the discrete areas of investigation within the three work paths (survey, publications and research, cost estimating), together with a comprehensive commentary in support of each particular finding. Additional supporting analysis is also provided in the appendices of the report, where required.

4.1 Summary Findings

4.1.1 Asset Management and Maintenance Task

Table 8 summarises the consolidated key findings for QR Network from the three investigation work paths in terms of impacts and considerations for QR Network in terms of asset management and maintenance task.

Table 8: Summary of Findings for Asset Management and Maintenance Task

No	References	Key findings for asset management and maintenance task
1	Sections 4.2.1, 4.2.8, 4.2.9 of Survey Findings. Section 4.3.1 of Publication & Research Findings	***Unique characteristics of the CQCN are key contributors to the maintenance task*** Two of the works paths identified that the unique characteristics of the CQCN, such as relatively high annual tonnages, significant temperature ranges, periods of extreme weather, high operating speeds, spillage of coal, poor formation support and narrow gauge track configuration all result in distinctive management and maintenance challenges for QR Network, and consequently contribute significantly to the magnitude of QR Network's maintenance task. A 'one size fits all" maintenance strategy will not always provide the most efficient solution as maintenance strategies need to appropriately account for unique network characteristics and the operating regime.
2	Sections 4.2.1, 4.2.9 of Survey Findings. Section 4.3.1 of Publication & Research Findings. Appendix E	***Ballast fouling significantly impacts the CQCN maintenance task*** Two of the work paths confirmed that in railways where coal contamination is present it significantly impacts the degradation of track components and thus the size of the maintenance task, and also presents environmental challenges. The CQCN has many locations where high levels of coal contamination are present. The risks associated with this, such as loss of structural integrity of the track have recently been acknowledged in the industry. QR Network and a number of Class 1 US railways now lead the industry in the research and strategies required to deal with these maintenance issues.
3	Section 4.2.9 of Survey Findings. Section 4.3.4 of Publication & Research Findings.	***Analysis of the maintenance intervention levels for ballast cleaning, mechanised resurfacing and rail grinding identified areas where intervention periods need to reduce on the CQCN*** International research found that for contaminated ballast, intervention periods for ballast cleaning/undercutting, mechanised resurfacing and rail grinding must reduce to address the accelerated degradation of the asset. An analysis of QR Network's maintenance intervention frequencies for these maintenance activities indicated that QR Network's ballast cleaning levels should be increased on all four systems. It further highlighted that mechanised resurfacing of the turnouts on the Newlands and Moura systems should be increased, and for these lower trafficked systems it may be more appropriate to consider maintenance intervention and condition in terms of time frequencies rather than tonnages transported. The analysis of intervention periods for rail grinding indicated that QR Network operates a robust program on all four major rail systems.

No	References	Key findings for asset management and maintenance task
4	Section 4.2.8 of Survey Findings. Section 4.3.5 of Publication & Research Findings.	*Maintenance task will be impacted in the future by availability of skilled resources to undertake maintenance works in Northern Queensland* *Maintenance task will be impacted in the future by availability of skilled resources to undertake maintenance works in Northern Queensland* Research highlighted that skilled resources available in the Central Queensland coal area are in short supply due to demand and earnings imposed by the utility sectors in Northern Queensland. This can potentially impact the maintenance task in terms of available skilled resources to undertake work, and also the labour cost proportion required to undertake the works. The survey highlighted that CQCN percentages of labour costs from total maintenance costs were currently in line with industry expectations, but there are significant variations in travel requirements from home base location to depot (thus increased cost) and the CQCN also had comparatively high maximum distances for staff to travel from home base to depot location.

4.1.2   Maintenance Cost Efficiency

Table 9 summarises the consolidated key findings for QR Network from the three investigation work paths in terms of impacts and considerations for QR Network in terms of maintenance cost efficiency.

Table 9:   **Summary of Findings for Maintenance Cost Efficiency**

No.	References	Key findings for maintenance cost efficiency
1	Sections 4.2.5, 4.2.7 of Survey Findings. Section 4.3.1 of Publication & Research Findings. Appendix C	*Improved asset management systems would offer QR Network an opportunity to optimise their capital and maintenance investment and achieve greater cost efficiency* The publication and research work path, combined with the competitor network comparator database developed from the survey work path, identified that QR Network applies an appropriate governance management framework of standards for the management of its assets in conjunction with multiple asset databases and legacy systems. Whilst consistent with some heavy haul railways of similar age, the application of an enterprise asset management system would offer the opportunity for QR Network to optimise capital and maintenance investment, and create an enhanced understanding of the asset performance and condition.
2	Section 4.2.6 of Survey Findings. Section 4.3.2 of Publication & Research Findings. Sections 4.4, 4.4.1, 2 & 3 of Cost Estimating Findings.	*Current possession management practices impact maintenance efficiency however current and future traffic densities may constrain opportunities for extended closures for some maintenance activities* All three work paths found that current possession management practices are impacting maintenance cost efficiency. There appears to be some room for improvement despite the acknowledgement that future traffic densities on the CQCN may constrain the opportunities for extended closures on highly trafficked sections of the network. Investigations into possession management practices of other rail organisations in Australia and overseas found that those operating with extended closures generally considered that this enabled them to achieve improvements in quality, and reduced costs, whilst providing better, more reliable services to customers.
3	Section 4.3.3 of Publications & Research Findings Appendix F	*Industry cost benchmarking demonstrated that unit maintenance costs on all CQCN systems, in general, were positively placed within the calculated efficiency trend lines* The industry cost benchmarking analysis identified the ARTC Hunter Valley Coal Network (HVCN) to be the most comparable to the CQCN systems in terms of key network characteristics, freight commodity and traffic hauled. The cost benchmarking analysis that was subsequently conducted clearly indicated that the unit costs of CQCN annual maintenance tasks appeared reasonable when compared with these similar national railways. All CQCN rail systems were positively placed within the calculated efficiency trend lines on a dollar per track kilometre versus net system

No.	References	Key findings for maintenance cost efficiency
		tonnage basis.
		Normalising factors associated with the characteristics of each individual rail system were accounted for where this was possible to do, however any additional potential cost contributors relating to inherited organisational issues, such as backlog maintenance, legacy asset management processes, or costs relating to varying outsourced maintenance activities were not considered in the analysis.
4	Section 4.2.3 of Survey Findings. Section 4.3.6 of Publication & Research Findings.	***Supply chain management, optimisation, and coordination costs can impact on maintenance efficiencies and costs of operations.*** The survey work path identified that the majority of benchmarked railways operated under open access regimes similar to the CQCN. Under this type of regime coordination costs can potentially impact on total maintenance efficiencies and the costs of operations. In addition, the Queensland State Government report of 2007 essentially determined that for the CQCN coal supply chain to operate optimally the coal unloaders must operate optimally, and consequently, other elements of the system must be designed to absorb system losses, and these system losses need to be equitably distributed across all components of the supply chain, including the below rail infrastructure. These findings highlight a need for greater transparency and coordination amongst the supply chain parties using the CQCN to ensure common objectives are in place which can in turn realise cost efficiencies on the network.
5	Section 4.37 of Publication & Research Findings.	***Regulatory Framework*** The high level review of national regulatory frameworks (QR Network, ARTC, WestNet and Victorian Rail) revealed that they are all reasonably consistent but it is evident from this review that there are areas within the commercial frameworks that could provide incentives for enhanced performance across the supply chain.
6	Section 4.35 of Publication & Research Findings.	***High plant and labour costs impact cost efficiency*** Rail is a capital intensive and specialised industry and maintenance providers need high volumes of work to survive. It is therefore recognised these cost components may be high, and consequently, the ratio of "effective" to "non-effective" working periods will be higher, which in turn impact the cost efficiency of maintenance.
7	Sections 4.4, 4.4.1, 2 & 3 of Cost Estimating Findings Appendix G	***QR Network generally maintains competitive per kilometre rates for rail grinding, ballast cleaning and mechanised resurfacing*** Due to QR Network maintaining some of their key maintenance activities in-house, the CQCN have maintained reasonably competitive per kilometre rates for rail grinding, ballast cleaning and mechanised resurfacing. Under the assumptions of the estimate in each case, QR Network's actual outputs for the 2011/12 financial year appeared to be reasonably efficient, when taking into account the constraints and limitations associated with achieving productive outputs within the available track access periods. For plain line rail grinding QR Network achieved an efficiency level of ███ %, with an average of ███ km of grinding per shift, and ███████ of productive grinding in a shift for the 2011/12 financial year. Optimum production however is achieved when greater than 4 hours of grinding can be achieved in a shift. For ballast cleaning, QR Network achieved, on average, ███ kilometres of ballast cleaning at a unit cost of ██████ per ███ deployment block in the 2011/12 financial year. Optimum production however occurs when ███ blocks achieve around ██ kilometres of ballast cleaning. For plain line mechanised resurfacing, in the 2011/12 financial year, QR Network achieved, on average, ██ kilometres of tamping at a unit cost of ██████ /km per shift, and ██ kilometres of tamping with stone blowing at a unit cost of $██████ /km per shift. Optimum production costs occur in each case when production rates achieve greater than 14 kilometres in a shift.
8	Sections 4.2.1, 4.2.6, 4.2.9 of Survey Findings. Section 4.3.1 of	***Network operating characteristics directly impact unit costs by "forcing" works to be carried out "non-efficiently"*** The access constraints of the current operating regime present the single most important factor for optimising maintenance costs on the CQCN as maintenance costs

No.	References	Key findings for maintenance cost efficiency
	Publication & Research Findings. Sections 4.4.1,2 & 3 of Cost Estimating Findings	are not considered to be efficient when they are undertaken during short possession times due to the relatively high proportion of set up costs. The growing density of traffic to carry increasing tonnages results in lower opportunities to obtain longer possession periods, and reactive works are sometimes forced to be undertaken during "non-efficient" cost periods, thus increasing the overall unit rate. The only way to minimise this may be to reduce the need for reactive maintenance which requires sophisticated asset management systems and predictive modelling tools.

4.2 Key Findings from Survey

4.2.1 Survey Responses

Survey Finding: Results from 2012 and 2008 were consolidated to provide more comprehensive benchmarking analysis due to disappointing level of response to Evans & Peck survey.

Only 5 railways provided completed questionnaires and 3 railways provided incomplete questionnaires as a result of corporate policy restrictions, commercial sensitivities, and resource and time constraints. To provide a more robust analysis, the responses for 2012 were therefore consolidated with the responses provided in 2008 in terms of appropriate network characteristics to ensure a more comprehensive benchmarking analysis.

In general, the response to the 2012 survey was disappointing with only a small percentage of the total number of railways invited to participate formally responding to the questionnaire. The reasons given for not participating included:

- members of the organisation forbidden to participate in questionnaires and surveys;
- members of the organisation too busy to allocate time and resources to respond; and
- lack of trust or fears of commercial sensitivity in divulging the required information.

In the previous 2008 survey, completed questionnaires were returned from 5 railways with incomplete questionnaires received from 3 railways. In the 2012 survey completed questionnaires were also returned from 5 railways and incomplete questionnaires were returned from 3 railways. The identical numbers are coincidental, however, as for both the completed and incomplete responses; the railways which responded in 2012 were not the same as those in 2008.

Although a disappointing response, given that the new data from the 2012 survey was combined with previous benchmarking results from 2008, the resulting matrix (refer Appendix C) is considered to be fairly comprehensive.

To protect participant confidentiality no railway names and specific details which indicate who the participants are have been provided.

The following findings, with supporting commentary, are presented in accordance with the survey headings and structure.

4.2.2   Network Characteristics

> *Survey Finding: Network Characteristics impact on CQCN maintenance tasks by either forcing increases in required maintenance tasks to perpetuate asset integrity or restricting the structural capacity.*
>
> Survey responses revealed that CQCN has:
>
> - one of the highest operating speeds;
>
> - a total system length comparable with some of the smaller Class 1 systems; and
>
> - a comparable high annual gross tonnage;
>
> Only CQCN and two other benchmarked railways had narrow and/or metre gauge, constraining them to low maximum axle loads ranging between 20 to 27 tonnes. All the other benchmarked railways have a maximum axle load capacity of over 30 tonnes. Consistent trends were difficult to substantiate with the response data provided indicating that there is considerable variation in the maintenance and renewals strategies implemented to counteract the unique constraints and requirements of each of the benchmarked systems. These variability's are dynamic aspects that affect the cost structure of maintenance on the CQCN higher tonnage lines and are important to explore further in the future.
>
> The respondents who mainly carried coal freight also had several common traits which included high ballast cleaning costs as a percentage of their maintenance costs, low tamping intervals and thus high tamping costs as a percentage of total maintenance costs, low contamination levels for ballast cleaning intervention and generally, lower ballast cleaning frequencies.

The following table lists the general characteristics of the participant railroads based on survey feedback. As can be seen from the table all respondents complied with the definition of heavy haul railways as given by the IHHA (refer Section 3.2.2).

Table 10:   General Characteristics of participant railways

Rairoad	Maximum Speed (km/hr)	Maximum Axle Load (tonnes)	Freight % of MGT	Track Layout
Moura	80	26.5	100	Single with passing loops
Newlands	80	26.5	100	Single with passing loops
Goonyella	80	26.5	100	Double in parts
Blackwater	80	26.5	99	Double in parts
Comparator A	60	30	95	Single, double & triple
Comparator B	-	-	-	Mixed
Comparator C	-	37.5	100	-
Comparator D	-	-	100	-
Comparator E	80	26	100	-
Comparator F	90	32	100	-
Comparator G	70	30	98	-
Comparator H	65	27.5	92	-
Comparator I	70	31.5	96	-
Comparator J	80	35.75	90	-
Comparator K	50	32.5	100	-

The findings show that CQCN has one of the highest operating speeds, a total system length comparable with some of the smaller Class 1 systems and a high annual gross tonnage (please note line lengths have not been specified to protect the confidentiality of the participants).

CQCN is only one of two participants constrained by narrow gauge. All railways with narrow and/or metre gauge have low maximum axle loads which range between 20 to 27 tonnes, with all other benchmarked railways having a maximum axle load capacity of over 30 tonnes.

The vehicle profile and axle load capacity on CQCN is constrained by the track gauge, yet findings show that parts of the CQCN are delivering a high annual gross tonnage comparable with benchmarked railways that are not constrained by gauge (Figure 3). Lower axle loads inhibit the amount of product that can be transported per wagon load, therefore to increase tonnages one must increase trains and thus increase density. As train densities increase, track possessions for maintenance may become constrained in duration and frequency, therefore it becomes increasingly necessary for track gangs to compete with revenue trains for track time. Consequently, increases in capacity increase unit cost because of the more frequent need for maintenance to get on and off track[2] and for increased requirement in protection and safety.

Narrow gauge has a number of disadvantages over standard gauge in terms of speed, stability, formation stresses and track maintenance tolerances. For example, in terms of track maintenance tolerances narrow gauge has been found to be less tolerant to errors of twist and running top (a 5 mm error on a standard gauge will have the same effect as a 7mm error on narrow gauge), therefore the cost of annual track maintenance is potentially aggravated on narrow gauge[3].

The findings indicate that there is considerable variation on the maintenance and renewals strategies implemented to counteract the unique constraints and requirements of each system, with considerable literature justifying the methodology under the circumstances and exemplifying the impact to overall capacity and cost that each constraint and strategy will instil. The levels and costs of maintenance are greatly dependent on operational requirements, as commercial costs for speed restrictions, derailments and disruptions to traffic increase, some maintenance component costs also increase as the pressure to minimise the risks of failure in these components increases. In some cases new technologies or materials can be implemented to lengthen the life and increase the strength of these components, however, in many cases the solutions lie only in increased monitoring and maintenance. Subsequent analysis of the responses confirmed that correlations between systems and networks are difficult to find especially between systems carrying lower and higher annual gross tonnages, different axle loads and traffic density. This supports empirical railway maintenance understanding that for lines with heavy tonnages (say 50 million tonnes per year and above) the variability in maintenance and renewal requirements and costs, which are driven by usage, will increase with significant impact on marginal short run costs. This further substantiates the conclusion that the static fixed model applied for short term costs potentially does not reasonably account for the variability's imposed as tonnages increase to the upper levels, and these dynamic aspects that affect the cost structure of maintenance on the CQCN higher tonnage lines are critical to explore further in the future.

The year of construction does not seem to have direct effect on the maintenance task or constrain capacity. The oldest system was constructed in the mid 1800's yet was currently the largest system carrying the largest annual tonnages. It is considered to be a reasonable assumption that significant works and extensions to the system have been implemented since its construction as gradual degradation of the asset over time is a proven effect, however as there is insignificant data on this area no conclusion could be made.

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[2] Cost-Effectiveness of Railway Infrastructure Renewal Maintenance, Avery Grimes et al, Journal of Transport Engineering, August 2006

[3] Rail Gauge Study Report, Rail Working Group for Department of Transport South Africa, August 2009

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Figure 3: Track tonnages carried by participant railways
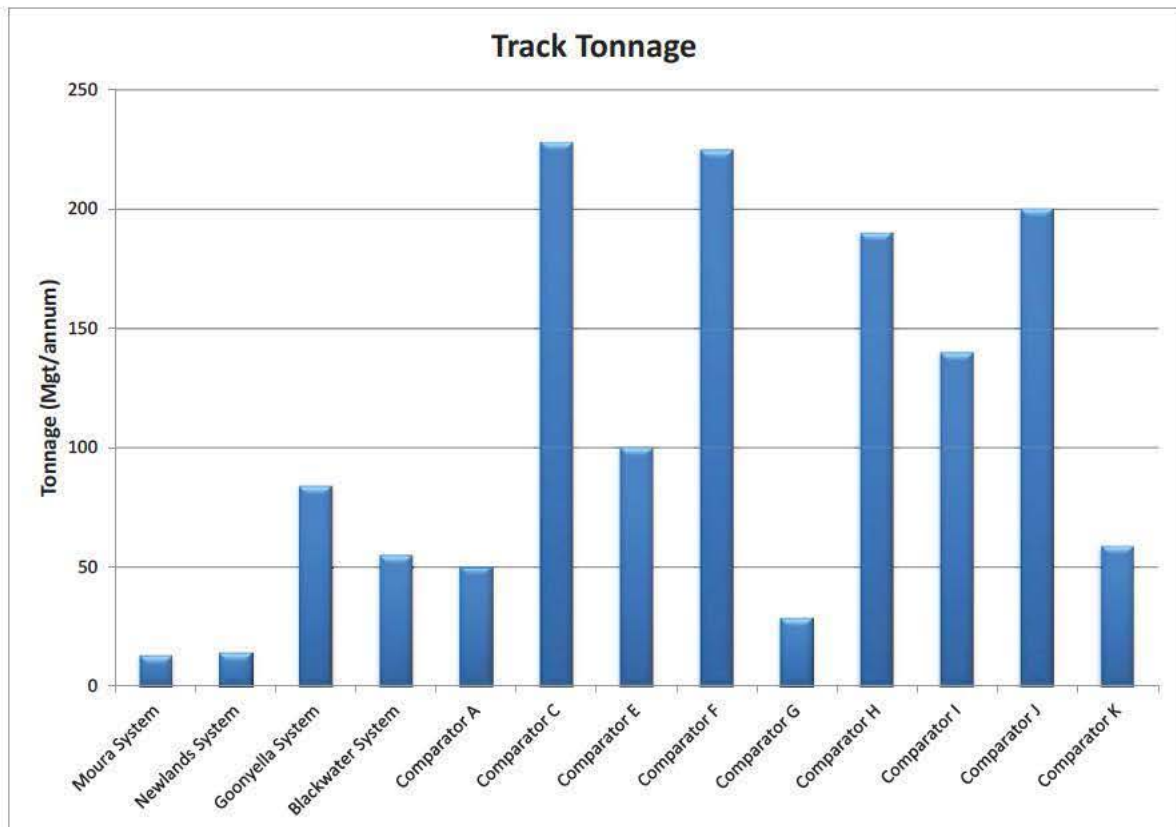
Based on survey responses, figure 3 shows that currently parts of the CQCN system are reaching comparatively high annual tonnages with the system as a whole currently averaging annual tonnages in the high limits of the range from benchmarked railways. Forecasts for 2014-2015 (which will be at the end of the current UT4 period) forecast that tonnages could reach in the order of 300mtpa[4]. As annual tonnages increase, the required maintenance tasks increase, the graph clearly indicates that the Goonyella System has significantly higher annual tonnages than the other three CQCN systems.

