2017 HUNTER VALLEY CORRIDOR CAPACITY STRATEGY

March 2018

ARTC

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INTRODUCTION

Context

On 5 September 2004, the Australian Rail Track Corporation (ARTC) commenced a 60-year lease of the interstate and Hunter Valley rail lines in New South Wales.

In early 2005, ARTC began to release annual Hunter Valley infrastructure enhancement strategies setting out how ARTC planned to ensure that rail corridor capacity in the Hunter Valley would stay ahead of coal demand.

This 2017 Hunter Valley Corridor Capacity Strategy (the "Strategy") is the eleventh of these annual strategies. It updates the 2016 Hunter Valley Corridor Capacity Strategy (2016 Strategy).

This Strategy has been released later in the year than previous Strategies. This new timing allows the Strategy to incorporate updated volume nominations from producers and to use the 2018 HVCCC declared inbound throughput (DIT) assumptions. The analysis therefore now focusses on the 2018—2027 period where under the old timing it would have adopted a 2017—2026 period with assumptions based on the 2017 DIT.

The Hunter Valley rail network (figure 1-1) is an integral part of the world's largest coal export supply chain. It consists of a dedicated double track 'coal line' between Port Waratah and Maitland, a shared double track line (with some significant stretches of third track) from Maitland to Muswellbrook in the upper Hunter Valley, and a shared single track with passing loops from that point north and west.

All export coal shipped through Newcastle is transported by rail across this network for shipping from Carrington (Port Waratah), or one of the two terminals on Kooragang Island.

In common with the earlier strategies, this Strategy identifies the future constraints on the coal network's capacity in the Hunter Valley, the options to resolve these constraints and a proposed course of action to achieve increased coal throughput.

The fundamental approach of ARTC in developing this Strategy has been to provide sufficient capacity to meet contracted volumes based on the principles of the ARTC Hunter Valley Access Undertaking (HVAU). It also identifies those projects that would be required to accommodate prospective volumes that have not yet been the subject of a contractual commitment, though this is a hypothetical scenario only and does not imply that those volumes will be contracted.

Throughout 2017 ARTC had interest expressed by existing or new access holders in potential contractual volume growth. To provide a richer level of analysis in the current demand environment, this Strategy also provides a 'most likely' volume forecast in addition to the usual 'contracted' and 'prospective' scenarios. This scenario is based on contracted volume, plus volumes for which there is strong evidence that they could be produced, and for which there is interest in contracting.

This Strategy identifies a preliminary scope of work to accommodate contracted plus prospective volumes of up to 241 mtpa. This is a reduction in the peak volume compared to the 2016 Strategy, reflecting an environment where prospective new volumes are increasingly offsetting declining volumes from older mines, rather than adding to total volume.

It also identifies a pathway for meeting demand under the most likely scenario. Contracted volumes do not require any investment for capacity.

It is important to note that the whole Hunter Valley coal supply chain is interlinked. The stockpiling and loading capability of the mines affects the trains required, the train numbers affect the rail infrastructure and so on. The capacity and performance of the system is entirely interlinked and the capacity of the rail network needs to be considered in that context.

Capacity analysis in this Strategy takes no account of the capabilities of loading and unloading interfaces, including the capabilities of private rail sidings and loops. In other words, at the conclusion of each project the identified rail capacity will be available, but this does not necessarily mean the coal supply chain will be able to make use of this capacity at that stage. This broader capacity analysis is undertaken by the Hunter Valley Coal Chain Coordinator (HVCCC).

In determining capacity ARTC makes certain assumptions which are generally covered in this Strategy. The delivery of throughput to align to capacity can be impacted by a range of performance issues across the supply chain. While some of these performance issues are covered in this document, it is not the key purpose of the Strategy.

Responding to Changing Needs

In comparison to the context of the 2016 Strategy, there has been a significant lift in the coal price which has in-turn flowed through to an increase in interest in contracting additional volume through the supply chain.

At the same time, ARTC appreciates that market conditions in global seaborne thermal coal can shift and that to maintain long term competitiveness as an industry it's important that additional capacity is delivered efficiently.

The 2016 Strategy included an explicit refocussing of ARTC's forward investment program toward technology and innovation with a view to increasing the efficiency and lowering cost on a whole-of-coal-chain basis. Underpinning this approach is the introduction of new processes and technology under the ARTC Network Control Optimisation (ANCO) project to optimise ARTC's train network management in the Hunter Valley through enhanced dynamic capability to manage variation as part of an interconnected supply chain where many operations interact and influence the network operation.

This can be supplemented by implementation of the Advanced Train Management System (ATMS) which provides communications based safeworking.

While these initiatives offer significant improvements in efficiency, they also have the potential to increase utilisation of existing assets at relatively low cost. The focus on technology and innovation therefore aligns well with a strategy of delivering both increased efficiency and capacity and accordingly this Strategy maintains its focus on these initiatives.

Volume Forecasts

Currently contracted export coal volumes are 192.5 mtpa in Q4 2017. They are essentially stable at approximately this level until export volumes start to decline in 2024, falling to 152 mtpa in 2027. ARTC contracts on a rolling 10 year "evergreen" basis and access holders are choosing to not roll-over some volume. This volume is not currently being replaced by new volume contracts.

Contracted volumes also include up to 10.1 mtpa of domestic coal. This volume is included in all modelling of capacity and utilisation. It includes recent growth in volume from the Hunter Valley to Central Coast power stations. This volume declines to 8.8 mtpa in 2021 and to zero in 2026.

In addition to contracted volumes, ARTC, in consultation with the HVCCC, has identified new mines that producers could develop and existing mines where volumes could potentially grow. These projects are at different stages of development and not necessarily at a stage where producers would consider contracting, but to ensure that ARTC is able to plan appropriately for possible future growth are all considered in this Strategy as a prospective volume scenario. No additional coal projects have been identified for this Strategy compared to the 2016 Strategy. There are four undeveloped mines in the prospective volume scenario, plus the planned reopening of Dartbrook. Lapsed domestic volumes are assumed to be diverted to export.

Under the provisions of the ARTC Hunter Valley Access Undertaking, it is a matter for the Rail Capacity

Figure 1-1 - The general location of the Hunter Valley network on the east coast of Australia.

Contracted plus Prospective Volume at Newcastle Ports

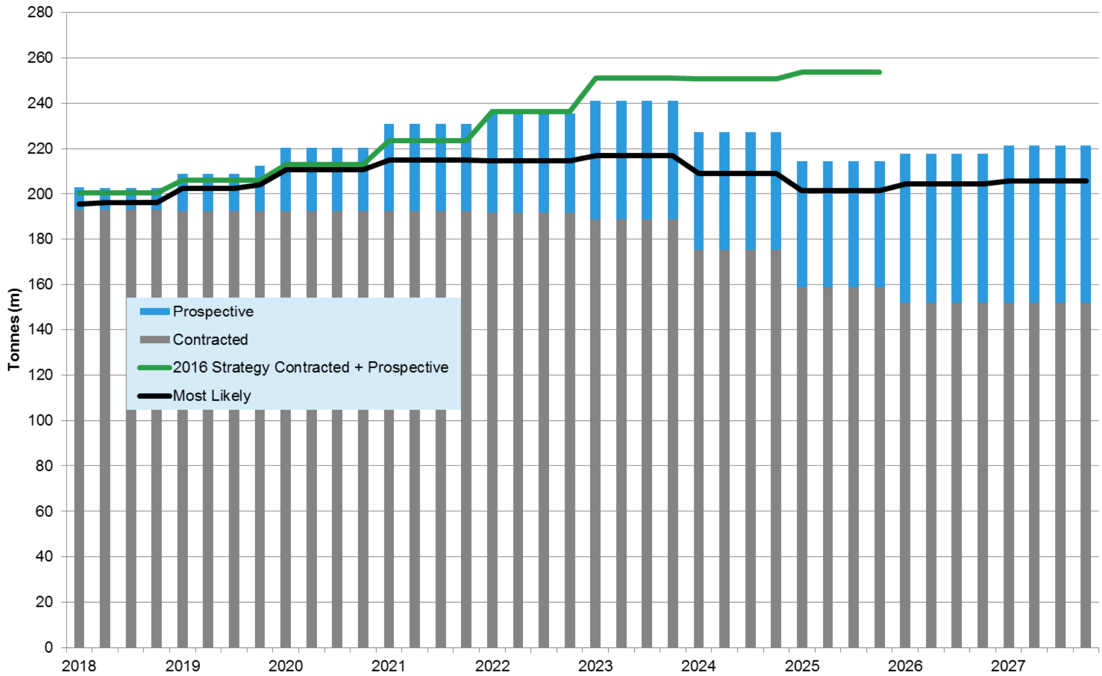

Figure 1-2 - Current Volume Forecasts vs. 2016 Strategy Volume Forecast, Newcastle Terminals (mtpa)