Infrastructure maintenance costs differ from above rail costs of operating trains as they are not directly variable with volume, but rather have two components which effect degradation of the asset, and hence subsequent maintenance requirements and costs. These two components comprise a fixed element which is factored as a direct function of both the quality of the track and the standard of construction, and a variable element[5] which increases hyperbolically with increases in usage. This means that the Goonyella system would experience higher costs for high volume and thus its costs per gross tonne-km would be expected to be higher than those of the secondary systems within CQCN.

The findings indicated that those respondents who mainly carried coal freight also had in common:

- High ballast cleaning costs as a percentage of their total maintenance costs;
- Low tamping intervals and higher tamping costs as a percentage of their total maintenance costs;
- Low contamination levels for ballast cleaning intervention; and

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[4] QR Network CQCN Actual and Forecast Track Tonnage (QR Network Data)

[5] "Usage-related infrastructure maintenance costs in railways" Working Paper 2, Queensland Competition Authority 2000

- In general, higher ballast cleaning frequency requirements

A US rail study has found that "extraordinary maintenance measures are required to deal with the problem of coal dust" with a need to substantially increase the frequency of undercutting to remove coal dust accumulations. In addition to the high costs of ballast cleaning operations, such requirements can adversely affect service availability and reliability[6].

Appendix E provides detailed information on ballast behaviour and the impact of coal on ballast strength and track integrity.

4.2.3 Supply Chain Management

> **Survey Finding: Supply Chain Management**
>
> Only one of the respondents operated under a true integrated supply chain, one other operated under a regime where the operator controlled both the railroad and the terminal ports but not the originating mines. All other benchmarked railroads operated under an open access regime or single operator.

Although a number of integrated supply chain railroads were invited to participate in the survey due to commercial sensitivies most of these railroads declined. Of those respondents that operated in an open regime, it is apparent that for the majority of them (although the supply chain components were separately owned) there appears to be some degree of coordination. Integration of the supply chain enables improved coordination and generally leads to greater efficiency[7]. It has been shown that the greatest achievements in operating efficiency have been achieved on integrated supply chains, with proven demonstrations of excellent equipment utilisation, high underlying quality of track infrastructure and high achievements in terms of volumes of annual tonnes moved per railroad track[8]. Contemporary evidence is indicating that coordination costs can significantly impact on the total maintenance efficiencies and costs of operation[9]. Further discussion on the CQCN supply chain is provided in section 4.3.6.

4.2.4 Maintenance Costs and Profile

> **Survey Finding: Maintenance Costs and Profile**
>
> From the survey it is evident that railway organisations as a whole seem to be reluctant to share maintenance cost information due to commercial sensitivities.

Unlike other infrastructure industries such as roads, there is a paucity of industry benchmarking information on unit costs available in the market on railway maintenance. For other industries various renowned publications such as Rawlinsons (amongst others) can provide industry players with relatively good benchmarked and current industry rates and information. This reluctance amongst the railway industry to share such knowledge appears to be inherent throughout the industry both in Australia and internationally. However, due to the lack of responses in this area Evans & Peck conducted their own independent build-up of costs as well as a comprehensive literature review of published regulatory and financial reports of railway maintenance costs, and

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[6] Laboratory Characterisation of Coal Dust Fouled Ballast Behaviour, Tutumluer et al, AREMA 2008 Annual Conference & Exposition, 2008

[7] "Possible benefits and costs of mandated access", Fagan et al, Harvard Kenedy School, 2007; BITRE 2003

[8] "Rail Infrastructure Pricing", Kain, Peter. 2003.

[9] "A Study of Competition in the U.S. Freight Railroad Industry and Analysis of Proposals that Might Enhance Competition: Final Report", Vol. 1-3. Laurits R. Christensen Associates. 2008. Prepared for U.S. Surface Transportation Board. http://www.stb.dot.gov/stb/elibrary/CompetitionStudy.html also Fagan et al 2008.

both of these gave a robust base upon which to provide some comparative and informative analysis. The results from the industry cost efficiency analysis are given in section 4.3.3 of this report.

4.2.5 Asset Management Organisation

> **Survey Finding: Asset Management Organisation**
>
> All participants that responded to this section of the questionnaire undertook maintenance planning "in house". The levels of outsourcing of maintenance tasks however appear to vary considerably, but in general the proportion of maintenance tasks outsourced for the CQCN appears to be less than for some of the other benchmarked railways. Justification for outsourcing is reliant on a number of factors, some of which are beyond the control of the organisation, the impact on cost of outsourcing is dependent on specific project/task circumstances.
>
> Whilst only a small number of participants provided details on whether their numbers of outstanding maintenance tasks were growing, steady or reducing, it is of note that those who did respond to this question stated that their maintenance tasks were growing with subsequent impact on total maintenance costs.

Table 11 summarises the most commonly outsourced maintenance activities found from survey responses.

Table 11: Summary of Outsourced Maintenance Activities

Activity	Outsourced CQCN	Outsourced Benchmarked Railroads
Testing and Monitoring	Y	Y
Field and Technical Specialists	Y	Y
Specialist supplies and delivery	Y	Y
Grinding	N	Y
Tamping	N	Y
Re-railing	N	Y
Turnout upgrading	N	Y
Drainage	Y	Y
Signalling	N	Y

Although major studies have been conducted in terms of the benefits of outsourcing road maintenance tasks, relatively little has been done in the area of railway engineering. Literature review conducted as part of this project revealed that outsourcing railway maintenance activities can, depending on circumstances and the maintenance task in question, be justified on the basis of the requirement for specialist technical knowledge, specialist equipment or the lack of resources of the organisation or anticipated and/or proven cost savings. However the literature and professional experience also can quote numerous examples in the rail industry where the cost savings were not attained, work was not carried out to the technical and safety requirements and litigation issues arose. This may be partially due to the fact that some proponents of rail maintenance work require specialist railway equipment and knowledge and a high degree of safety regulation. Hence the impact of costs on outsourcing can be dependent on a variety of elements and should be evaluated on a network task by task/project by project basis.

It is of note that despite only a small number of participants providing details on whether the number of outstanding maintenance tasks were growing, steady or reducing all that responded

stated that it was growing. The reasons given for the growing outstanding maintenance tasks were:

- Increased traffic reducing track availability for carrying out maintenance tasks; and

- Severe weather conditions limiting available work time.

Due to commercial sensitivities surrounding some of the questions in this area, there was a paucity of information received. Only one other respondent stated the proportion of maintenance tasks completed on schedule and what proportion of the maintenance tasks were completed within 10% of the allocated task budget. The percentage proportions were comparable between CQCN and the respondent; however limited data in this area makes it unreasonable to state a trend from the results.

4.2.6   Possession Planning and Management

Survey Finding: Possession Planning and Management

The survey results confirmed that there is a reasonable variation in the planning strategies for possessions amongst railway organisations, and with all railways there appeared to be potential for improvement within the possession planning processes for maintenance activities.

From 2008 to 2012, CQCN's possession cancellation rates appear to be improving, and by comparison to other benchmarked railways, are now lower.

The 2012 survey has shown that the CQCN has improved its rate of cancellation of planned possessions, from being relatively high (10% compared to 0.5% averaged over other benchmarked railways) to being less than 0.5%. Whereas the average rate of cancellation of planned possessions, overall, for benchmarked railways has increased to 2%.

Key differences were also identified between the railroads with the minimal time required for possession planning ranging from 6 – 18 months. Some of the railroads are flexible in relation to changes to the operation plan, whilst others make changes on a fixed (7-10 days) schedule.

The survey results were incorporated with the key findings in the comprehensive WorleyParsons report "New Closure Model – Business Case Support and Review of World Practices". A synopsis of the findings from both of these works is provided in Section of 4.3.2.

4.2.7   Strategy and Asset Management

Survey Finding: Strategy and Asset Monitoring

The survey revealed that all railroad participants have an asset register and use appropriate centralised data standards, and with the exception of one, all of the participants stated that they adopted the RAMS (Reliability, availability, maintainability, and safety) principals in their asset strategy.

CQCN's planning strategy period appears to be less than other benchmarked railways, with CQCN covering a maximum of 4 years as opposed to 7 years covered by other railways.

Of further note, all international railway organisations are now using some form of predictive modelling for maintenance planning and this is something that QR Network should consider implementing.

Inclusive of CQCN all national participants based their maintenance requests on information provided by field engineers from historical and site inspection data. Information and requests are then processed into a centralised plan from which budget and program are produced. This method is confirmed as the traditional proven approach to asset maintenance planning, hence CQCN conforms with current Australian practice. However, due to significant costs and time consumed for track visual inspections most international organisations (and those with larger networks), are moving towards reliance on geometry data obtained from automated inspections such as the Track Recording Car (amongst others). Research is currently being developed by some US Class 1 railroads on the use of neural networks as predictive tools with automated inspections to provide the understanding of the structural defects of track without any need for visual inspection[10]. Through close monitoring and managing of the rate of degradation of the asset, enhanced strategies of proactive and predictive maintenance can be implemented thus reducing the need to conduct reactive maintenance under inefficient cost conditions and minimising speed restrictions and unplanned closure. Thus the use and implementation of automated inspection methods in combination with asset management enterprise systems has been proven within the larger heavy haul US Class 1 railroads to provide significant maintenance task efficiencies[11] with subsequent potential cost reductions.

4.2.8   Work Practice Engineering

Survey Finding: Work Practice Engineering

From the information provided by participants on percentage of labour costs, CQCN percentages of labour costs from total maintenance costs were in line with industry expectations. There are, however, significant variations in travel requirements from home base location to depot. CQCN had comparatively high maximum distances for staff to travel from home base to depot location.

Additionally, only one participant did not have multi-skilled gang structures, indicating that CQCN's gang structure follows current industry trends.

Further discussion on labour costs and gang structure can be found in Section 4.3.5.

4.2.9   Technical Network Characteristics

Survey Finding: Technical Network Characteristics

CQCN was found to be following industry trends in relation to engineering standard and structure of track for heavy haul operations.

In respect of ballast cleaning the Moura and Newlands systems on the CQCN are achieving ballast lives[1] that exceed those on most other benchmarked railways, however the Goonyella and Blackwater systems are experiencing ballast lives that are considerably less than other railroads. The results also indicated that short ballast cleaning intervals generally occurred on track where ballast pollution is severe, and generally this appears to be mainly on lines transporting high percentages of coal.

The 2008 benchmark study indicated that CQCN are achieving longer rail life on tangent and curved track than other benchmarked railroads. Data from the 2012 study confirms this for Moura and Newlands, however the recent results indicate that rail life on tangents and curves on Goonyella and Blackwater has decreased significantly and is now comparable with other benchmarked railroads.

The survey also confirms that intervention levels applied by CQCN for rail grinding and ultrasonic testing are appropriate. Efficient monitoring reduces the risks of defects and failures thereby reducing costs caused by derailments, operational disruptions due to reactive maintenance and speed restrictions.

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[10] "Application of neural networks in evaluation of railway track quality condition" Class I Railroads, Sadeghi et al. Journal of Mechanical Science and Technology, Volume 26, Number 1 (2012)

The following table provides a synopsis of the track construction characteristics that could be determined from the survey participants.

Table 12:   Track construction of participant railways

Railroad	Track Gauge (mm)	Rail section (kg/m)	Fastening Type	Sleeper Type	Sleeper Spacing (mm)
Moura	1067	60	Fist, E-clip	Concrete mostly	685
Newlands	1067	60	Fist, E-clip	Concrete mostly	685
Goonyella	1067	60	Fist, E-clip	Concrete mostly	685
Blackwater	1067	60	Fist, E-clip	Concrete mostly	685
Comparator A	1435	60	Pandrol, Fastclip	Concrete mostly	600
Comparator B	-	-	-	-	-
Comparator C	1435	-	-	-	-
Comparator D	1435	-	-	-	-
Comparator E	1067	60	Fist, eclip	Concrete	650
Comparator F	1435	70	Safelok	Concrete	600
Comparator G	1435	60	Pandrol	Concrete	600
Comparator H	Meter	68	Deenik	Steel	600
Comparator I	Broad	68	Deenik, E-clip	Timber	540
Comparator J	1435	68	Pandrol, cut spikes,	Concrete, Timber mix	-
Comparator K	Broad	68	E-clip	Timber	540

The results indicated that railways tend to use heavier sections for heavier axle loads, CQCN by using 60kg//m rail for 26.5 tonne axle load is consistent with the general trend. It was difficult to ascertain a trend with sleepers with heavier axle loads using a mix of timber and steel sleepers as well as concrete.

The following graph plots the ballast cleaning cycles of the CQCN systems by comparison to other railways systems.

Figure 4: **Ballast cleaning periods for benchmarked railroads**

Ballast Cleaning Period
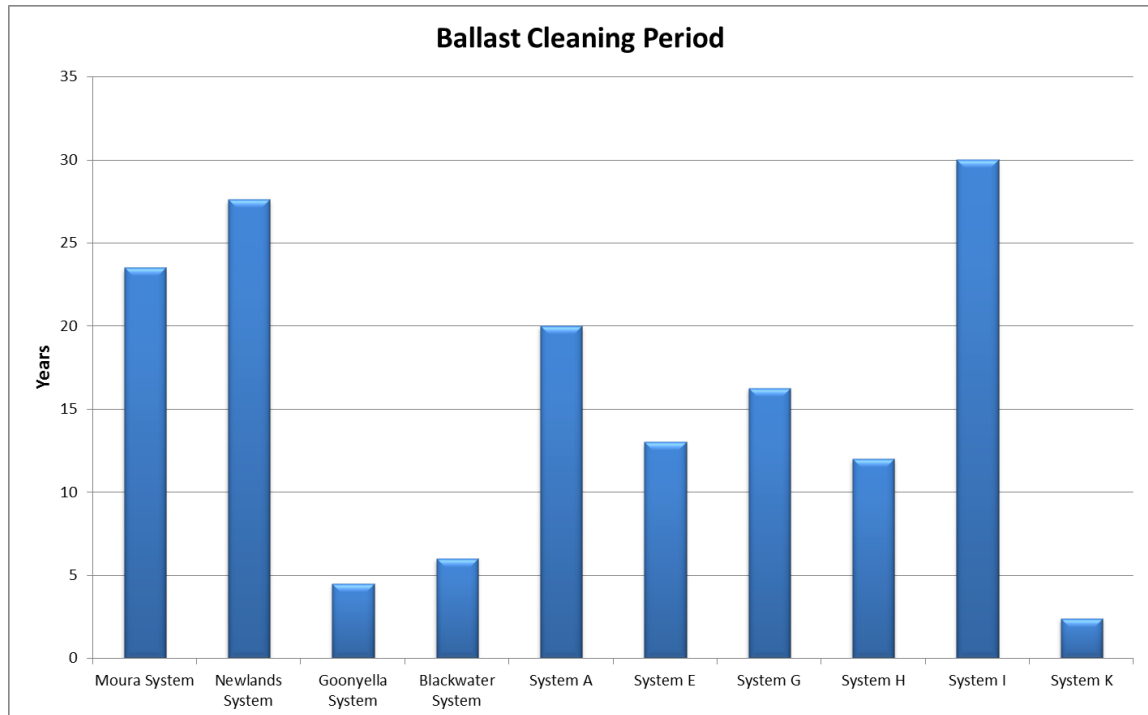
It is assumed from the above graph that the short ballast cleaning intervals generally occurred on track where ballast pollution is severe, generally from the survey results this appears to be mainly on lines transporting high percentages of coal. This is assumed to be due to the amount of ballast pollution from the coal trains on these systems. Results from the other benchmarked railway that is experiencing coal pollution issues substantiates this finding, and they are currently undertaking ballast undercutting at shorter intervals than those implemented by CQCN (3 – 5 years), with other benchmarked railways generally achieving 10 – 20 years ballast life.

The 2008 survey data indicated that QR Network was achieving lower mean time between rail defects and failures than other benchmarked railroads. This indicated that CQCN had excellent processes in place for monitoring and preventative maintenance.

The 2008 benchmark study indicated that CQCN are achieving longer rail life on tangent and curved track than other benchmarked railroads. Data from 2012 study confirms this for Moura and Newlands, however the recent results indicate that rail life on tangents and curves on Goonyella and Blackwater has decreased significantly and is now comparable with other benchmarked railroads.