Contracted plus Prospective Volume - at Muswellbrook

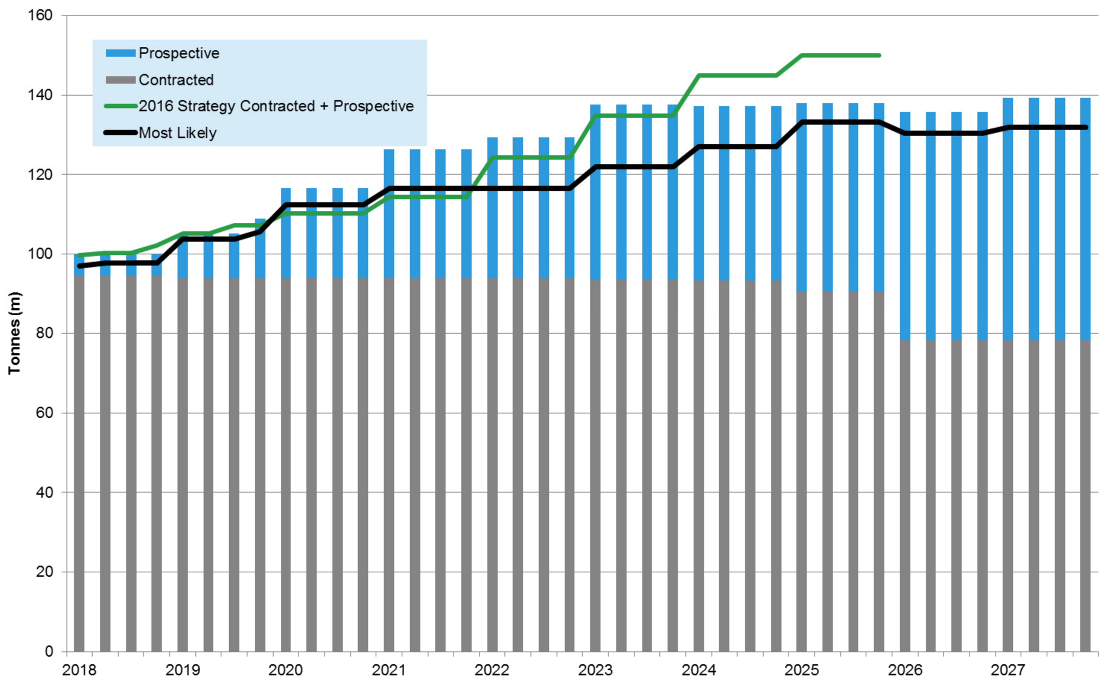

Figure 1-3 - Current Volume Forecasts vs. 2016 Strategy Volume Forecast, Muswellbrook (mtpa)

Group (RCG) to determine the prospective volumes that are to be used for the purposes of this Strategy. The RCG comprises representatives of the access holders, along with the HVCCC and rail operators.

The prospective volume scenario was considered at the August RCG meeting and endorsed.

The prospective volumes are hypothetical and have been used for modelling purposes with no firm commitment that the prospective volumes will be realised. Prospective volume is estimated at around 9.7 mtpa in 2018, 17.4 mtpa in 2019, 27.9 mtpa in 2020, 38.4 mtpa in 2021, 43.7 mtpa in 2022, 52.2 mtpa in 2023,and 2024, 65.8 in 2026 and 69.3 mtpa in 2027.

These prospective volumes are somewhat smaller than those adopted last year reflecting the buy-back of the Caroona exploration licence by the NSW Government, uncertainty about the Mt Penny and