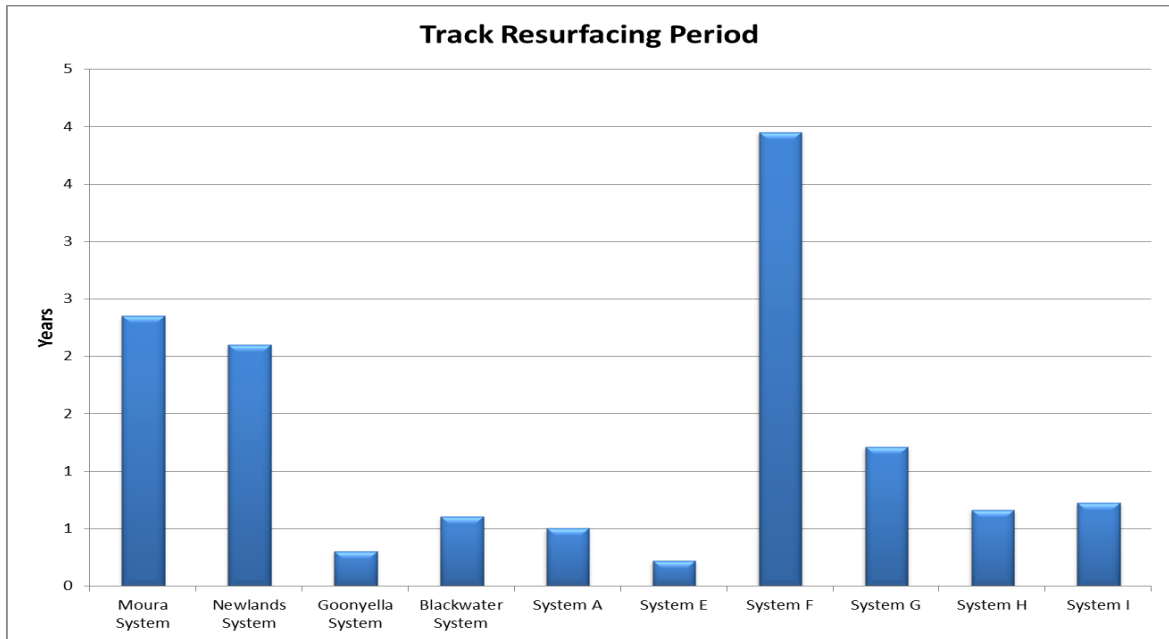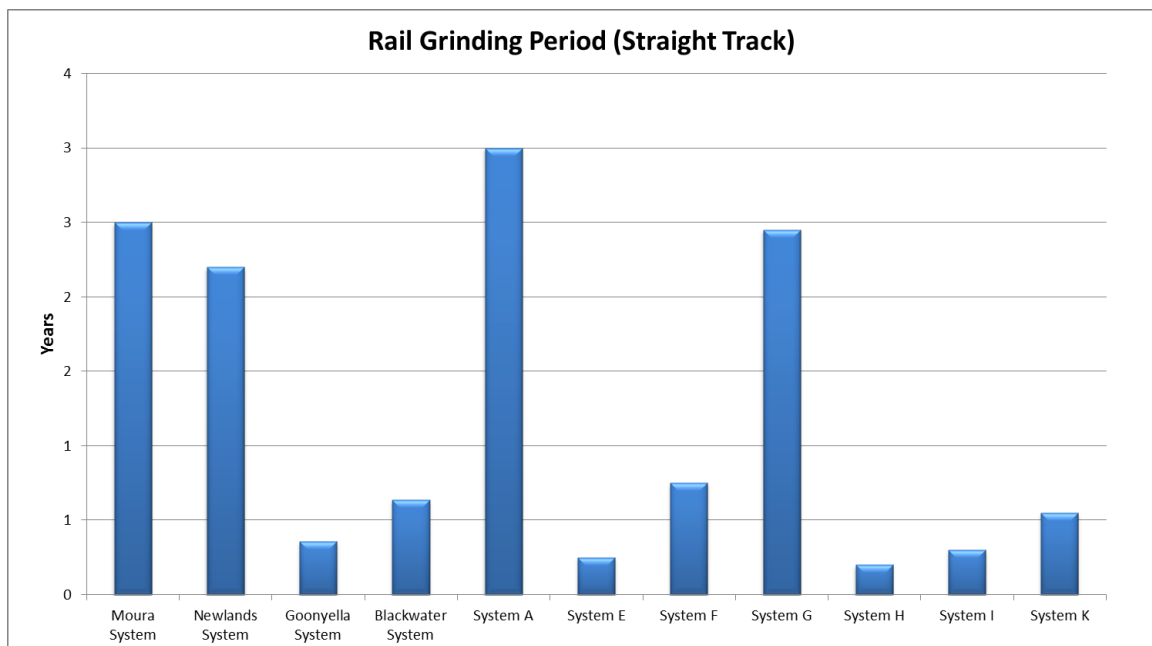**Figure 5:   Tamping intervals on benchmarked railroads**

Figure 6:   Rail grinding intervention periods from railway participants

As can be seen from the above figures, the survey confirms that the intervention levels applied by CQCN for rail grinding and ultrasonic testing are appropriate.

The low incidence of failures and defects would indicate that rail grinding and ultrasonic testing intervals are appropriate. Grinding intervention requirements on CQCN have not altered from the previous survey.

Regular measurements of rail wear and the information from monitoring sites on curves enables good decisions to be made on rail renewal requirements. This information has allowed CQCN to increase the permissible rail wear, thereby extending rail life.

During the previous benchmarking study CQCN were modernising their fleet of rail grinding machines, currently it is not clear as to the impact of increased production and reduced disruption to operations this change should have instigated.

4.3 Key Findings from Publication and Research Investigations

4.3.1 CQCN Configuration and Management

> **Publication and Research Finding: Network characteristics a key contributor to maintenance task load**
>
> A review of the 2010 WorleyParsons' Asset Condition Report, the Competitor Network Comparator Database, and UT3 and UT4 Access Undertaking source documents indicated that the unique characteristics and constraints of the CQCN, combined with forecasted increases in freight traffic, result in distinctive management and maintenance challenges for QR Network. These unique factors are considered to increase QR Network's maintenance task load.

A review of the source documents set out in table 3 reinforces that the CQCN is a unique heavy haul railway network in several key aspects by comparison to other heavy haul railway systems. Key network differentiators are highlighted in the Competitor Network Comparator Database and include the consistently high axle loads transported over the systems by the rolling stock and coal wagons, the narrow gauge construction of the CQCN, and the electrified track of the Goonyella and Blackwater systems. By comparison to others, the CQCN also transports significant amounts of coal over the network and this is expected to increase by almost 80 MTPA by 2017. Table 13, below, provides a summary of the tonnages (to nearest whole number) over each rail system on the CQCN based on actual figures supplied by QR Network for financial years 2009/10, 2010/11 and 2011/12, and the current corporate planned tonnages projected out to financial year 2016/17*.

Table 13: CQCN Actual and Forecast Corporate Plan Tonnages (mtpa)

| Financial Year	Newlands	Goonyella	Blackwater	Moura	GAPE	NAPE	CQCN

[*__Note:__ Corporate planned tonnages are based on internal figures used by QR Network for business planning purposes, and at the time of writing, equated to approximately ▮% of maximum tonnage levels requested by the various operators using the CQCN.]

A further key difference between the CQCN and other rail networks is the volume of fines, primarily coal dust, emitted along the network by freight trains. This coal dust accumulates in the track formations, leading to ballast fouling. Ballast fouling affects the track geometry, as well as corridor drainage. The details of this are described in depth in Appendix E.

Furthermore, black soils (vertosols, also known as cracking clays) are predominating across much of the network. Black soils are clayey soils which swell considerably when wet, and shrink and crack when dry. The pressure caused by this ground movement impacts the long-term structural integrity of the network, and consequently leads to poor track geometry.

In contrast to other rail networks in Australia, the CQCN is also exposed to tropical seasonal variations, with extreme periods of high rainfall experienced annually between the months of January and April. The CQCN experiences an annual average rainfall between 400mm and 600mm, as shown in Figure 7. This high rainfall exacerbates the network issues of ballast fouling and poor foundation soils, and leads to speed restrictions and an increased maintenance task. Additionally, the CQCN's associated port operations are affected by cyclonic weather patterns; this is particularly significant for the Goonyella System, as trains are scheduled to meet a specific shipping program.

Figure 7: Average Annual Rainfall (Based on a standard 30 year climatology (1961 – 1990), Bureau of Meteorology)
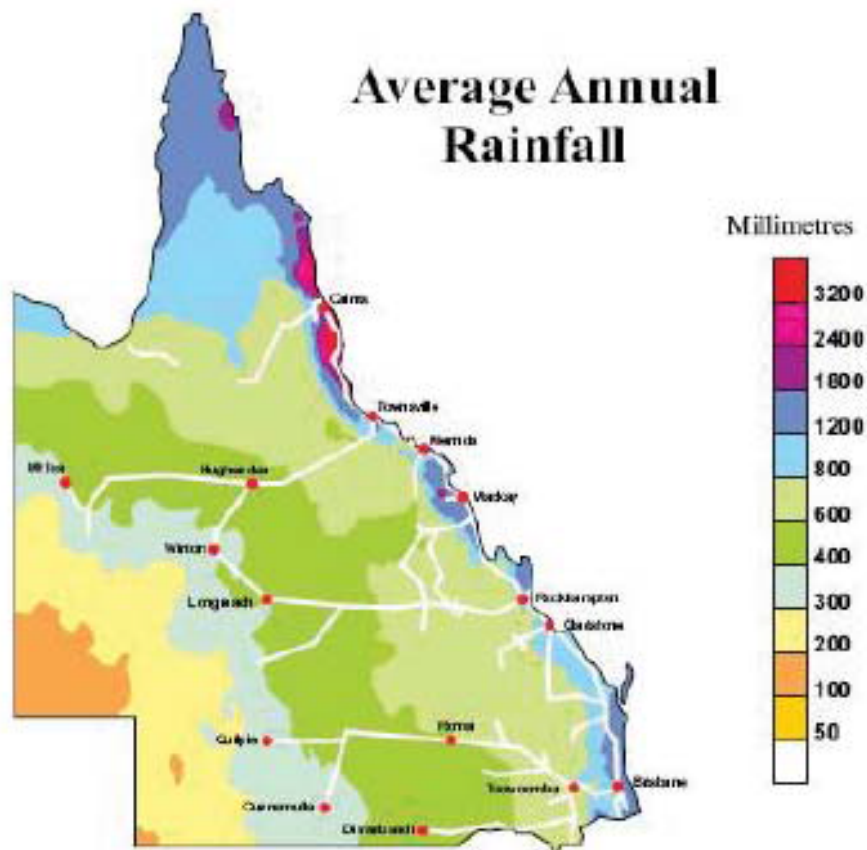
> **Publication and Research Finding: Asset governance and management systems**
>
> A review of the Asset Condition Report, in conjunction with the Competitor Network Comparator Database, identified that QR Network applies a governance management framework of standards to the management of its assets in conjunction with multiple asset databases and legacy systems. This is consistent with other heavy haul railways of similar age and therefore does not significantly disadvantage QR Network, however the application of an enterprise asset management system in the future would offer the opportunity for QR Network to optimise capital and maintenance investment planning and management, and enable a greater understanding of asset performance and condition. This is something that QR Network should consider implementing as a priority.

As required by all Australian railways, QR Network manages its network through the application of a framework of governing standards which have been developed for each of the major infrastructure categories, based on the historical performance of the network, in conjunction with regulatory, legislative compliance requirements and Australian or other equivalent Standards. QR Network's governance standards are summarised in Table 14.

Table 14:   Below Rail Asset Management Standards

Asset	Standards and Procedures	Details
Track	QR National Governance & Management Framework, Safety and Security Management System Standard – Civil Engineering Track Standards (CETS)	System modules detail management, maintenance, design and construction requirements
Structures	QR National Governance & Management Framework, Safety and Security Management System Standard – Civil Engineering Structural Standards (CESS)	System modules detail management, maintenance, design and construction requirements
Signals	QR National Internal Quality Procedures; and Manufacturing Specifications	Incorporate work instructions, work methods and checklists
Power	Integrated Quality Management System (IQMS)	Databases incorporating work instructions, work methods and checklists
Communications	Track Systems Maintenance System (TSMS)	Faults are reported to two fault recording centres, where they are logged and actioned
Level Crossings	QR National Network Safety Management System Standard – Level Crossing Safety	Policy details management, maintenance, design and construction requirements

Table 15: Planning Documents, Databases, and Systems used by QR Network for Asset Management

Document, Database or System	Description	Role

Publication and Research Finding: Ballast fouling impacting maintenance task

Ballast fouling from coal dust is a significant maintenance task for QR Network's maintenance and with forecasted growth in coal freight MTPA on the CQCN, this task will need to increase.

International research has identified several sources of ballast fouling and the chemical consistency of coal is known to have a caustic effect on concrete, steel and some stone materials[14], and the extent of this breakdown and the impact of coal dust on the ballast types used in Queensland could potentially significantly impact the rate of breakdown and subsequent fouling.

International railways with coal dust fouling issues are now intensifying track maintenance, with resurfacing increased to yearly and ballast cleaning increased to "every 3-5 years"[15]

The primary function of ballast is to resist vertical, lateral and longitudinal forces applied through traffic and axle loads to the sleepers to retain the track in its required position. Ballast deteriorates with repeated stress from rail loading, and from contaminants (mud) rising from the sub-grade. Fouling of the ballast occurs when ballast has become contaminated, and the fouling of ballast may jeopardise its ability to perform its primary function.

International research has found that there are many sources of ballast fouling, namely:

1) ballast breakdown
2) infiltration from ballast surface
3) sleeper wear
4) infiltration from underlying granular layers
5) subgrade infiltration

The most important source of fouling has been found to be ballast breakdown, even though it was primarily expected that track subgrade was expected to be the major source of fouling[11].

It is known that the chemical consistency of coal has a caustic effect on concrete, steel and some stone materials[12], the extent of this breakdown and the impact of coal dust on the ballast types

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[11] Imad L, Al-Qadi, Wei Xie, Roger Roberts "Scattering analysis of ground-penetration radar data to quantify railroad ballast contamination", NDT&E International 41 (2008) 441-447

used in Queensland could potentially, significantly impact the rate of breakdown and subsequent fouling.

The WorleyParsons' report "UT3 Parallel Comparison Exercise" for the Queensland Railways in August 2008 drew attention to the significance of coal contamination in relation to ballast fouling within Central Queensland coal railways, and the implication of this for maintenance costing in the Access Undertaking being reviewed by the Queensland Competition Authority.

The dust issue however, is not unique to Queensland Coal systems, major impacts on maintenance and operational efficiencies with coal dust have been identified overseas. For example, at ██ ██ the track maintenance has had to intensify due to coal dust creating significant ballast fouling which was found to be a primary cause in several major derailments in 2005. The situation was aggravated by a season of significant "snow and rain" in 2005. As a result of the derailment and the issues identified with coal dust BNSF conducted a comprehensive study in conjunction with the coal mines and National Coal Transportation Association to research how dust is deposited and what types of preventative solutions would be most effective and economical. As a result three major initiatives were implemented, one of which was a high intensification of track maintenance, with resurfacing increased to yearly and ballast cleaning increased to "every 3-5 years"[13]

That the effects of coal fouling on rail infrastructure are deteriorative is undeniable, both through theoretical knowledge of ballast fouling and the effects of coal dust, and through empirical and anecdotal evidence. Engineering research and field evidence has also indicated that the deteriorative effect of coal dust extends to other rail components in addition to ballast.

However, how to quantify the percentage of deterioration upon the rail infrastructure asset, and subsequent loss of quality of railroad track[14,] specifically due to coal dust as opposed to the number of other known factors which are proven to cause and/or increase the rate of deterioration in the track is extremely difficult to quantify.

Studies in the UK and initial emerging conclusions indicate there is prima facie evidence that costs and variable charges have diverged from when the increases of revenue were seen to be funded through increases in fixed charges only with no increase in variable changes[15]. Emerging principals and findings due to the coal management study report[16] indicate that future principals of long run marginal cost pricing should reflect that any "reference train" classified as extra traffic does not spill coal, reference train data should reflect the amount of coal loaded and speed through the unloaders, so that a charge may be levied when these values are breached.

On CQCN ballast fouling degrades the ballast function and rail fastenings and drainage system. Consequently, ballast fouling increases the risk of system failure, as poor track geometry accelerates rail wear and the development of other rail defects in the system. The 2010 WorleyParsons' Asset Condition Report on the CQCN stated that there was considerable coal dust contamination across the Central Queensland Coal Network in 2010, as evidenced by the following illustrations.

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[12] A.J. Hutchinson, J.B. Johnson, G.E. Thompson, G.C. Wood, P.W. Sage, M.J. Cooke, 1992, David E. Searle, David J. Mitchell 2006, David E. Searle, David J. Mitchell, David P. Halsey, Stephen J. Dews, John P. Smith 2000, amongst others

[13] Van Hattem, Matt "Sweeping aside a dusty problem', *Trains*, 00410934, Nov 2007, Vol 67, Issue 11

[14] Track quality: a track condition index based upon standard deviations of track geometry

[15] McMahon, Paul (2005) "Structure of costs and charges review: Emerging Conclusions"

[16] Halcrow - reference

Figure 8: **Ballast Fouling on the CQCN**

QR Network consequently undertakes significant ballast maintenance and renewal programs across the network, as well as allocating funding to their Coal Loss Minimisation Program to manage the risk associated with ballast fouling.

> ### Publication and Research Finding: Environment and regulatory considerations of ballast fouling
>
> **The emission of coal dust from freight trains is an environmental and regulatory issue. The QR Network Environmental Evaluation Notice led to the need to develop a coal dust management plan to manage the issue of emitted coal dust from freight trains.**

Following a number of community complaints regarding nuisance dust levels from passing coal trains in Central Queensland, the Department of Environment and Resource Management (DERM, formerly EPA) issued QR with an Environmental Evaluation Notice under Section 323 of the Environmental Protection Act 1994 on 2 July 2007 (QR Network, Rationale for Coal Loss Project, 2008).

The Environmental Evaluation detailed the sources of coal emissions from trains and the contributing factors to the emission rate for the Goonyella, Blackwater, Newlands and Moura rail systems. The emission rate of coal on these systems was estimated to be 5,416 tonnes as total suspended particles (TSP) in 2006/2007, with this estimated to increase to 7,882 tonnes in 2014/2015 due to predicted increases in coal freight usage of the network. The Environmental Evaluation recommended that QR (at the time) develop a coal dust management plan to manage the issue of emitted coal dust from freight trains.

In cooperation with the Central Queensland coal supply chain, QR Network's Coal Loss Management Project produced a Coal Dust Management Plan to provide a framework for managing coal dust across the coal supply chain. The Coal Dust Management Plan was determined to be a key deliverable of the Transitional Environmental Program, and crucial in ensuring continuing environmental compliance and appropriate stakeholder management across the network. As detailed in the plan, the cost of managing coal dust is paid for by the operators using the network.

4.3.2   Possession Management Practices

> ### Publication and Research Finding: Possession Management Practices
>
> **The key finding of the WorleyParsons' report, New Closure Model - Business Case Support and Review of World Practices determined that a system of extended closures is operated by many railway authorities and other industries in Australia and overseas and enables a more efficient use of the maintenance closure period planned, achieves improvements in quality, and reduces costs, whilst generally providing better, more reliable services to customers and QR Network should consider adopting a policy of extended closures in collaboration with all parties involved through the pit, rail and port supply chain.**

The following table summarises the possession management approaches that were found to be applied by the various railway authorities and by the refinery processing industry, including commentary on the impact of their possession management approach to the individual organisation.