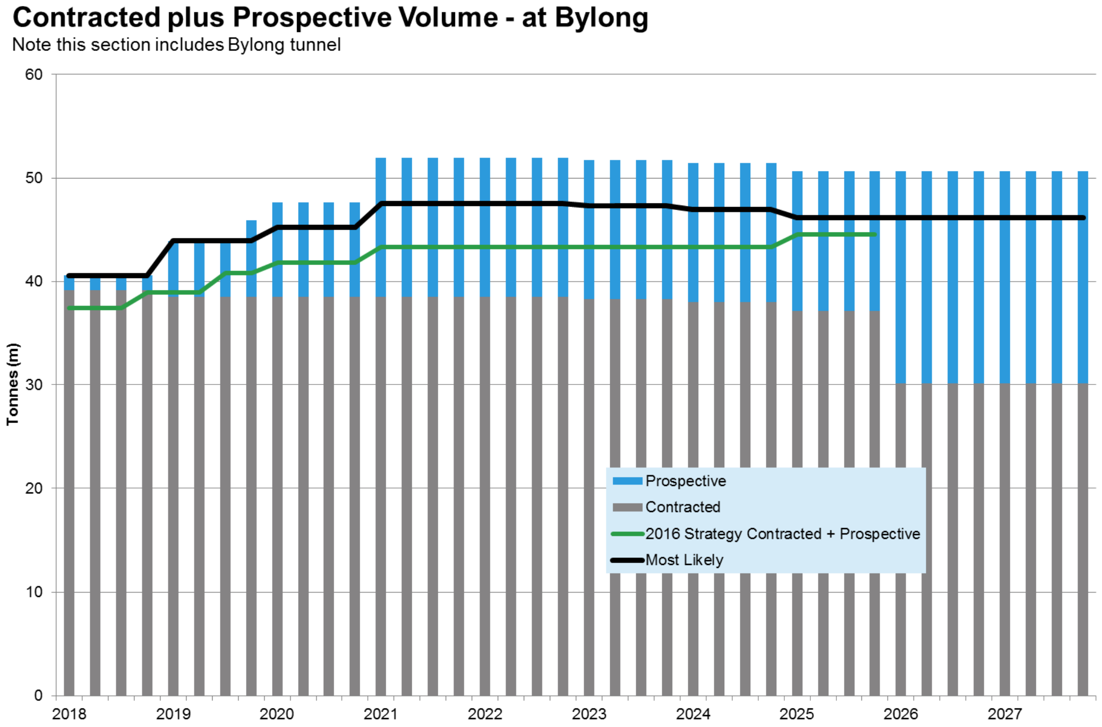

Figure 1-4 - Current Volume Forecasts vs. 2016 Strategy Volume Forecast, Bylong—Mangoola (mtpa)

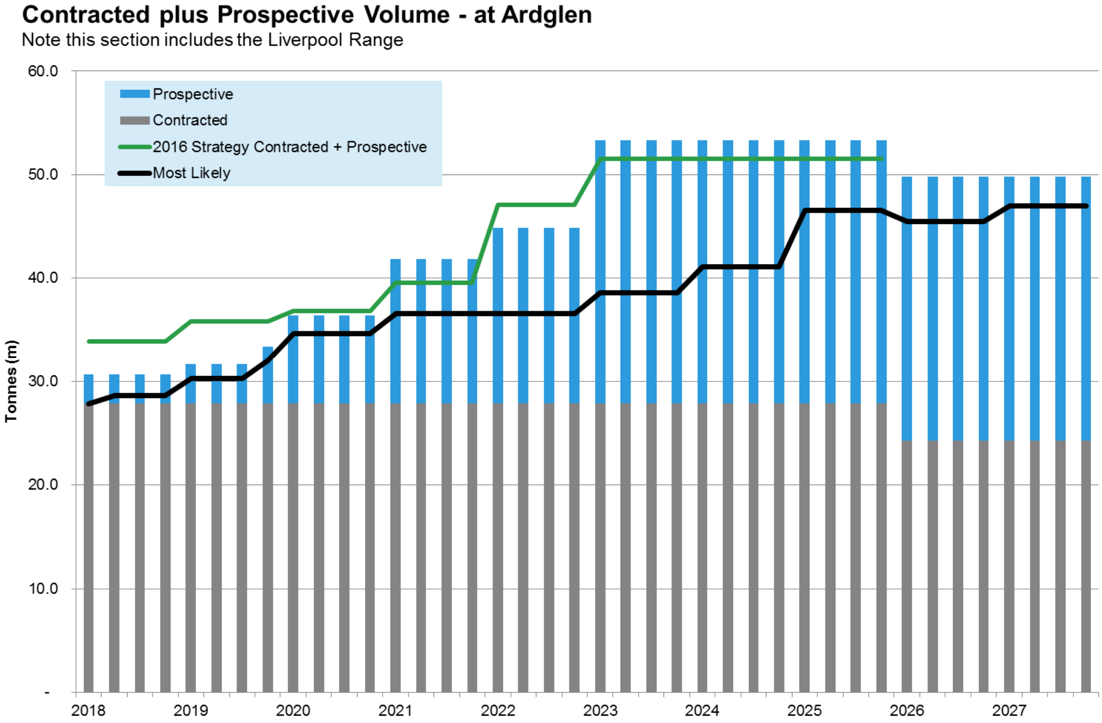

Figure 1-5 - Current Volume Forecast vs. 2016 Strategy Volume Forecast, Werris Creek—Muswellbrook (mtpa)

Doyle's Creek mines, and a less sanguine outlook for a number of potential mine life extensions. The reduction in peak total volume reflects the decision of some producers to not roll-over contracts for existing volumes as part of the 10 year rolling contract arrangement. This has not been offset by a corresponding increase in additional prospective projects.

In the most likely scenario, volume at Newcastle peaks in 2023 before falling back to around 200 mtpa in 2027. This is an increase relative to current volumes.

Figures 1-2 to 1-5 compare the forecast volumes from the 2016 Strategy with the forecasts used for this Strategy. A comparison is made at the Newcastle terminals, at Muswellbrook, for the Bylong – Mangoola section (which is the majority of the Ulan line), and

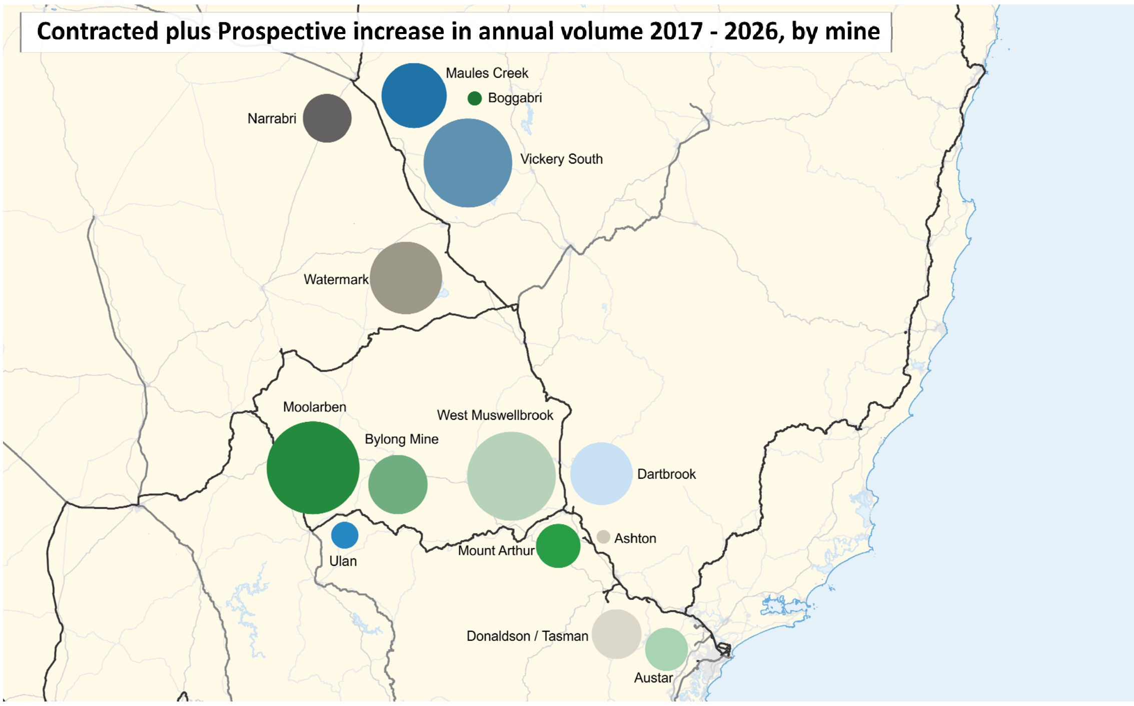

Figure 1-6 - Volume forecasts by mine, contracted plus prospective. Note that growth is represented by diameter

Werris Creek – Muswellbrook (which is representative of most of the Gunnedah basin line). Figure 1-6 shows net growth under the prospective scenario geographically, while figure 1-7 shows train numbers by zone. These figures highlight the ongoing transition of volume from south of Muswellbrook to the north and west.

In recent times there has been a small but notable volume of traffic from the Western and Southern coal fields that has been being exported through Newcastle rather than the traditional Port Kembla export pathway. This volume is generally using paths contracted from the coal fields south of Newcastle and on this basis has been included in the volume forecasts in this Strategy.