Table 16: **Possession Management Benchmark Summary**

System	Description	Possession Management	Impact to Organisation
	Suburban Passenger Rail	Combination of short term and long term closures used to conduct maintenance (typically up to 50 hours)	
	Passenger Rail	Long term closures (typically three days over a weekend)	
	Freight Rail	Medium term closures (typically 12 hours)	
	Passenger Rail	Mix of short and long term closures	
	Passenger Rail	Long term closures	
	Complex Underground Passenger Rail	Predominantly long term closures (typically 50 to 72 hours)	
	Passenger Rail	Predominantly long term closures (typically in the order of 75 hours)	
	Freight Rail	Mix of short and long term closures (typically 72 hours)	
	Freight Rail	Unknown (no information provided)	
	Freight Rail	Long term closures (up to 10 days)	
	Processing Industry	Long term closures	

As shown, many other railways operate applying a system of extended closures to undertake key maintenance activities. For QR Network, however it is recognised that such a transition would require careful development and planning of procedures and processes to enable this philosophy to be applied and implemented on the CQCN, and would need the full cooperation of all parties involved through the pit, rail and port supply chain in order to be successful.

4.3.3   Published Industry Costs Benchmarking Analysis

Publication and Research Finding: Industry Cost Benchmarking

From available information, the industry cost benchmarking review determined that the closest comparison to QR Network's systems was provided by ARTC's Hunter Valley Coal Network (HVCN) in terms of the key network characteristics, freight commodity and traffic hauled. Consequently, extensive analysis has been carried out comparing QR Network's four systems with the ARTC HVCN and this analysis clearly indicated QR Network's CQCN cost efficiency to be reasonable and prudent when compared with the ARTC HVCN on a unit cost basis of dollars' per track kilometre versus net system tonnage.

Where possible, the analysis included normalising factors associated with the network characteristics of these rail systems, however, it did not consider any additional potential cost contributors relating to inherited organisational issues, such as backlog maintenance, legacy asset management processes, or a cost impact relating to varying outsourced maintenance activities as the information was not available for this additional level of analysis.

The range of source documents applied to the industry cost benchmarking analysis, as set out in table 5, enabled a comparison of maintenance costs to be carried out on the following Australian railway networks.

- QR Network (all fours systems);
- ARTC's Hunter Valley Coal Network;
- ARTC's Interstate Rail Networks;
- WestNet Rail (now Brookfield); and
- Victorian Rail Freight Network.

Overseas railway organisations were not considered as part of this analysis due to issues associated with exchange rates, escalation and network normalisation.

Where financial information was not provided by the organisation, the analysis was carried out using publicly available information on tonnages and costs. Full details of the data and underlying principles applied to the methodology are provided in Appendix F of the report, with the analysis considered to be reasonably comprehensive. However, it should be noted that there are some caveats to the analysis in that the figures for each organisation have not been comprehensively normalised to account for all the different characteristics of the different rail systems and the impacts of these on each system, for example, levels of coal contamination with resulting drainage problems, percentages of each individual network that have steep gradients, or any inherited maintenance lags requiring increased maintenance focus. Rigorous normalisation may strengthen the correlation and alter the final output, perhaps significantly, however there is no reliable method of doing this without spending significant time and analysis to ensure that every characteristic is befittingly normalised. For the purposes of this analysis Evans & Peck did apply a degree of normalisation (as detailed in Appendix F), however as there is considerable controversy as to the value of normalisation in this instance the process was not continued. Differences in unit rate may also be due to the level of outsourcing of the maintenance tasks, although the exact extent of outsourcing for each task was not provided. For example, it is understood that ARTC does outsource a greater portion of its maintenance task than the CQCN, which will naturally account for a higher unit cost.

The review of all rail systems determined the closest comparison to QR Network's systems to be ARTC's Hunter Valley Coal Network (HVCN) in terms of the key network characteristics, freight commodity and traffic hauled. An in-depth analysis of the maintenance costs of QR Network's four systems compared with ARTC's HVCN was therefore carried out focussing in on the range of costs for each system against the traffic tonnages transported by each system.

Figure 9[17] shows the unit maintenance cost expressed in dollars per track kilometre plotted against net system tonnage, based on the cost information that could be extracted from the source documents in respect of those systems for the financial years of 2007/08 through to 2010/11 for QR Network and 2005/06 through to 2010/11 for ARTC HVCN. To draw out efficiency comparisons, upper and lower bands of ± 10% and ± 25% have been applied to the figure, with a simple linear regression analysis used to compare the maintenance expenditures.

Figure 9: Benchmark $/Track km Maintenance Costs against Net System Tonnage
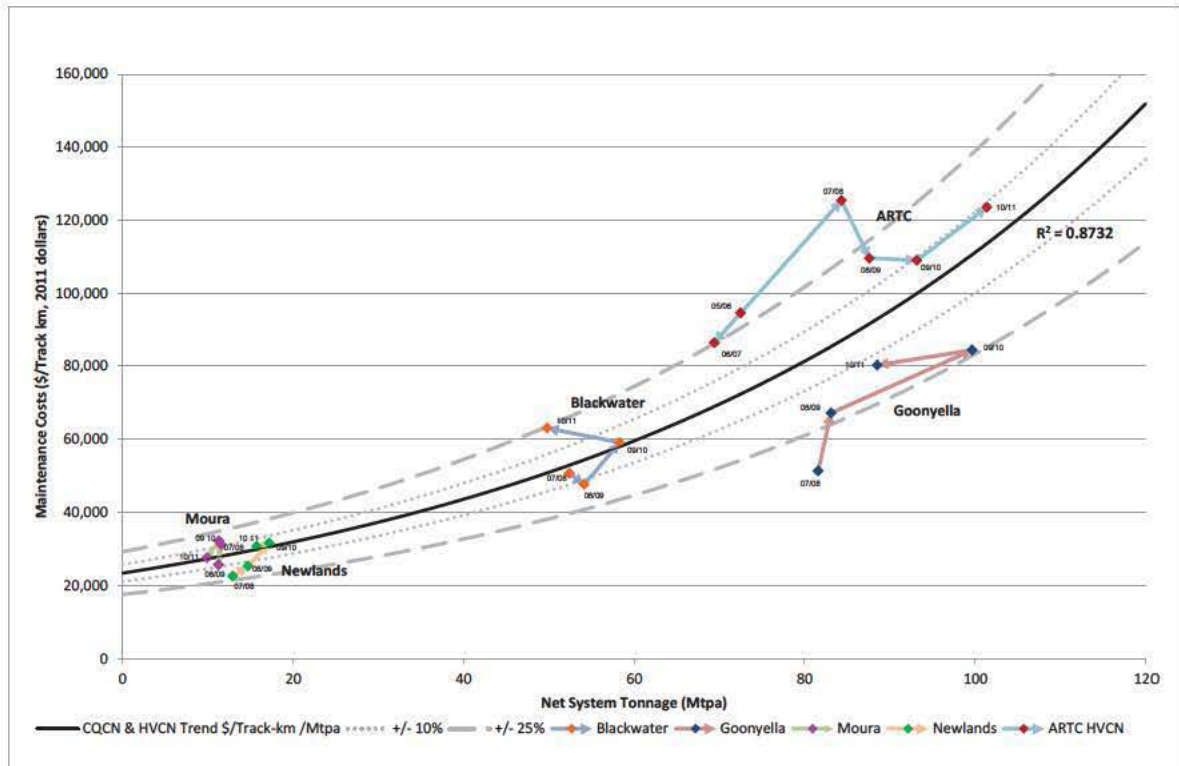
The above figure shows that the unit maintenance costs for the CQCN systems appear reasonable in that they are generally on or below the trend line, with all ARTC's HVCN points above the trend line. This would suggest that QR Network's maintenance cost efficiency is certainly prudent by comparison to the ARTC HVCN on a dollar per track kilometre versus net system tonnage basis. The figure also demonstrates the increases in unit rates due to differentials in the variable component as tonnages rise above the 50-60 tonne profile.

Additionally, the figure highlights deviations to the normal trend for both the QR Network and ARTC systems. It is evident that the QR Network systems transported lower tonnages in the financial year 2010/11. This is considered to be due to the significant flooding experienced in Queensland at that time. ███ ███ Both of these deviances move the respective systems away from the overall exponential trend line.

Additional graphs can be found in Appendix F, including forecasting based on system trends, and the addition of ARTC's interstate systems, Westnet's Eastern Goldfields Railway and Victorian

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[17] Traditionally one would expect the curve to increase exponentially and then begin to flatten as tonnages increased over a certain level. However the correlation of $R^2 = 0.08732$ was the best fit non-linear graphical representation. It is considered that a higher number of data points and some available points that sit beyond the 100-120Mtpa would show the trendline beginning to flatten and plateau as opposed to continuing in the exponential increase shown, however this was not possible to determine with the data available.

Freight's Regional Fast Rail line. Whilst analysed as part of the wider industry cost benchmarking exercise, these rail systems were not considered to be highly comparable to the systems on the CQCN.

4.3.4   Maintenance and Renewal Asset Management Policy

> ### Publication and Research Finding: Maintenance and Renewal Asset Management Policy
>
> A review of the Draft Asset Policy Maintenance and Renewal document indicated that the significant factors impacting QR Network's maintenance requirements related to the environmental contributors experienced by the CQCN (coal dust fouling, extreme weather and salt spray in coastal locations), the increasing traffic haulage demands on the network, and the historical poor quality of the formation support structures.
>
> The analysis of the intervention levels for the key maintenance activities of mechanised resurfacing, ballast cleaning and rail grinding indicated that the level of ballast cleaning on all four systems needs to be increased, mechanised resurfacing on the Newlands and Moura systems on turnouts should be increased and it may be more appropriate on lower trafficked lines to set intervention levels in terms of time frequencies and condition rather than tonnages transported. A robust program for rail grinding appears to be in place on all four systems.

The review of QR Network's Draft Asset Policy Maintenance and Renewal document identified that QR Network uses a reliability centred maintenance approach to the management of their below rail assets. Preventative maintenance regimes are in place and are based on appropriate levels of asset availability at the least cost of ownership through the entire asset life cycle. QR Network conducts maintenance with a focus on meeting the business requirements of their customers, and intervention is largely based on the historical performance of the assets in the CQCN operating environment, in conjunction with industry knowledge and experience, and the governing standards and regulatory compliance requirements.

QR Network's approach, classification and the measurement criteria applied to key asset maintenance and renewal activities is summarised briefly below, with asset inspections, monitoring and like-for-like repairs classified as maintenance related activities (OPEX), and asset replacement classified as renewal activities (CAPEX). This is considered a typical and common split between asset maintenance and renewal, and comparable to the philosophies applied by other heavy haul railway organisations.

Table 17:   Asset maintenance and renewal management

Key Activity	Management Approach	Classification and Measurement
Mechanised track maintenance: • Ballast Cleaning • Rail Grinding • Track Resurfacing • Stone blowing	Intervention level based on specified traffic levels for: • Net tonnes • Gross tonnes • Gross tonnes • Gross tonnes	Preventative maintenance measured in unit track km based on deterioration due to: • Coal fouling • component wear • component wear • component wear
General track maintenance.	Intervention level based on specified frequencies for maintenance activity. Various techniques applied, including track recording car, inspections, hi-rail, and non-	Preventative maintenance measured in unit track km based on deterioration due to component wear.

Key Activity	Management Approach	Classification and Measurement
	destructive testing.	
Structures and Facilities Maintenance	Specified frequencies for activity (typically annually) and fix on failure.	Preventative maintenance typically measured in combination of km, numbers achieved, and linear metres per year.
Signalling maintenance	Specified frequencies for activity and fix on failure.	Preventative maintenance typically measured in component replacement, numbers achieved per year.
Traction power system maintenance	Specified frequencies for activity and fix on failure.	Preventative maintenance typically measured in section, numbers achieved, track km per year.
Civil track asset renewals ▪ Rail (straights and curves)	Replacement based on deterioration assessed by traffic volume in gross tonnes, and rail section weight.	Renewal measured in single rail km
Civil track asset renewals ▪ Sleepers	Replacement based on deterioration measured through asset age, material type and rolling stock axle load	Renewal measured in track km.
Civil track asset renewals ▪ Ballast	Replacement based on deterioration measured on basis of specified expected life.	Renewal measured in track km.
Civil track asset renewals ▪ Points and crossings	Replacement based on deterioration assessed by traffic volume in gross tonnes and type of crossing (fabricated, RBM, swing nose) and rail section weight.	Renewal measured in complete turnout replacement.
Civil Structure Asset Renewal	Replacement based on deterioration measured on basis of specified expected life.	Renewal measured in linear metre replacement.
Civil right of way asset renewal	Replacement typically based on deterioration measured on basis of specified expected life.	Renewal measured through single unit replacements and through track km and linear metres.
Signal equipment asset renewal	Replacement based on deterioration measured on basis of specified expected life	Renewal typically measured through unit or component replacements and through track or route km.
Traction power equipment asset renewal	Replacement typically based on deterioration measured on basis of specified expected life.	Renewal typically measured through unit or component replacements and through track km.
Telecommunications asset renewal	Replacement typically based on deterioration measured on basis of specified expected life.	Renewal typically measured through unit or component replacements and through track or route km.

Environment factors contributing to maintenance load

The policy document identifies ballast fouling as the main external environmental factor impacting QR Network's maintenance, accounting for 20-25% of their maintenance budget. Issues associated with this are further affected by the unique climatic conditions experienced by the CQCN, in particular tropical seasonal weather variations, the extreme periods of heavy rainfall, and coastal areas which are subject to salt spray due to prevailing winds. The combined environmental effect creates significant formation and drainage problems for the CQCN, breakdowns in the ballast structure resulting in mud holes. Importantly it is noted, there are also secondary impacts on the asset, such as deterioration of sleepers through sleeper pumping action, corrosion of fastenings, and poor top and line, which necessitates repeated resurfacing until the ballast cleaner operation is programmed to remediate the ballast profile. Additional manual track clean-ups and maintenance to turnouts, especially in major yards and at ports are also required. At the heavily fouled locations the service life of the ballast, sleepers and sleeper fastenings are considered to reduce by a significant factor. In some cases, QR Network has deemed this to be as much as fifty per cent.

QR Network also conducts percentage void contamination (PVC) testing of the ballast and applies an intervention level of 30 to 50% to the ballast composition. They heavily invest in the application of stone blowing, an alternative to traditional mechanised resurfacing, used to help improve track geometry under trafficked conditions. The application of the stone blower is unique to heavy haul railways, and is specifically used by QR Network to address high ballast contamination and deficient drainage, and is used in combination with the more traditional mechanised ballast cleaning operations.

Rising traffic haulage contributing to maintenance load

The document also identifies increasing traffic haulage as a significant contributor to the maintenance load on the CQCN, necessitating sustained increases in maintenance to ensure the asset remains fit for purpose. Increasing traffic introduces additional stress on the infrastructure, and for the CQCN, component wear has been identified specifically in respect of the rails, turnouts and sleepers due to the increasing gross tonnages transported over the network. For rail, this means that the rate of growth of defects becomes the limiting rail life factor. That said, QR Network's rail life is considered to generally be comparable with industry norms based on the survey benchmarking analysis.

As with other heavy haul railways, there has been a need to install head hardened rail on curves to increase the asset life and allow longer intervals between grinding. Typically, for QR Network this is considered to have doubled the life of their rail on curves.

Due to onerous maintenance demands on turnouts, and maintenance staff being unable to cope with the required rate of renewal of turnouts, gradually QR Network has also moved away from fabricated crossings to Rail Bound Manganese (RBM) and swing nose crossings as tonnages have increased, but many fabricated crossings remain in the CQCN requiring significant maintenance until such time as they are all replaced under capital renewal programs.

It is also noted from the policy document, that the concrete sleepers used throughout the CQCN were traditionally designed for lower tonne axle loads of 22.5 tal. With increasing traffic haulage, the operating environment has become more onerous and sleepers are now required to accommodate higher 26.5 tal with the effect of a resulting reduction in their average service life.

Poor formation support structures contributing to maintenance load

The policy document also highlights the historical issues associated with the quality of the formation, where there has been uneven settlement of large depths of very poor sub grade material, in particular in expansive clay areas, where high embankments were constructed of very poor local material. This has been evident across the network, and in particular on the Newlands and Moura systems, and has necessitated a program of formation rebuilding due to the continued onerous maintenance task that is associated with the resulting impacts on track geometry.

Maintenance intervention too low for ballast cleaning on all four CQCN systems, mechanised resurfacing intervention too low for turnouts on the Newlands and Moura systems; robust rail grinding program in place on all four systems

The analysis of the key maintenance activities in respect of mechanised resurfacing, ballast cleaning and rail grinding has been summarised in the table below for financial years 2009/10 to 2016/17 based on actual and forecast corporate planned tonnage information supplied by QR Network for those periods. For the purposes of this analysis, tonnage profiles have been calculated for maximum expected traffic levels of up to 90% and 100%.

Table 18: Analysis of intervention levels for key maintenance activities

Year	Unit	Blackwater		Goonyella		Moura		Newland	
Tonnage Profile		90%	100%	90%	100%	90%	100%	90%	100%

Year	Unit	Blackwater		Goonyella		Moura		Newland	
Tonnage Profile		90%	100%	90%	100%	90%	100%	90%	100%
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Year	Unit	Blackwater		Goonyella		Moura		Newland	
Tonnage Profile		90%	100%	90%	100%	90%	100%	90%	100%
■		■	■	■	■	■	■	■	■
■		■	■	■	■	■	■	■	■
■		■	■	■	■	■	■	■	■
■	■								
■		■	■	■	■	■	■	■	■
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Considering industry trends for systems with coal fouling problems, this tables indicated that there is a need for additional ballast cleaning on all systems and a need to increase mechanised resurfacing on the Moura and Newlands systems in respect of turnouts.

The analysis also indicates that QR Network applies a robust rail grinding program across all systems on the CQCN.

4.3.5   Plant and Labour Costs

> **Publication and Research Finding: Plant and Labour Costs**
>
> GHD report disputes QR Networks claim in the UT3 submission for increased labour costs[1] on the basis that due to an known exodus of labour from rail to other industries such as mining "falling staff numbers should ameliorate the effect of increasing labour costs" and thus the "impact of labour costs is likely to be smaller than QR Network's expectations". Literature review conducted as part of this project supports the Booz and QR Networks submission that the last decade has seen marked increases in mining industry in Northern Queensland with subsequent significant increases in labour costs.
>
> Rail is a capital intensive industry and maintenance providers need high volumes of work to survive. That is rail maintenance is a high volume low margin business which is why it is dominated by a handful of large public companies. Due to the nature of such skilled and specialised industries, it is recognised that the labour cost component may be higher.
>
> The optimisation of depot location and demarcation of skills to increase efficiencies in overall maintenance for both ordinary and renewal based maintenance is an area where significant efficiencies and improvements can be gained for CQCN, further analysis is recommended.

The literature review conducted as part of this project revealed that earnings in Queensland per employee were highest in the mining industries[18] and whilst demand for employment within the utilities lifted, competition and wages also rose highly in engineering and construction (i.e. those industries competing with the utilities for skilled workforce) to compete with the utilities sector which, relative to the Australian average, experienced an average salary growth of 0.6 percentage points faster per year for the decade through to early 2010[19]. It is considered that these increases

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[18] www.abs.gov.au earnings including gross wages and salary - assessed May 2012

[19] "Forecast growth in labour costs: update of August 2011 report" Deloitte Access Economics for the AER, March 2012

will have impacted labour costs in CQCN in addition to the requirement to pay existing staff overtime to cover the shortfall in labour experienced by the exodus of staff to the utility sector from QR Network. Anecdotal evidence and Evans & Peck professional experience in other industries such as road maintenance and reconstruction in Northern Queensland also substantiates QR Network's claim, as high labour costs and skill shortages in the coal region were found to have an impact on the estimate and costs of flood reconstruction work in the area.

Labour costs are associated with travel requirements and in-house and outsourcing profiles. From information available on rail maintenance practice, current industry practice for outsourced labour charge out rates is comprised of:

- Direct costs – (35%) salary plus on costs

- Indirect costs – (65%) include site rental plus outgoings/tooling/travel etc.

- A profit margin (the rail maintenance sector appears to charge a profit margin of 10% to 15% on work contracted[20]

This equates to a current normal labour charge of approximately $90.00 to $150.00 per hour (dependent on skill and experience) with ad hoc rates (e.g. emergency turn out) charged at $115 - $175 per hour. These rates do not include additional cost for FIFO (Fly in Fly Out) or long travel distances.

For the UT3 submission WorleyParsons conducted a review of travel requirements for QR Network staff based upon the number and location of depots on the CQCN. The analysis clearly showed that the current location of depots along the CQCN was not optimum with distances over 100km having to be travelled from some locations. In consideration of the factors discussed in the previous paragraphs (increasing labour costs and resource shortages) these travelling times will have an impact upon overall maintenance costs and are a waste of valuable resource time. The report recommended several alternative options for depot location, but considered only mathematical models without taking into consideration types of activities and skills required at each location.

In addition to optimisation of the depot location it is evident from literature and discussions with railways that gang structure and optimum demarcation of skills at different depot locations in order to increase maintenance task efficiencies is a subject of debate and an area where there is considerable potential for improvement in most railway organisations. Larger mechanised gangs (traditionally characteristic of renewal maintenance) have become a more efficient method of conducting routine maintenance in the larger railways such as the US Class 1 due mainly to improvements in delivery technology for routine track maintenance (i.e. rail laying equipment, ballast delivery systems, etc.). The increased use of larger mechanised gangs can provide greater economies of scale compared to the traditional small section gangs performing selective ordinary maintenance, however these changes may only be cost effective and practical in the large network high density lines.

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[20] "Maintenance Margins – comparable for below-rail maintenance – CGI Consulting, 2008

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4.3.6   Supply Chain Optimisation

> **Publication and Research Finding: Supply Chain Optimisation**
>
> The **Queensland State Government report of 2007** essentially determined that for the **CQCN** coal supply chain to operate optimally the coal unloaders must operate optimally, and consequently, all other elements of the supply chain are forced to absorb system losses, and these system losses then need to be equitably distributed across all components of the supply chain, including the below rail infrastructure.

The Queensland State Government 2007 report essentially determined that for the CQCN coal supply chain to operate optimally the coal unloaders must operate optimally and consequently, all other elements of the supply chain are forced to operate, to an extent, sub-optimally; including below rail infrastructure and the maintenance of this infrastructure.

"The coal supply chain is a complex system. Not only from an operational aspect with the different stakeholders but also considering the different commercial agendas and regulatory frameworks." [21]

The "below rail" infrastructure, and the maintenance of that infrastructure, is only one element of the total coal supply chain. Other critical elements include:

- coal loaders at the mine loop;
- above rail assets; and
- coal unloaders at the terminal.

Each of these assets has, in turn, contributing characteristics that can constrain that particular element. These contributing characteristics include, but are not limited to:

- coal loaders at the mine loop;
  - type of coal;
  - moisture content of coal;
  - unloading loop configurations;
  - stockpile size and configuration; and
  - weather.
- above rail assets;
  - wagon characteristics;
  - locomotive characteristics;
  - power supply;
  - provisioning strategies and facilities; and
  - crew and crew change strategies.
- coal unloaders at the terminal;
  - unloading loop configurations;
  - stockpile size and configuration; and
  - weather.

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[21] *Goonyella Coal Supply Chain Capacity Review,* Queensland Department of Transport, 2007

In order for the total supply chain to operate optimally it must be designed to ensure the critical element of the supply chain is operating optimally; at 100 % capacity. Any element, or characteristic of an element, of this supply chain can act as a constraint to the critical supply chain element and consequently total system capacity.

The 2007 report commissioned by the Queensland State Government, quoted above identified that "Assuming there are no rail bottlenecks, the capacity of the rail haulage system will ultimately be set by the coal unload stations". For the supply chain to operate at 100 % of the coal unloaders; other elements of the system must be designed to absorb system losses. In relation to achieving 100 % operation of the coal unload stations the 2007 Report recommends that the above rail resources be designed to be able to manage 100 % of the capacity of the unloaders.

The 2007 Report does not comment on the overcapacity required to be designed into the below rail infrastructure, and maintenance of below rail infrastructure, to achieve 100 % at the coal unloaders. However, it is reasonable to deduce that if the above rail capacity is to be 10 % over the capacity required for the coal unloaders then the below rail capacity must be designed to at least meet this overcapacity. In addition, a further allowance is required for system losses due to late running of trains and system interface issues between the myriads of mines each with train paths often carrying different coal products. To manage these system losses; QR Network rely on experience and base capacity planning on historical records of train speed restrictions and plan only to commit to 75 % of a systems theoretical capacity.

The essence of the Queensland State Government 2007 report is for the coal supply chain to operate optimally the coal unloaders must operate optimally and consequently, all other elements of the supply chain will be forced to operate, to an extent, sub-optimally by providing capacity in excess of the coal unloaders; including below rail infrastructure and the maintenance of this infrastructure.

4.3.7   Regulatory Framework

> **Publication and Research Finding: Regulatory Framework**
>
> The high level review of the commercial aspects of QR Network Access Undertaking against those of ARTC, WestNet and Victorian Rail revealed that the commercial frameworks for each are broadly similar but there is little transparency around the incorporation and measurement of key performance indicators within the contracting arrangement and there appears to be limited mechanisms within the commercial structure to reward or penalise parties (both asset owner and operators) in respect of performance.

The access undertakings of QR Network, ARTC, WestNet and Victorian Rail are generally similar, with the exception of an "over payment" reimbursement policy which appears to be unique to WestNet.

QR Network has a range of service level categories and key performance indicators (KPIs) which Evans & Peck considered reasonable measurements to assess performance under the access undertaking, however the detail of the target levels for each KPI appeared to be unclear, and the application of financial rewards and penalties do not appear to exist.

Of note, WestNet's commercial structure has KPIs which are set for the train operators over and above those of the network maintainer and they have in place financial rewards and penalties associated with the achievement of these KPIs, however no detail of these KPIs was available for Evans & Peck to review.

The following table summarises the key points of note for comparative purposes in terms of the various access undertakings.

Table 19:   Summary comparison of Access Undertaking frameworks

Organisation	Summary comments
QR Network	CQCN regulated by the Queensland competition Authority (the QCA). QR Network owns and manages the CQCN which is subject to the following three access charges passed on to the operators using the CQCN. (i) Asset related charges[1] (ii) Operating costs; and (iii) Maintenance costs. Upper and lower bound limits applied in relation to the access tariffs which are agreed between QR Network and the QCA. [1] relates to both Return on Assets (ROA) and net depreciations using Depreciation Optimised Replacement Cost (DORC) analysis.
ARTC	The Hunter Valley rail corridor (HVRC) is regulated by Australian Competition & Consumer Commission (ACCC). ARTC operate a 60 year lease of the HVRC from NSW government. The network primarily services 16 coal producers located in the Hunter Valley region. Access charges are similar to QR Network with pricing based on: (i) Network's direct costs, charged to operators on the basis of actual network usage; (ii) Operating costs; (iii) Depreciation costs; and (iv) Return on Assets.
WestNet (now Brookfield)	Network regulated through Economic Regulation Authority (ERA) of Western Australia. Network formerly owned and leased from the WA government. Access charges based on similar principles to QR Network designed to recover the following from the operators using the network: (i) Capital costs, reflecting cost of establishing and replacing infrastructure capacity over time, with allowances for a suitable return on asset and depreciation; (ii) Operating costs, reflecting cost to maintain the network; (iii) Overhead costs; One unique aspect of this commercial framework is an obligation from the regulator to adhere to "over payment" rules. This requires WestNet to reimburse train operators should the total revenue collected from a particular route exceed the total cost to maintain and operate that route.
Victorian Rail	Network regulated through the Essential Services Commission (ESC) in Victoria which covers freight, terminal and passenger rail services. Guideline indicates that Victorian railway owners are also obliged to adhere to agreed revenue caps and floors but unlike WestNet are allowed to "retain over recovery of revenue to provide a financial incentive to the access provider to increase utilisation of the rail network"

Organisation	Summary comments
	No information was available on the commercial framework of the specific Victorian railway owners.

The following tables summarises the service level specification range and key performance indicators of QR Network in regards to asset reliability and fitness for purpose.

The service levels are separated into 4 categories (maintenance asset reliability/condition, performance, safety and cost control). Under each service level category are specific KPIs used to measure and assess the performance of QR Network, however the actual target range for each of these KPIs could not be determined from the documentation reviewed.

A summary of the service target categories and associated KPIs are outlined in Table 20.

Table 20:   Summary of QR Network Service Level Specification and KPIs

Service Level Category	KPI
Maintenance Performance	**Fault Response:** ▪ Traction Power (High Priority) ▪ Signal (High Priority)
	Production Against Program infrastructure ▪ Resleepering ▪ Resurfacing ▪ Rail Grinding ▪ Ballast Undercutting ▪ Track Recording ▪ Non Destructive Testing *Trackside (traction)* ▪ Routine Maintenance ▪ Major Maintenance *Trackside (signal)* ▪ Routine Maintenance ▪ Major Maintenance
Asset Reliability/Condition	**Transit Time Delay:** ▪ Track and Structures ▪ Trackside Systems (Signal) ▪ Trackside Systems (OHL)
	Track ▪ Derailments (due to Infra.) ▪ Track Condition Index ▪ Buckles/Pull Aparts ▪ Rail Defects

Service Level Category	KPI
	Trackside Systems – Traction Power ▪ Dewirements (due to Infra. Equip.) ▪ Transformers ▪ Faults (non-resettable trips)
	Trackside Systems - signals ▪ Faults ▪ Wrong side Failure ▪ Restored in face of train (RIFOTS) ▪ Signals passed at danger (SPADS)
Safety	**Employee** ▪ Injury down time rate ▪ Lost time frequency rate ▪ Lost time injuries
	Public ▪ Trespass ▪ Level Crossing collisions ▪ Wildfire (outside boundary/infrastructure damage)
Cost Control	**Expenditure versus budget**
	Inventory Value
	Major Maintenance Cost ▪ Resleepering ▪ Resurfacing ▪ Ballast Undercutting ▪ Rail Grinding ▪ Track Recording

As seen from the above table QR Network's KPIs are unclear although the listed service level categories and KPI measures appear reasonable. The review indicated that there was insufficient detail in the definition of the service level KPIs. In particular there is:

▪ no clear outline on a means or methodology applied to measure the performance of each service level KPI;

▪ no set targets or minimum requirements in relation to the required service level performance;

▪ no apparent financial incentives (penalties or rewards) in place for either QR Network or train operators to achieve the KPIs or service level requirements;

▪ Comparing the KPI regime with others it was noted that:

▪ ARTC make no mention of any financial rewards or penalties, and its appears that their KPIs are only applicable to ARTC and not the train operators;

- WestNet make claim to having a KPI regime that covers both WestNet and the train operators, and the KPIs enable financial rewards or penalties based on the performance; and

- No information was available in respect of Victorian Rail.

- Note: Evans & Peck was not able to access actual examples of others' KPIs as part of this high level review.

- The above offers certain areas for potential improvement of the commercial frameworks of the Access Undertakings which are identified and outlined in the recommendations section of this report.

4.4 Key Findings from Independent Cost Estimating

On the basis of the assumptions applied to the cost estimating summarised in Table 7 of the report, Evans & Peck's cost estimates assume new equipment with full repair, and include maintenance, depreciation, replacement and ownership costs in the estimating build-ups.

As expected, the possession regime, and the consequent access constraints, is the single most important factor for optimising maintenance costs. In other words, due to the significant capital costs of equipment, the ratio of effective working time to non-effective mobilisation and demobilisation time has a major impact on the costs.

The following sections present the findings of the individual cost estimating build-ups for rail grinding (mainline), ballast cleaning (mainline) and mechanised resurfacing.

The supporting analysis, including all underlying assumptions and conditions applied to the estimating build-ups, are provided in Appendix G.

4.4.1 Rail grinding

Cost Estimating Finding: Rail Grinding

Taking into account the constraints and limitations on track access, for the 2011/12 financial year QR Network achieved an efficiency level of approximately ▮ %, with an average of ▮ km of rail grinding achieved per shift, with ▮ productive hours of grinding in each shift.

QR Network's rail grinding operations fell within the best and worst case efficiency boundaries developed for the estimate, and indicated that they are operating at an efficient level, particularly when accounting for the constraints of the current track access regime.

Under the assumptions of the estimate, costs for grinding range from less than $▮/km for very long runs to in excess of $▮/km for runs under ▮ kilometres, with optimum production being achieved when greater than ▮ hours of productive grinding can be achieved during a possession shift.

QR Network uses two types of rail grinders; an 80 stone mainline rail grinder (MMY031) and a smaller 24 stone rail grinder for turnouts (MMY030,) with the rail grinding crew generally being deployed for single shifts under the available track possession regime.

Evans & Peck's estimate is based on the 193 working shifts that QR Network achieved in the 2011/12 financial year, and the operating capacity of the 80 stone rail grinder. The analysis therefore applies to plain line rail grinding only for the purposes of the estimating build-ups, and excludes grinding carried out on turnouts.

The estimating build-up considers varying conditions of operations, and based on this, presents efficiency boundaries to show best and worst case scenarios. The major variables accounted for in the best and worst case scenarios reflect changes in:

- speed of the rail grinding;

- condition of the rail and the extent of grinding required; and

- duration required in a shift to attend to spot fires.

Other, less significant, allowances are also included in the estimating scenarios to reflect other unexpected delays that may occur on site. The full list of variables are provided in Appendix G.

Estimating boundary lines have been plotted for a 10% efficiency range to highlight unfavourable conditions for rail grinding operations (the worst-case-scenario), and a 90% efficiency range to represent near perfect conditions (the best-case-scenario) for the grinder in terms of maximum productivity during a track possession.

Figure 10, below, shows the unit cost ($/km) for rail grinding plotted against productive hours achieved in a shift, applying the 10% and 90% efficiency boundaries.

**Figure 10:   Rail grinding - cost per km plotted against total km achieved in one shift**
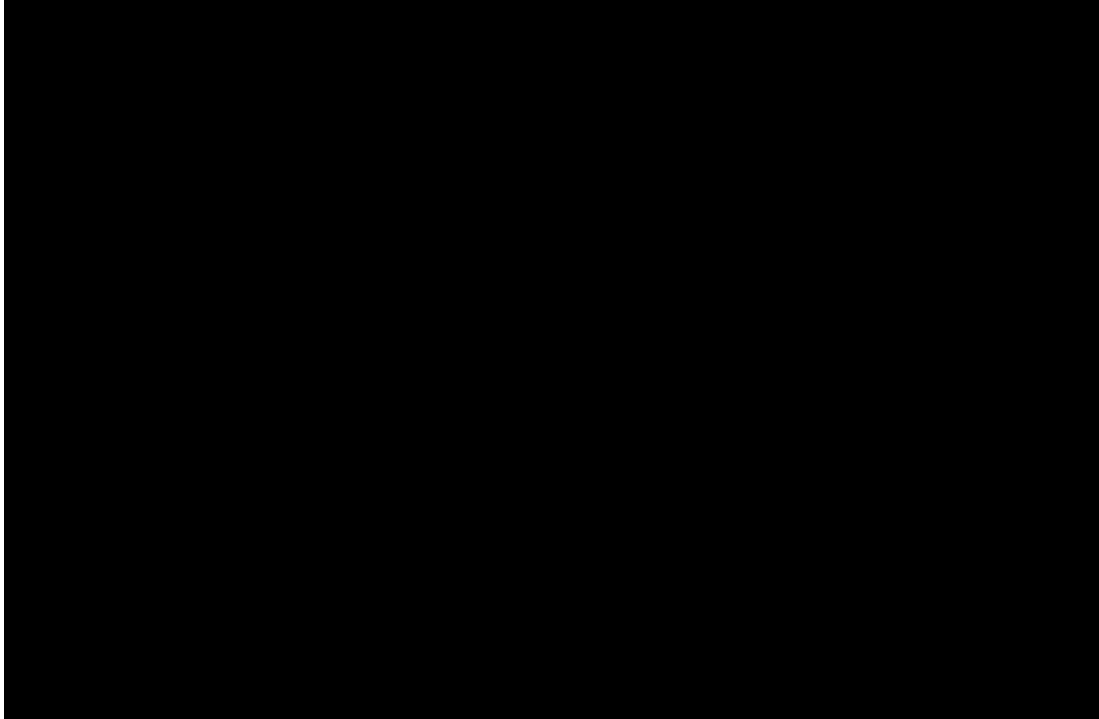
As can be seen, the costs for rail grinding range from less than $███/km for very long runs to in excess of $████/km for runs that are less than █ kilometres in length.

It can also be seen that the 90% efficiency line approaches an asymptote at approximately $███/km, with the optimum production being achieved when shifts achieve above 4 hours of productive rail grinding. Of further note, is the steep increase that can be seen in the costs when productive grinding is less than 2 hours in a possession shift.

Adding QR Network's actual 20011/12 costs and production outputs, this indicates that QR Network was operating at a reasonably efficient level, under the assumptions of the estimate.

The following figure plots the kilometres of rail grinding against productive hours in a shift, again applying best and worst case efficiency boundaries, and highlights the increasing range in length of rail grinding that can be achieved, applying the varying conditions of operation.