How this Strategy has been developed

The development of this Strategy retains the methodology of the 2016 Strategy.

In compliance with the HVAU, the RCG, which is the official approval body representing access holders under the HVAU, has endorsed the prospective volume assumptions required to be used as the basis for the development of the Strategy.

In common with previous Strategies, coal capacity is analysed using a set of principles for the practical utilisation of track. Capacity is calculated using headways. On single track the headway is defined as the time the front of a train enters a section between loops until the time that the rear of the train clears the turnout for the loop at the other end of the section. The longest headway between two loops on a section of track defines the capacity limit for that section. This is then adjusted to reflect practical rather than theoretical capacity using an adjustment factor of 65%.

On double-track, the headways are calculated on the basis of the 'double-green' principle. Under this principle both the next signal and the one after are at green, meaning that the driver theoretically will never see a yellow signal. This ensures that drivers should always be able to drive at full line speed.

On single track there is also a transaction time applied to recognise the time incurred by trains executing a cross, specifically signal clearance time, driver reaction time, acceleration and delays to the through train when it approaches the loop before the train taking the loop has fully cleared the mainline. Simultaneous entry loops and passing lanes reduce this transaction time by reducing both the probability and time delay from both trains arriving at the loop at around the same time.

After adjusting the capacity to reflect contracted non-coal trains, saleable paths are calculated as a percentage of practical coal paths. This adjustment covers maintenance, cancellations and a surge buffer.

Consistent with the HVAU, the buffer has been formalised in the form of the Target Monthly Tolerance Cap (TMTC). The RCG stated preference is for a 10% TMTC which is applied across all three pricing zones.

The calculation of the adjustment factor, based on cancellation and maintenance loss assumptions as determined by the HVCCC for calculation of the 2018 DIT is shown in Table 1-1. Note that the adjustments are

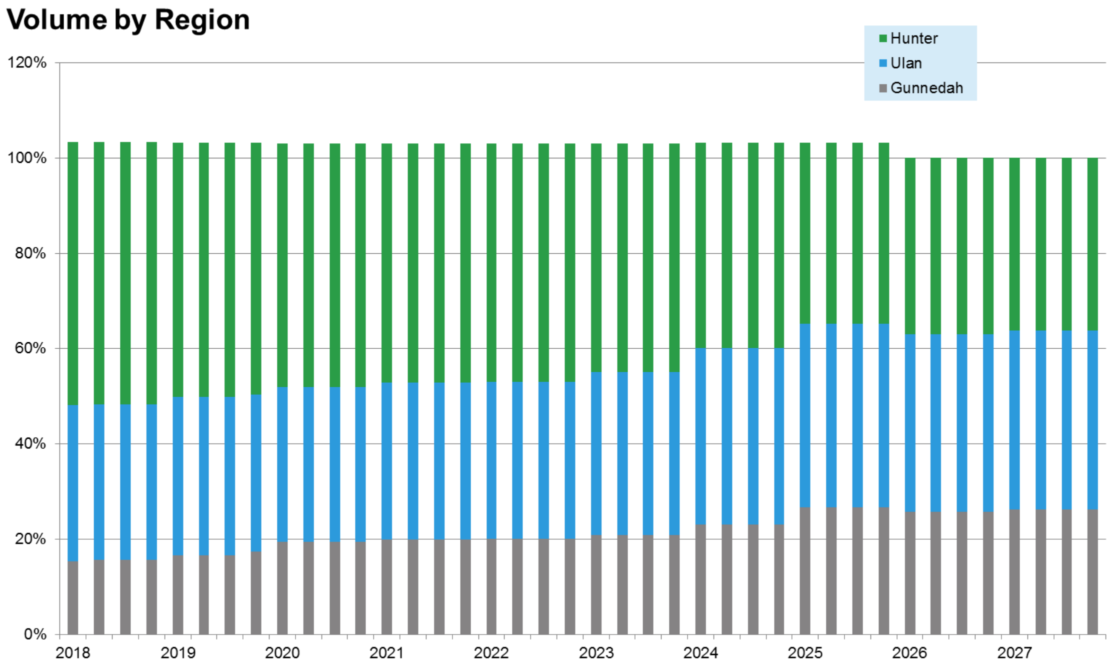

Figure 1-7 - Percentage of Trains by Sub-Network by Year, including prospective volume (see Note 1)

Note 1: Total train numbers in figure 7 are calculated as trains from each of the three zones as a proportion of all trains arriving at the port. The total number of trains exceeds 100% up to Q4 2025 due to domestic coal.

cumulative (that is, sequentially multiplied) rather than additive.

The estimated cancellation rate is 9.1%, which equates to the 8.3% cancellation rate as per the 2018 DIT assumptions released by the HVCCC. It is expressed as 9.1% as it is applied as an escalation rather than a reduction.

Both cancellations and maintenance losses are higher than the rates used in the 2016 Strategy. This causes a small reduction in the theoretical capacity.

To the extent that cancellation or maintenance loss assumptions change in future years it will flow through to the required adjustment factor, which in turn may trigger the addition or deletion of projects. Ideally this Strategy would be based on forward estimates of cancellations and maintenance losses on a year by year basis. However, at this time the HVCCC only finalises these losses for the year ahead and only does so when determining the DIT. Accordingly this Strategy assumes the HVCCC estimates for 2018 apply for all years.

An alternative approach that may create greater certainty would be to hold the cancellation rate for each tranche of volume from each mine at the level it was when that volume was contracted. ARTC will consider adopting this approach for the 2018 Strategy.

Adjustment factor	2016	2017
Cancellations	8.0%	9.1%
Maintenance	11.5%	12.1%
TMTC	10.0%	10.0%
Adjustment Factor	**75.5%**	**74.3%**

Table 1-1 - Adjustment Factor (note that the final total is arrived at by multiplication of the percentage rates rather than addition)

The 2016 Strategy described the background to moving from simulated performance as the basis for calculating capacity to actual performance derived from the digital train radio system. This was applied to the Gunnedah basin in 2016 and has now also been applied on the Ulan line.

In addition, the system has been used to calculate actual rather than theoretical transaction times. Previous Strategies adopted a transaction time of 5 minutes for a standard crossing loop, 4 minutes where a simultaneous entry loop is involved and 3 minutes where a passing lane or the start of double track is involved, but these have now been replaced by actual transaction times as discussed in the relevant Chapters.

When two opposing trains arrive at a loop at around the same time it is necessary for both trains to stop, or at least slow down. One train is held on the mainline before the loop while the other train enters the loop. This can lead to a significant delay for the through train. The effect of these simultaneous arrivals is not picked-up in the process for calculating transaction times from the train location data.

To further improve the robustness of the transaction time assumption, the effect of simultaneous arrival has been modelled in more detail than previously. This modelling has taken into account both the time loss effect of a through train needing to stop and the probability of a simultaneous arrival event occurring.

This has suggested that the appropriate allowance for simultaneous arrival is in the order of one minute rather than the two minutes previously allowed. A simultaneous entry loop, which has either a longer length or additional signalling, saves around 15 seconds of this, rather than one minute as previously assumed. These values have been adopted as supplements to the actual calculated value of signal clearance time, driver response and acceleration.

The methodology has also been modified to better model capacity utilisation where a mine branch connects part way through a single track section. This has not resulted in any changes to scope or timing of projects. It does have the effect though of in some cases causing capacity on a section to differ between volume scenarios. This can be seen in Figures 7-1 and 7-2.

Terminal Capacity

ARTC's understanding of terminal capacity is that nameplate capacity currently sits at 208 mtpa.

Significant growth beyond 208 mtpa would be expected to be met by the PWCS development of Terminal 4 (T4). The T4 project was granted planning approval on 30 September 2015 but in the absence of contracted demand remains on hold. There is also a prospect of modest increases in terminal capacity in advance of T4. For the purposes of this Strategy it has been assumed that incremental capacity could be available progressively from Q1 2020 if required and that T4 could start to ramp up in 2022.

There is no requirement for additional terminal capacity for ARTC contracted volumes. The most likely scenario could require incremental enhancement in late 2019. The prospective scenario would potentially exceed the capacity of the terminals even with incremental enhancements, but only for a few years.

The relationship between contracted volumes, prospective volumes as endorsed by the RCG, ARTC's 'most likely' scenario, and potential terminal capacity as assumed for this Strategy, is shown in Figure 1-8.

HVCCC Master Planning

The HVCCC is responsible for the co-ordination of coal chain planning on both a day-to-day and long term basis. It is continuously developing a Hunter Valley Master Plan that deals with the optimisation of capacity enhancements across all elements of the coal chain with a view to providing an integrated planning road map.