Figure 11:   Rail grinding - productive hours in a shift and versus production (efficiency)
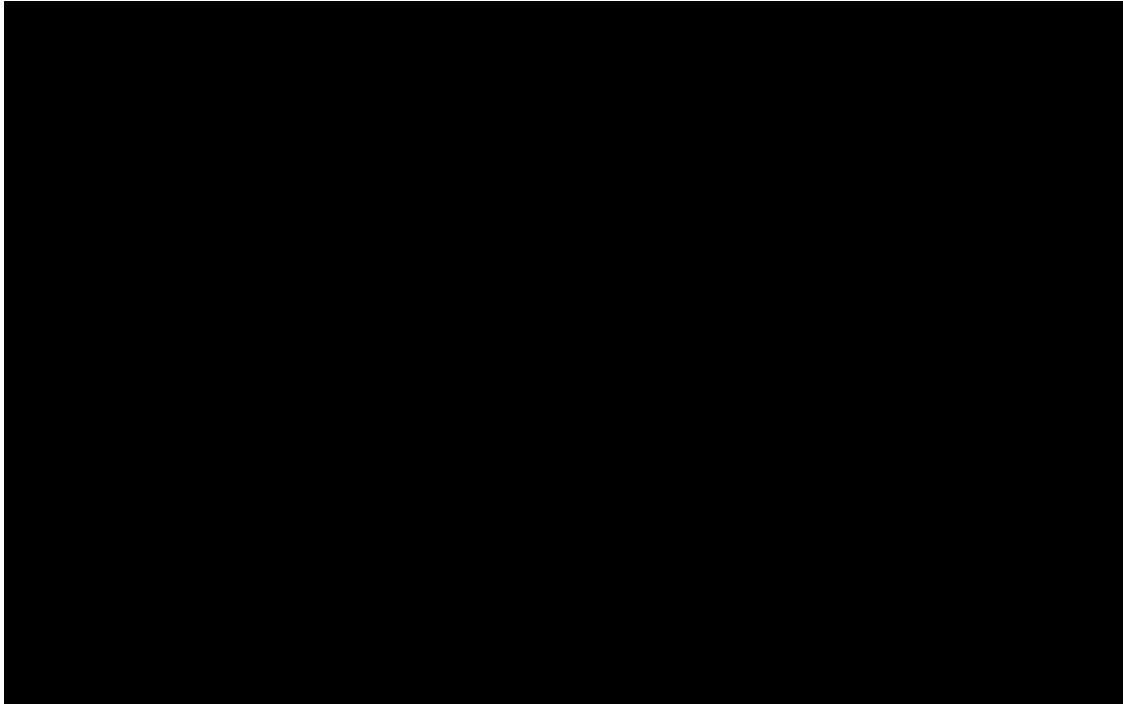
The results shown in figure 11, applying QR Network's actual costs for the 2011/12 financial year, show that QR Network was operating at an efficiency level of approximately ▮▮▮ %, achieving an average of ▮▮▮ km of rail grinding in the ▮▮ productive hours per shift.

Figure 12, shows a LORAM plain line rail grinder used by QR Network.

Figure 12:   MMY031; QR Network's 80 stone LORAM Rail grinder

4.4.2   Ballast cleaning

> ### Cost Estimating Finding: Ballast Cleaning
>
> QR Network typically deploy the ballast cleaner in ▮ block periods, and for the 2011/12 financial year achieved, on average, ▮ kilometres of ballast cleaning at a unit cost of ▮ per ▮ block, equating to approximately ▮ kilometres of ballast cleaning on the CQCN network.
>
> Under the assumptions of the estimate, QR Network's ballast cleaning operations for the 2011/12 financial year were on the cusp of the maximum efficiency trend line, indicating that the scope for improved ballast cleaning is highly dependent upon increasing capacity, for example, greater output from the existing ballast cleaner, deployment of an additional ballast cleaning machine or greater productive track access to undertake maintenance.
>
> Plotting ballast cleaning as a unit cost ($/km) against kilometres achieves for QR Network's typical ▮ deployment block provided a cost range for ballast cleaning of less than $▮/km long runs, to in excess of $▮/km for runs less than ▮ kilometres, with costs approaching an asymptote at approximately $▮/km indicating that optimum production costs occur when ▮ blocks achieve around ▮ kilometres of ballast cleaning.

QR Network uses the RM 900 ballast undercutting machine, with ballast cleaning crews generally deployed in "blocks" of ▮, and ballast cleaning programed for ▮ each year.

The estimating build-up considers varying conditions for ballast cleaning operations, and based on this, presents efficiency boundaries to show best and worst case operating scenarios. Under the conditions of the estimate, the two major variable conditions applied to the ballast cleaner represented changes in:

- speed of the ballast cleaner; and

- condition of the ballast in the field and magnitude of ballast that can be recycled.

Additional, less significant, allowances are included in the estimating scenarios to reflect other unexpected delays that may occur on site, and are provided in Appendix G.

In terms of programming and scoping ballast cleaning work, it is understood that this is significantly influenced by the accuracy of the results of field tests on the ballast. The current approach used by QR Network is the Percentage Void Contamination (PVC) method which is based on sieving field samples to obtain grading curves. This method has, on occasions in the past, been inaccurate and led to underestimating the quantity and depth of ballast replacement required. As a consequence, it is being superseded by a Ground Penetration Radar (GPR) technique with the objective of improving the accuracy and scoping of ballast cleaning maintenance work programs.

In the context of this, it is noted that during the 2008 benchmarking study, CQCN were one of only two organisations considering and trialling GPR for this purpose, and that since this time a number of other rail organisations have started to use this technology. This indicates that not only has QR Network been a world leader in trialling this technology, but is a world leader developing a process that is gaining the confidence and acceptance of the industry worldwide.

Figure 13, plots the ballast cleaning unit cost against production for an 8-day block duration. The boundary ranges shown represent a 300mm depth of ballast cleaning with significant recovery (e.g. greater than 90% of ballast can be recycled) to show a best case scenario, and a 600mm depth of ballast cleaning operation with virtually no ballast recovery (e.g. closer to 0% of ballast can be recycled) to represent a worst case scenario.

Figure 13: **Ballast cleaning - unit cost plotted against production per 8 day block**
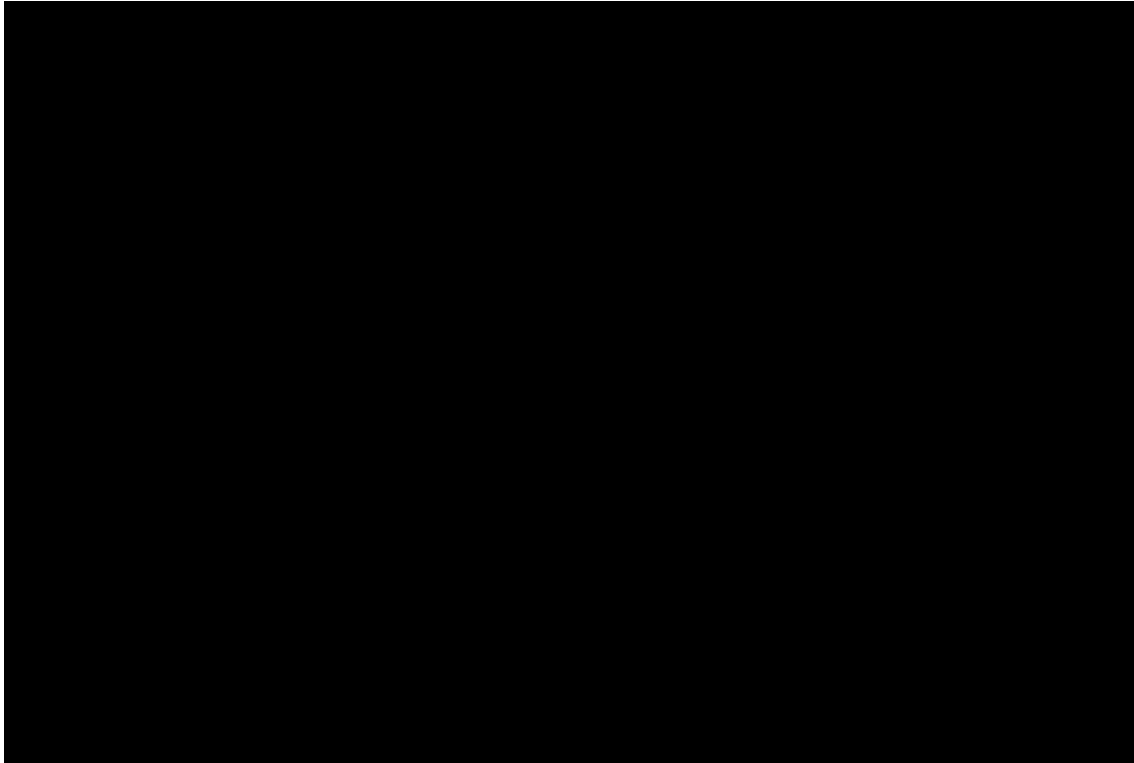
The graph shows that the costs for ballast cleaning can range from under ██████0/km for long runs to in excess of ████████/km for runs less than ██ kilometres.

Additionally, it can be seen that the cost approaches an asymptote at approximately $██████/km, indicating that optimum production costs occur when ballast cleaning operations achieve greater than 15 kilometres in an ██████ block.

From QR Network's actual 20011/12 costs and ballast cleaning production outputs, we can see that the results are on the cusp of the maximum estimating efficiency boundary line, and QR Network achieved, on average, ██ kilometres of ballast cleaning at a unit cost of ████████ per ██ block, which equates to approximately ██ kilometres per annum of ballast cleaning on the CQCN.

Increased production may be achieved through enhancing the capacity of the existing machine, deploying an additional ballast cleaner, or increasing productive track access.

Figure 14 shows an RM 900 Ballast Undercutter used by QR Network

Figure 14:   RM 900 Ballast Undercutter

4.4.3   Mechanised Resurfacing

Cost Estimating Finding: Mechanised Resurfacing

For the 2011/12 financial year QR Network achieved, on average, ▮ kilometres of tamping at a unit cost of ▮▮▮▮ /km per shift, and ▮▮ kilometres of tamping with stone blowing at a unit cost of $▮▮▮ /km per shift.

For tamping, under the assumptions of the estimate, costs can range from under ▮▮▮▮ /km for long runs to in excess of ▮▮▮▮ /km for runs under ▮ kilometres. For tamping with stone blowing, costs can range from under $▮▮▮ /km for long runs to in excess of ▮▮▮▮ /km for runs under ▮ kilometres.

In each case, costs approached an asymptote at approximately $▮▮▮ /km indicating that the optimum production costs for mechanised resurfacing occur when achieving production rates above ▮ kilometres per shift.

Plotting QR Network's 2011/12 actual results on the graphs showed them to be lower than the best case efficiency boundary line, indicating that operations are relatively efficient, when accounting for the constraints and limitations associated with the track access regime.

QR Network generally deploys mechanised resurfacing maintenance crews in single day shifts to conduct the works under the available possession regime.

Evans & Peck's estimating build-up for mechanised resurfacing maintenance (tamping and tamping with stone blowing) includes only the planned resurfacing works that are conducted on the CQCN to ensure the estimate reflects "true" unit rates, and thus prevents any unnecessary skewing of the results due to unplanned critical "spot" maintenance works.

The estimating build-ups consider the varying conditions of operation for mechanised resurfacing maintenance and apply efficiency boundaries again to show best and worst case scenarios.

The major variable conditions that have been applied to the estimating build-up for mechanised resurfacing represent changes in:

- speed of tamping operations;

- speed of stone blowing operations; and

- the quality and condition of the track geometry and supporting ballast.

Additional, less significant, variable conditions that could lead to other unexpected delays are provided in Appendix G.

The boundary lines are plotted for the best and worst case scenarios, based on a maximum track lifting capability of the tamping machine, and shown as a 10% track lift (best case) and 90% track lift (worst case).

Figure 15, below, plots the unit cost ($/km) for tamping operations against kilometres achieved in a single day shift, and shows that the costs for tamping can range from less than $ ▮▮▮ /km for long runs to in excess of $▮▮▮▮▮ /km for runs under ▮ kilometres.

As shown, the cost approaches an asymptote at approximately $▮▮▮▮ /km indicating that optimum production costs occur when achieving targets above ▮▮ kilometres per shift.

Plotting QR Network's actual costs and production for the 2011/12 financial year, it can be seen that they achieved, on average, ▮ kilometres of tamping at a unit cost of $▮▮▮▮ /km per shift.

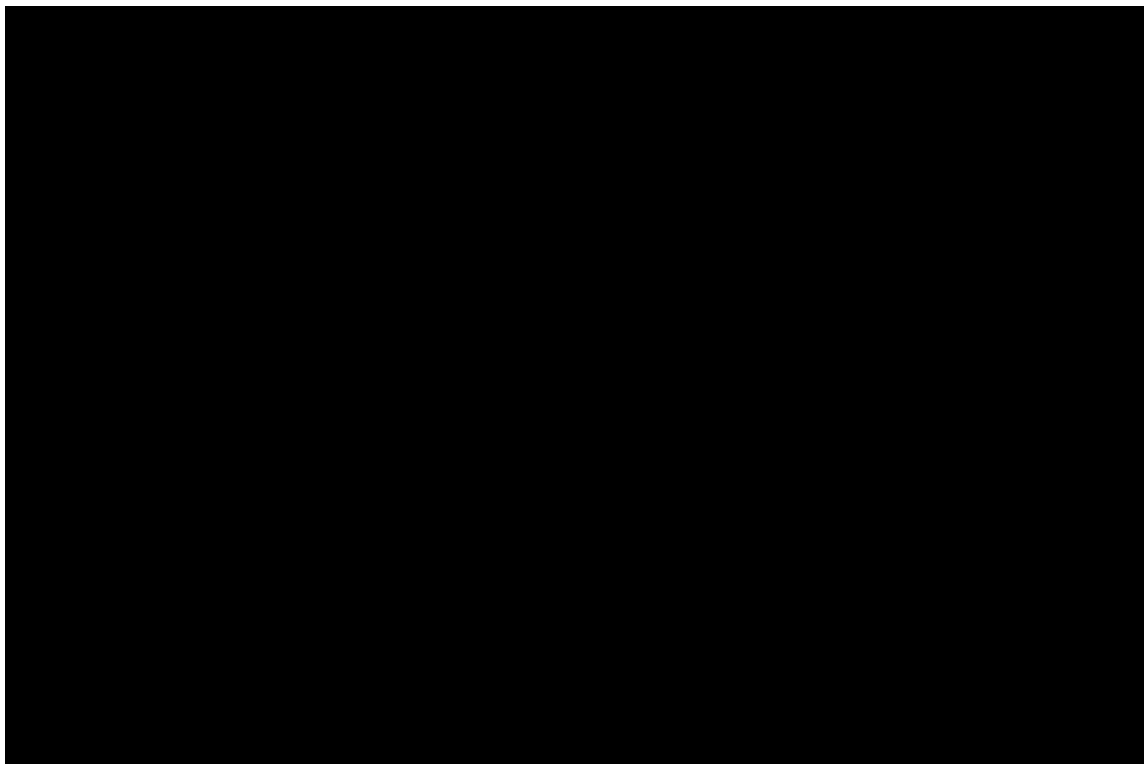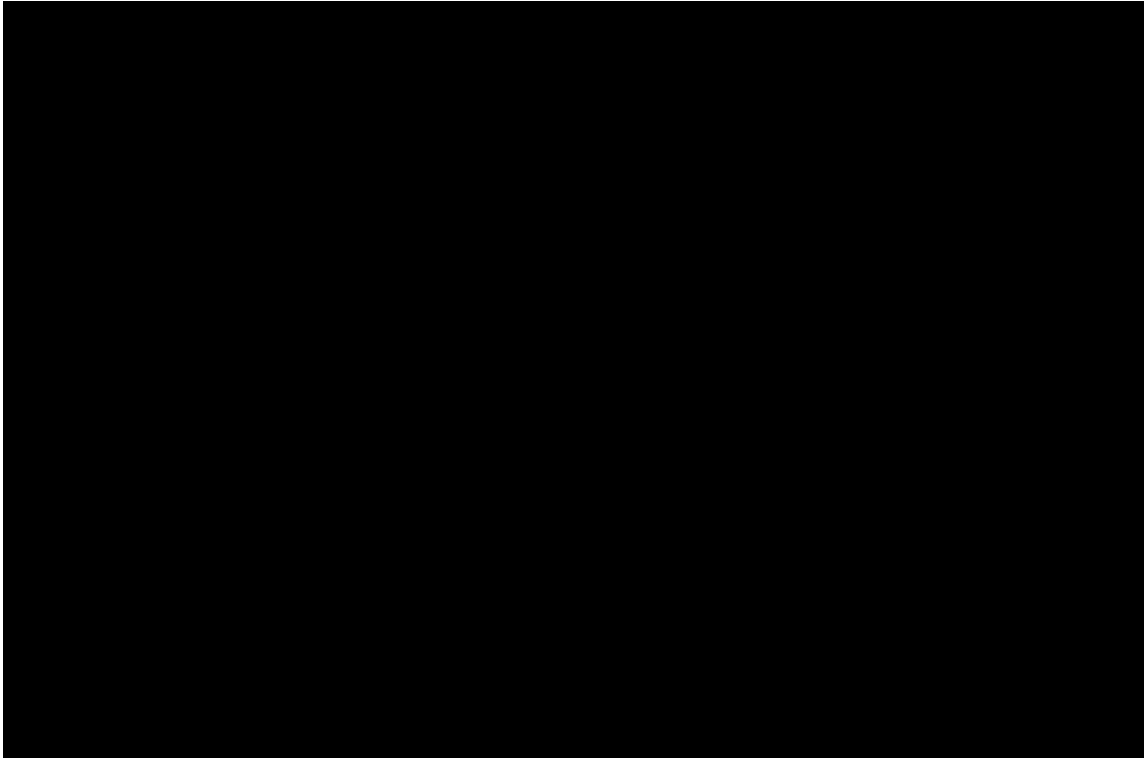**Figure 15:   Resurfacing - tamping cost per km versus kilometres per shift**

Figure 16 includes the additional costs of the stone blowing in the mechanised resurfacing as part of track geometry restoration.

Figure 16:   Resurfacing - tamping and stone blowing cost per km versus kilometres per shift

This graph shows that the unit costs for tamping with stone blowing can range from less than $████/km for long runs to in excess of ██████/km for runs under █ kilometre, and the cost approaches an asymptote at approximately $████/km, again indicating that optimum production costs occur when achieving targets above ██ kilometres per shift.

Plotting QR Network's actual costs and production for the 2011/12 financial year on this graph, indicates that QR Network achieved, on average, ████ kilometres of tamping with stone blowing at a unit cost of $████/km per shift.

For each case, the mechanised resurfacing works show QR Network's costs to be lower than the best case efficiency boundary line. This would indicate that operations are relatively efficient, accounting for the constraints and limitations experienced in terms of track access.

Figure 17 below shows a standard ballast tamping machine.

Figure 17:   Ballast tamping machine

5　Recommendations

Based on the key findings of the study, Evans & Peck considers that the following recommendations would offer QR Network scope to enhance their asset management and maintenance practices, and consequently, provide opportunities for improved cost efficiency.

In presenting these recommendations, Evans & Peck recognises, and is mindful, that the adoption of some of these measures may present some challenges for QR Network, and in a number of instances necessitates the cooperation and support of all parties involved in the supply chain.

5.1　Asset Management and Maintenance

The following recommendations for asset management and maintenance practices are based on the key findings presented in Table 8: Summary of Findings for Asset Management and Maintenance Task.

Table 21:　Recommendations for improved Asset Management and Maintenance

Link to Key Finding	Recommendation
Key Finding 1, Maintenance Cost Efficiency	**_Adoption of an Enterprise Asset Management System_** The adoption of an enterprise-wide asset management system would enable QR Network to optimise their allocation of capital and maintenance investment on the CQCN to meet the needs of their customers, whilst at the same time achieve greater understanding of asset performance and condition. In the future the subsequent application of predictive modelling tools for maintenance planning could also provide maintenance task efficiencies.
Key Finding 2, Maintenance Cost Efficiency	**_Investigate policy of Extended Closures on CQCN_** The investigations conducted as part of this study indicate that a policy of extended closures generally provides better, more reliable services to customers. Whilst such a policy would require the support of all parties in the pit, rail and port supply chain the reasonableness and practicalities of trialling and implementing such a policy through an open collaboration forum, combined with cost and reward sharing arrangements could achieve benefits for all parties.
Key Finding 3, Asset Management and Maintenance Task	**_Increase ballast cleaning maintenance_** The investigations indicated that there is a need to increase ballast cleaning maintenance on all the CQCN systems. This was evident from the findings of both the survey and the publications and research work paths, and is critical to the continued integrity of the track structure support. As such, it is recommended that ballast cleaning maintenance be increased. The analysis also indicated that on the lower trafficked systems of Moura and Newlands that the maintenance intervention levels in respect of ballast cleaning and condition may be more suited to time frequency and condition cycles as opposed to net tonne unit measurements and this should be considered as part of QR Network's asset maintenance policy requirements.

Key Finding 3, Asset Management and Maintenance Task	**Increase mechanised resurfacing of turnouts on Moura and Newlands systems**
	The investigations indicated that there is a need to increase mechanised resurfacing maintenance for turnouts on the Moura and Newlands systems. This was evident from both the survey and the publications and research work paths, and is critical to the continued integrity of the track geometry and structure. Again, maintenance intervention levels in respect of mechanised resurfacing on the lower trafficked systems may be more suited to time frequency and condition cycles as opposed to gross tonnes unit measurements and this should be considered as part of QR Network's asset maintenance policy requirements.
Key Findings 2 & 3, Asset Management and Maintenance Task	**Continue robust coal loss management programs**
	Given the issues that are clearly evident in respect of coal fouling on the CQCN, QR Network should continue with their coal loss management programs and initiatives to ensure the continued and proactive management of the risks associated with coal fouling.

5.2   Maintenance Cost Efficiency

The following recommendations for maintenance cost efficiency are based on the key findings presented in Table 9:   Summary of Findings for Maintenance Cost Efficiency.

Table 22:   Recommendations to enhance Maintenance Cost Efficiency

Link to Key Finding	Recommendations for maintenance cost efficiency
Key Finding 5, Maintenance Cost Efficiency	**Improve the access undertaking framework**
	Changes to the Access Undertaking framework applied to the CQCN could offer opportunities to optimise cost efficiency.
	It is recommended that a review of current arrangements be undertaken, with a view to introducing a financial regime that introduces penalties and rewards to both the asset owner and maintainer and the operators.
	Key performance indicators that are clearly measurable and verifiable against pre-specified targets should be adopted with service level specifications that are aligned with QR Network's organisational, business and service level objectives. Such a regime should also consider penalties and incentives against aspects of train maintenance which significantly impact infrastructure maintenance, for example the condition of coal wagon bottom door mechanisms, and wheel profiling. In addition, factors that provide for discount opportunities to stimulate use of paths that may not be desirable due to timing or other factors should be considered.
	Current marginal pricing theory applications should be reviewed, specifically short run marginal cost variables that are currently applied and alternative variables such as energy supply, distortions to system caused by traction motors, etc. should be considered as improvement measures.

Key Finding 3, Maintenance Cost Efficiency	*Conduct a sensitivity analysis to optimise maintenance intervention levels* The maintenance intervention analysis conducted on the three key maintenance activities of rail grinding, ballast cleaning and mechanised resurfacing identified some areas where maintenance intervention should be increased. A similar sensitivity analysis should be conducted on other maintenance activities to ensure that intervention periods and production levels are optimised across all systems on the CQCN.
Key Finding 4, Asset Management and Maintenance Task	*Undertake labour optimisation investigation* It is recommended that a further investigation and analysis on the impact to maintenance costs arising from the location of depots, with a focus on optimisation the demarcation of depot locations and skills to specifically cater for CQCN maintenance activities.
Key Finding 4, Maintenance Cost Efficiency	*Investigate ways to improve coordination and understanding of the supply chain* Although it is noted that CQCN is reasonably proactive within the supply chain network, empirical data from international and national railways strongly indicates that the price of coordination does impact on maintenance and operational costs. It would be in CQCN's advantage to review the current coordination plan, to ensure that transparency and inclusion is applied at all levels of the supply chain network, at least within the CQCN. It may be worth considering the formulation of common objectives with other supply chain parties, with common indicators to measure how each component of the supply chain is progressing towards the goals that have been set.

6 Disclaimer

This report "Operating and Maintenance Costs: Investigation and Benchmarking" and has been prepared for the exclusive use of QR Network Pty Ltd ('QR Network') and is for the sole purpose of assisting QR Network in its internal consideration of its upcoming Access Undertaking (UT4) Submission to the Queensland Competition Authority (QCA). This report is subject to and issued in accordance with the agreement entered into between QR Network and Evans & Peck Pty Ltd (E&P) on or about the 13^h April 2012 and amended as described in "QR Network's Requirements".

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Evans & Peck has used all reasonable endeavours to inform itself of the parameters and requirements of the QR Network "Below Rail" assets management and maintenance requirements to support its Access Undertaking Submission to the QCA. Accordingly, this review did not attempt to address other aspects or divisions associated with submission process. It also did not attempt to comprehensively address all contributing factors in support of the Submission.

Evans & Peck has taken all reasonable steps to ensure that the report is as accurate as possible given the data and information sourced by Evans & Peck and provided to E&P by QR Network and the scope of services under the Agreement. It must be accepted that there may be additional information that was not reviewed due time constraints or lack of availability. Therefore some information that may have provided additional support to the review findings may not have been considered.

This report is valid only for the conditions reported herein and as of the date issued. Evans & Peck is not required to and does not accept any responsibility to update this report. Evans & Peck does not represent by this report that any assumed conditions concerning the subject matter of the report will be achieved.

Appendix A.

Central Queensland Coal Systems

Newlands System

The Newlands coal system is the northernmost of the systems, and consists of 328km of single track with passing loops at regular intervals. The system services mines operated by Xstrata, Peabody and QCoal, at McNaughton, Newlands, Collinsville and Sonoma, conveying export coal to Abbot Point Coal Terminal (APCT) and domestic coal to the Queensland Nickel Refinery and the Bowen Coke Works. A diagram of the Newlands System is shown in Figure A-1.

Figure A-1: Newlands Coal System

Source :QR National, Newlands Coal System, http://www.freight.qr com.au/Images/1_Newlands_external_tcm12-23882.pdf (14 May 2010)

The Newlands system is not electrified. A typical Newlands Length Train (NLT) consists of 3 x 2250 class 1649kW diesel electric locomotives and 76 x 78 tonne (20 tal) coal wagons.

Currently a project called the Goonyella to Abbot Point Expansion (GAPE) is underway to construct "the northern missing link" connecting the Goonyella System at North Goonyella to the Newlands system at Newlands. This project includes approximately 70 kilometres of new construction and upgrading of the Newlands system to enable it to take 106 tonne coal wagons with 26.5tal. This GAPE project is due to commence transportation of coal in the 2012/13 financial year.

Goonyella System

The Goonyella system includes 978 route kilometres and carries coal to the Hay Point Coal Terminal (HPCT) and Dalrymple Bay Coal Terminal (DBCT). The Goonyella system is connected to the Blackwater system via Gregory and the Oakey Ck Branch. The system services 24 mines and carried 99 million tons in 2009/10. Figure A-2 shows a diagram of the Goonyella System. East of Coppabella loaded trains are constrained by the descent down the Connors range at Black mountain. This has been the site of a major derailment in 2001 and operational constraints are in place to mitigate the risk of future incidents.

Figure A-2: Goonyella Coal System
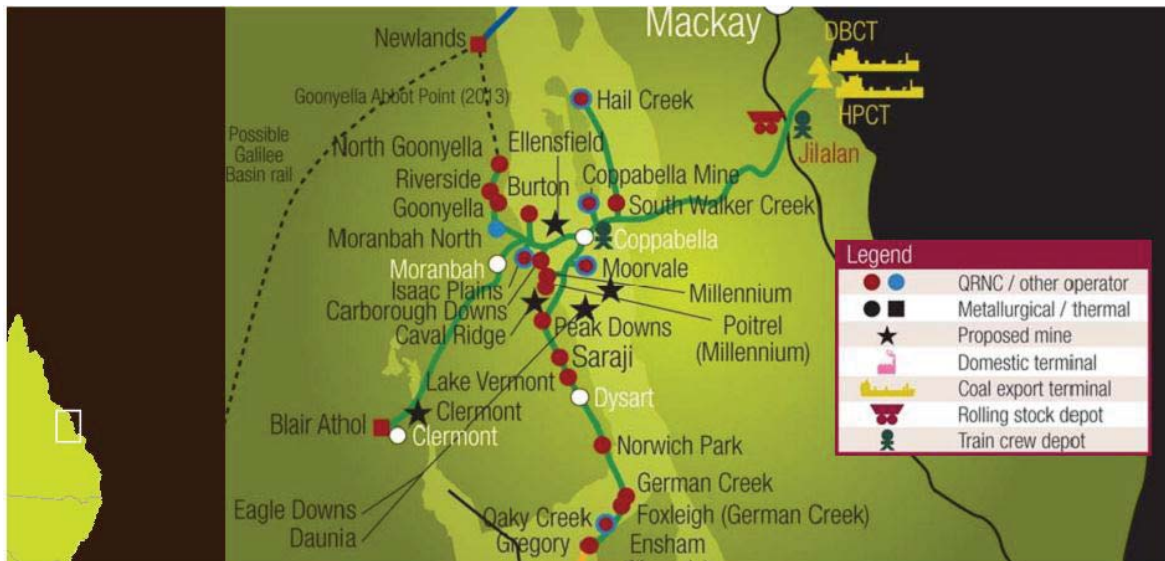
Source :QR National, Goonyella Coal System, http://www.freight.qr.com.au/Images/2_Goonyella_external_tcm12-23883.pdf (14 May 2010)

The railway comprises a bi-directional duplicated track between the ports and Wotonga (west of Coppabella); the remainder is single line with passing loops. The whole system is electrified by an autotransformer system with the overhead line equipment operating at 25 000 volts, 50 Hertz alternating supply. The original electrification occurred in the early to mid-1980's. A typical Goonyella length train (GLT) consists of 3 x 3700 class 4000 kW AC locomotives and 120 x 106 tonne (26.5tal) coal wagons or 5 x 3100/3200 Class 2900 kW DC locomotives and 120 x 106 tonne coal wagons (26.5tal). All trains on the system are electrified. The system handles 96[12] different types of coal products.

Coal is exported out of two ports with stockpile capacity of 1.5 Mt with four ship berths and three ship loaders. The ports are constrained by tide and handle approximately 720 vessels a year (with each vessel approximately 83,000 tonnes). The system currently operates under a demand-pull model or "cargo assembly[13]" driven supply chain. The supply chain aspects of this system have been the subject of some discussion and review; but rail infrastructure has not been identified as the major supply chain constraint.

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12 DBCC Supply Chain Snapshot

13 A "cargo assembly" supply chain is constrained by the capacity of the later elements of the supply chain; such as the stockpile capacity at the port.

Blackwater system

The Blackwater system is the longest network in the CQCN at 1,107 route kilometres; slightly longer than the Goonyella system at 978 km, and carries the second highest tonnages on the QR National network. Approximately 300 km of this line is duplicated and the remainder bidirectional with passing loops. The system carries coal to Stanwell and Gladstone Power Stations and the two major export coal terminals at the port of Gladstone; RG Tanna Coal Terminal (RGTCT) and Barney Point Coal Terminal (BPCT). The system services 15 mines carrying 60 million tons of coal from sources operated by BMA, Xstrata, Rio Tinto, Curragh, Ensham, Felix, and Jellinbah.

A diagram of the Blackwater System is shown in Figure A-3.

Figure A-3: Blackwater Coal System

Source :QR National, Blackwater Coal System, http://www.freight.qr.com.au/Images/3_Blackwater_external_tcm12-23884.pdf (14 May 2010)

In 1988 most[14] of the system was electrified by an autotransformer system with the overhead line equipment operating at 50,000 /25 000 volts, 50 Hertz, alternating supply (50kV/25kV, 50 Hz, a.c).

The Blackwater Line operates both diesel and electric consists. A typical Blackwater length train (BLT) consists of 4 x 3500/3600 Class 2900 kW DC electric locomotives and approx. 88 x 106 tonne (26.5tal) coal wagons. Typical diesel hauled trains consist of 3 x 4000 class 3100 kW diesel locomotives and 88 x 106 tonne (26.5tal) coal wagons. 823 km of the 994 km.

Moura system

The Moura line was the first purpose built coal line in Queensland opening in 1968. The Moura system includes 260 route kilometres and services industrial and rural communities of the Dawson and Callide Valleys, hauling coal to export facilities at RGTCT and BPCT. The system services four mines operated by Anglo Coal. The Moura system is single line with passing loops. The system connects to the Blackwater system at Callemondah. A diagram of the Moura System is shown in Figure A-4.

Figure A-4: Moura Coal System

_ *Source :QR National, Moura Coal System, http://www.freight qr.com.au/Images/4_Moura_external_tcm12-23886.pdf (14 May 2010)*

All trains are hauled by diesel locomotives over single line sections with balloon loops at three locations. A typical Moura length train (MLT) consists of 2 x 4000 diesel locomotives and

Appendix B.

Surveys

20 March 2012

Company Name

Address

Address

Suburb   STATE   PCode

Attention:

Dear

Benchmarking Study: Heavy Haul Railway Operational Review

Evans & Peck has been engaged by QR Network to conduct an independent investigation and benchmarking exercise into operational practices for heavy haul freight railways in Australia and overseas.

QR Network owns and manages the Central Queensland Coal Network and in July 2012 is required to make a submission to the Queensland economic rail regulator in regard to anticipated operational expenditure for maintaining "below rail" assets. This investigation and benchmarking exercise is aimed at gaining an understanding of comparable railway organisations to assist QR Network to base their submission on Australian and international best practice.

Your participation in this study is encouraged. Confidentiality in the data provided by your organisation is assured. QR Network itself will be providing detailed data into the survey. In appreciation of your participation in this study you will have access to data and information in aggregated formats (averages, trends, frequency histograms etc.) and an opportunity to connect with industry peers.

We encourage you to take advantage of this unique opportunity and share information in an open and supportive manner. Please send your responses to the undernoted email account, or alternatively, complete the survey online by **Monday 16 April 2012.**

In support of the survey process we will also follow up with your nominated representative(s) throughout the week of the 9th to 13th April, and will be happy to talk through any areas that require some further clarification or assistance. In the interim period, you are most welcome to contact me directly a

Subject: Heavy Haul Railway Operational Review

Email Response: benchmarking@evanspeck.com

Yours faithfully

EVANS & PECK PTY LTD

Senior Associate

Benchmarking Study
Heavy Haul Railway Operational Review

Disclaimer

In completing this questionnaire, Evans & Peck agrees to make available to you certain data and information received from other questionnaire participants and/or any consolidated report prepared by Evans & Peck which is largely based on the data and information received from other questionnaire participants (**Information**).

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ACKNOWLEDGEMENT AND ACCEPTANCE

I have read, understood and agree to accept the terms of this acknowledgement for and on behalf of [##insert Participant name in full] and I am duly authorised to sign this letter for and on behalf of [##insert Participant name in full]:

Signed by: ....

Print name: ....

Title: ....

Date: ....

Appendix C.

Competitor Network Comparator Database

Appendix D.

Reference Material

Appendix E.

Ballast Fouling Technical Notes

Technical Notes on Ballast Undercutting

The purpose of ballast is to provide drainage and structural support for the heavy loading applied by trains. It provides structural support[22] by:

- Spreading the load from sleepers to underlying formation – in order to do this effectively it must be high in strength. Required strengths for capacity requirements are as specified in the original specifications and design of the track. Poor ballast strength leads to a loss of vertical geometry and the ballast must be replaced.

- Holding the sleepers in position through the angularity of the stones within the ballast. This angularity provides an interlock between the particles, 'digging' into the sleepers and preventing movement of the 'block'. Loss of this angularity leads to longitudinal and lateral instability. Failure of this type is called failure due to attrition and where this occurs at least partial replacement of the ballast should be undertaken

- Providing adequate drainage - loss of voids within the ballast and poor ballast drainage leads to a loss of vertical geometry and if left untreated to the failure modes listed in 1 and 2.

As ballast ages, it gets progressively fouled with fine-grained materials filling the void spaces

When ballast has reached the end of its life through degradation or fouling, intervention and replacement of spoiled ballast is required to avoid impact damage to both track and rolling stock.

Ballast can be replaced manually or mechanically through a variety of methods. However, the most common method of ballast replacement in railways throughout the world is through the use of the Automated Ballast Cleaning machine, which is the main equipment used in the maintenance task of ballast undercutting (and/or ballast cleaning).

Ballast undercutting (or ballast cleaning) is a critical infrastructure preventative maintenance activity. It reduces both above and below operational costs through:-

- Minimising track related speed restrictions

- Reduced risk of derailment

- Avoiding premature replacement of formation, sleepers, rail & fastenings

- Avoiding excessive track maintenance

- Reuse of valuable ballast

Healthy ballast life with designed loading and no adverse environmental conditions is expected to be in the range of 15-20 years. However if normal ballast degradation rates are combined with coal fouling of ballast, increased axle loads and increasing tonnages and subsequent traffic, intervention periods will necessitate significant increases to maintain the required service and reliability. Timely intervention is critical to mitigate the risks of derailments through track structure failure and irregularities. This is particularly relevant for heavy haul systems such as the CQCN, and specifically critical on high density heavy lines such as the Goonyella and Blackwater systems.

Ballast undercutting must be undertaken before too much damage to the ballast is permitted and ballast begins to loose strength and angularity on a large scale. If this happens the ballast may need to be fully replaced in which case and formation work may also be required and the project is then usually considered as asset replacement rather than a maintenance task.

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[22] "Soil Mechanics in Engineering Practice", 3rd Edition Terzaghi et al

Determining Intervention Levels for Ballast Undercutting

Traditionally methods used to assess track ballast condition involved visual checks for evidence of fouling, pumping and water accumulation at ditches and shoulders. This method however can provide insufficient information to determine the condition and extent of fouling and an alternative and more comprehensive method is to adopt ballast sampling and testing for fouling through sieve analyses to provide some insight into the composition of the larger aggregate particles and amount of fines, the results from this analysis are called the percentage void contamination of the ballast. When the UT3 benchmarking survey was conducted in 2008 CQCN were world leaders in the use of regular measurements of per cent void contamination to plan ballast cleaning.

However, since 2005[23] several major derailments have occurred in the US Class 1 railway BNSF which have increased the level of scrutiny and research in the US into finding a better evaluation of the serviceability and proper function of the existing ballast layer, ballast strength and deformation behaviour of the ballast. What is specifically driving this research is a need to be able to differentiate the fouling as different percentages not only based on void contamination but also to recognise the extent of each of the fouling materials, such as plastic soil fines, mineral fillers, and more recently coal dust coming for coal trains. The main reason for this is the recent determination that coal fouling appears to have a greater degradation and derailment risk than perhaps other types of mineral fouling, the following extract is from a US research paper underlining the importance of determining the levels of coal dust contamination

"As the demand for coal transportation increases with the growing energy need, the coal transportation in the U.S. strongly relies on rail transport. Since rail transport, particularly a unit train, provides the most efficient means of transporting bulk commodities such as coal24, the role of rail lines in coal transport has always been predominant.

Today, Powder River Basin (PRB) coal is the largest source of incremental low-sulphur coal supplies in the U.S25. From 2000 to 2005, the 5.6 per cent increase in nationwide coal production chiefly stemmed from the concurrent expansion in PRB coal production, and the Burlington Northern Santa Fe/Union Pacific (BNSF/UP) joint line provided for over 60 per cent of the total increase in PRB coal production (42 million tons of 69 million tons) from 2000 to 2005. However, while the National Coal Transportation Association forecast of the corresponding total coal shipments was 348 million tons, the joint line was able to achieve 325 million tons of the total forecast value because of major operating problems on the joint line2. In 2005, two derailments occurred in the BNSF/UP joint coal line in PRB which threatened to interrupt the supply of coal to power plants. Both of the derailments were suspected to be attributed by coal dust fouling, where coal dust spilled over the ballasts and accumulated moisture, resulting in the loss of strength of the track. In both places where derailments happened, ballast was heavily fouled by coal dust.

BNSF and other coal carrying lines in US are increasing their use of Ground Penetrating Radar as method of assessment for coal fouled ballast

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[23] The accident investigation analysis information from the 2005 derailments was not publically available during the UT3 study

[24] "Transportation of U.S Western Coal: The Impact of Deregulation on Unit Train Rates" Energy Policy 1985 Morrison 1985

[25] "Update on PRB Coal Transportation – Still a hot issue http://www.paceglobalcom/paceglobal/pdfs/publications/Recurring%20Articles/CA_pg32-35-June%202006.pdf , Gaalaas 2006

Ballast Fouling

Two indices have been traditionally used to describe ballast fouling[26]:

▪ "fouling index" is the sum of the per cent by weight of ballast sample passing the 4.75mm sieve plus the per cent passing the 200 sieve; and

▪ "percentage of fouling" is the ration of the dry weight of material passing a 9.5mm sieve to the dry weight of the total sample

Partially fouled ballast will have voids in between contacting aggregates however there will still be aggregate to aggregate contact, in fouled ballast, aggregate to aggregate has been eliminated due to excessive amount of fine particles. In excessive fouling conditions, i.e. the 2005 PRB derailments wet coal dust was completely filling all voids in the ballast and pumping was occurring on the track. In this case the coal (or fouling agent) was carrying the wheel load and hence a derailment occurred due to unstable support for the heavy load.

Technical Notes on Coal

The following are relevant technical and chemical attributes of coal that potentially impact on railway infrastructure:

▪ chemical consistency of coal has a caustic effect on concrete, steel and some stone materials[27] - **thus potentially increasing the risks of attrition failure**;

▪ Coal dust distributed on the track tends to be fine thus fills the voids required within the ballast, clogging up drainage and reducing elasticity of the ballast;

▪ **Coal size has a direct effect on dustiness and heap size** – may also impact leakage from doors. Some mines in the United States are testing increased coal size but currently there is no public information on dust distribution in various sizes;

▪ **Coal dust is weak in stress tests** (approximately 10 times lower than weak DuPont Clay at optimum moisture content);

▪ **Direct shear test results** indicate that coal fouled ballast exhibits a significant decrease in shear strength; and

▪ When dry coal dust is wetted, this results in and even more drastic loss of strength.

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Appendix F.

Industry Cost Benchmarking Analysis

Industry Cost Benchmarking Methodology

A list of national railway organisations was compiled for industry cost benchmarking, based on publically available information of the respective organisations. The financial information relating to maintenance costs was extracted for the purposes of the analysis.

The following railway systems were considered as part of the benchmarking exercise.

- AR Network Central Queensland Coal Network (Moura, Newlands, Blackwater and Gooneyalla systems)

- ARTC Hunter Valley Coal System (HVCN)

- ARTC Interstate Rail Networks

- WestNet Rail (now Brookfield)

- Victorian Rail Freight Network

The ARTC HVCN provided the greatest comparison to the four QR Network systems in terms of characteristics, freight commodity and traffic hauled, and on this basis, the detailed benchmarking was conducted focussing on these five systems. Notwithstanding this, all systems were analysed based on the available information. Normalising, however, was only applied to the QR Network systems and the ARTC HVCN.

The normalisation factor was calculated for comparison between the different railway systems. The benchmarking data was normalised, applying the principles used previously for the '*Benchmark Heavy Haul Line – International and National Comparison*' report developed by WorleyParsons, 2008.

All maintenance expenditure figures were escalated to June 2011 dollars, utilising ABS producer price indices (Road and Bridge Construction) dependent upon geographic location.

Conversion factors between Gross Tonne Kilometres (GTK) and Net Tonne Kilometres (NTK) were calculated utilising track and train consist information acquired through the survey responses and publicly available information, and applied to the analysis where required.

Numerous graphs were subsequently created with the aim of finding the optimal correlation between industry costs in Australia. For the primary benchmarking figure used for the five key rail systems, net system tonnage was chosen as the independent variable, with 2011 dollars per track kilometre chosen as the dependent variable, allowing for a unit cost basis representation.

An exponential trend line was also applied to the graphs to construct efficiency bands based on a simple linear regression analysis to present efficiency boundaries of ±10% and ±25%.

The following sections of this appendix summarise the data used, underlying principles applied to the regression analysis and normalising process, together with the additional supporting findings to section 4.3.3 of the report.

1. Benchmarking Data and Figures (QR Network and ARTC HVCN systems)

2. Regression Analysis

3. Supplementary Figures

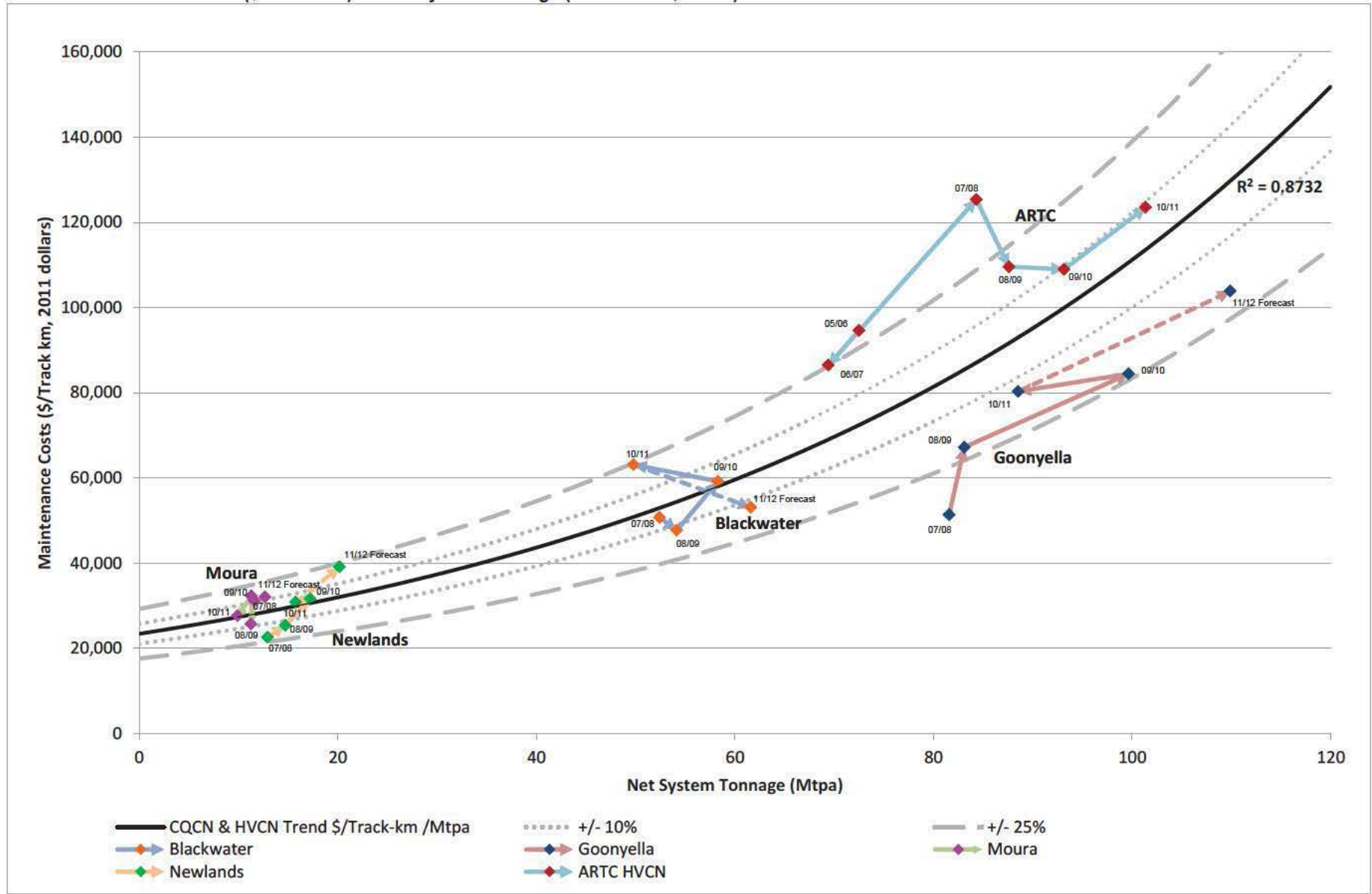4. Normalisation

3   Supplementary Figures

Figure 1 and Figure 2 found below, plot the comparisons for maintenance costs in dollars per track kilometres against net system tonnages, and are extensions of Figure 9 found in Section 4.3.3 of the report. Figure 1 expands on the figure in the main body by attempting to forecast maintenance costs for the 2011/12 financial year by utilising the 100% value of the corporate planned tonnages along with individual system trends[1]. For the majority of systems, the forecasted values appear to closely relate to the overall exponential trend found for all systems.

Figure 2 adds ARTC's East-West and North-South lines, Westnets Goldfields Railway and Victorian Freight's Regional Fast Rail data to the existing QR Network and ARTC HVCN data; however, due to limited information on tonnages, these are depicted as horizontal lines rather than discrete points and do not influence the overarching trend line of the graph.

Figure 3 below plots maintenance costs in dollars against system net tonne kilometres. Due to its lower coefficient of determination as compared to Figure 9 in section 4.3.3 of the report and its alternate independent variable (NTK), it has not been included in the main body of the report. However it is of note that the findings from this analysis substantiate those found in Figure 9, which demonstrates that generally, CQCN systems appear to be within the calculated efficiency band.

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[1] ARTC HVCN did not provide forecasted tonnages for 2011/12, and were thus not forecasted in Figure 1.

Figure 1: Forecasts - Maintenance Costs ($/Track-Km) vs Net System Tonnage (QR Network, ARTC)

4   Normalisation

To increase accuracy in comparison of factors relating to track, it is generally necessary to account for variables which contribute to such a comparison. Thus, prior to establishing relationships and trends, the benchmarking data was normalised using a 'normalising factor', using methodology found previously in the *'Benchmark Heavy Haul Line – International and National Comparison'* report by WorleyParsons, 2008.

It should be noted that where insufficient factor data was available, those factors were either negated[2], or proportioned according to network characteristics. Further, as mentioned in section 4.3.3, other factors such as ballast contamination, maintenance lags and renewals could not be accurately accounted for. Although further rigorous normalisation may strengthen correlations, the combination of a lack of a reliable method to do so, the significant time required, and the considerable controversy to the inherent value of normalisation led to a decision to continue to utilise the previous normalisation methodology.

The normalising factor is calculated using the undernoted formula, using 4 individual factors (A – Formations, B – Structures, C – Track Quality and D – Track Gauge):

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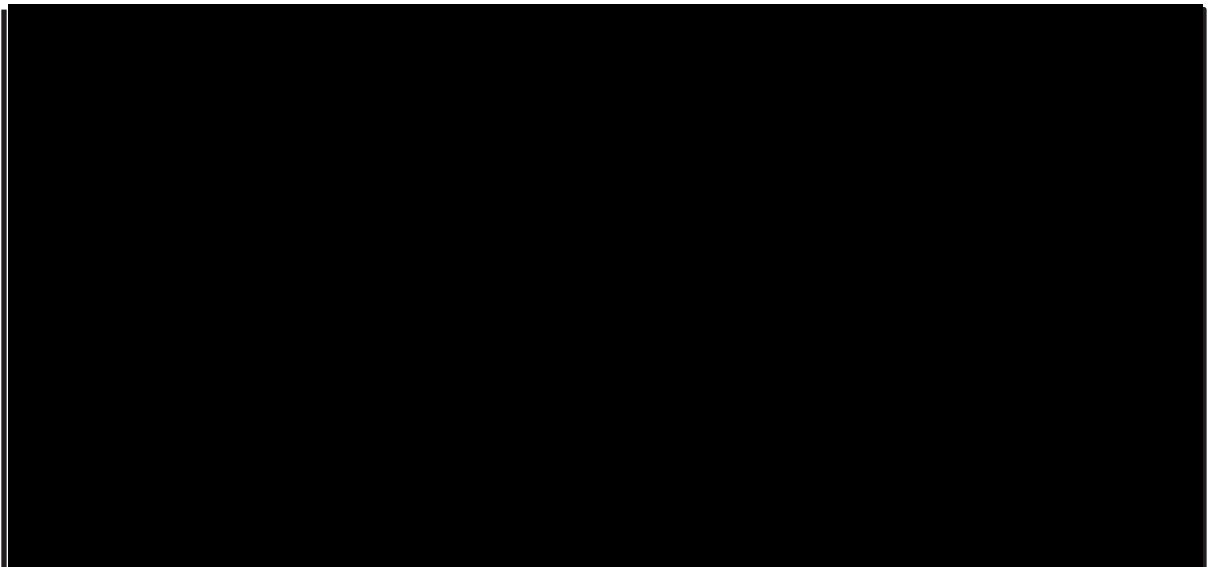
[2] As highlighted in yellow in Table 3.

5   Escalation of Maintenance Costs

The maintenance expenditure figures used in the analysis come from the financial years 2005/06 to 2010/11. For the benchmark analysis, all the costs were escalated to June 2011 dollars. The costs were escalated using the ABS Producer Price Index – Road and Bridge Construction from the Australian Bureau of Statistics (ABS 6427.0). The respective state index was applied for each network's maintenance expenditure, with the Australian index used for the ARTC Interstate Network. The cumulative escalation in the indices from June 2006 to June 2011 is shown in Figure 4.

Figure 4 Cumulative escalation from June 2006 from ABS Producer Price Index - Road and Bridge Construction (ABS 6427.0)
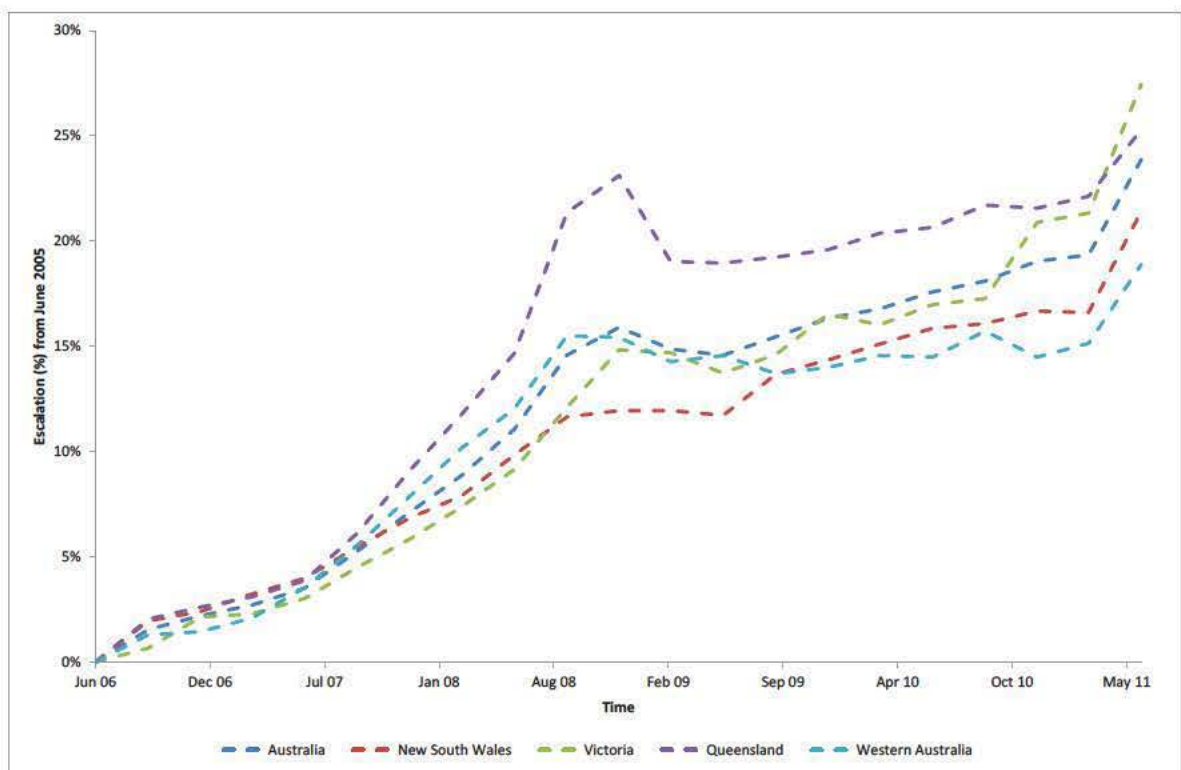
Appendix G.

Independent Cost Estimates