ARTC is strongly supportive of this master planning process. It sees this Strategy as both needing to provide the supporting rail infrastructure analysis for the master planning process, and to respond to the investment options identified in the master plan.

The HVCCC also makes an annual declaration of the system capacity of the Hunter Valley coal chain. This is the lesser of terminal system capacity, rail system capacity and demand. Terminal and rail capacity are determined through simulation modelling. For 2018, the HVCCC has determined a DIT that was less than track system capacity. HVCCC has forecast that track system capacity will not constrain currently contracted volumes.

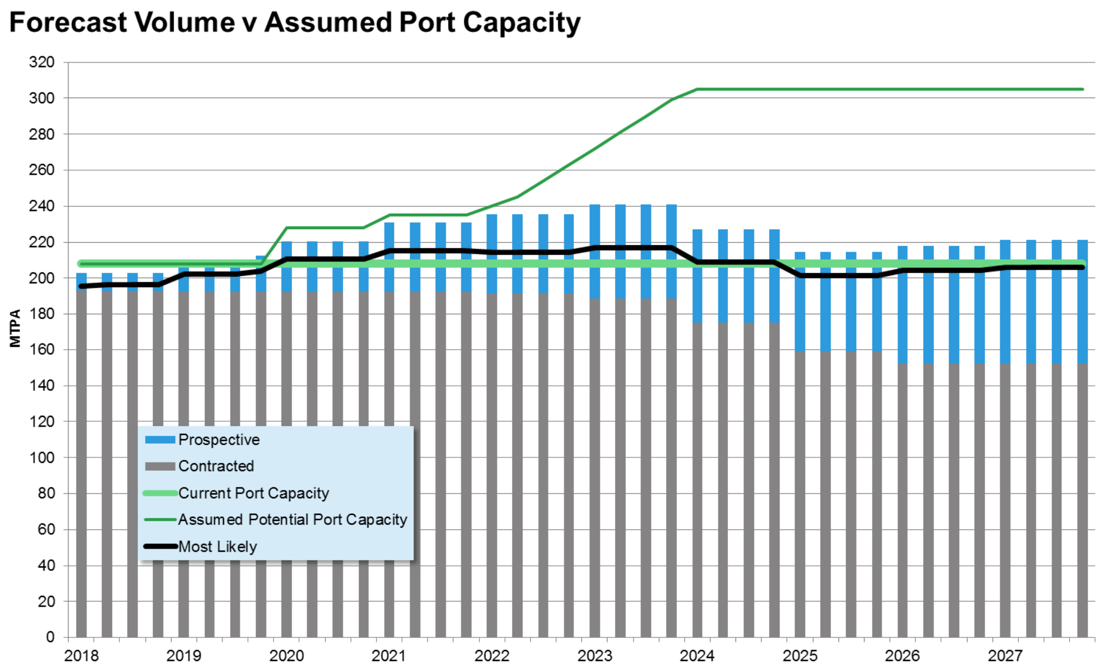

Figure 1-8 - Forecast volume at Newcastle Port compared to assumed port capacity (mtpa)

2

OPERATIONS AND SYSTEM OPPORTUNITIES

Context

Operational and system opportunities have become increasingly important as the coal chain focusses on optimising efficiency and capacity within the constraints of the existing infrastructure. Increasing efficiency provides the platform for the Hunter Valley to maximise its competitive advantage within the global export coal market.

The Hunter Valley coal chain is built around the need to feed coal into the export terminals owned by Port Waratah Coal Services (PWCS) and Newcastle Coal Infrastructure Group (NCIG). These two terminals run to different operational modes. PWCS, which provides approximately 65% of export capacity, utilises a pull based system assembling discrete cargoes to meet vessel arrivals. NCIG, responsible for the remaining 35% of export capacity, operates largely on a push based system with a large percentage of its stockpiling capability allocated to dedicated storage for individual customers.

Operational planning and live-run disruption coordination is undertaken by the HVCCC. The daily schedule is constructed by the HVCCC to achieve coal deliveries in accordance with the Cargo Assembly Plan (CAP). Execution of the plan is optimised through real time decision making undertaken in accordance with principles and protocols agreed by the industry.

ARTC is actively engaged with the HVCCC, rail operators and other supply chain partners in working together to review planning and operational processes to reduce waste and to identify opportunities to improve operational performance.

Rail Operations

Most of the Hunter Valley coal network is capable of handling rolling stock with 30 tonne axle loadings (i.e. 120 gross tonne wagons), but the North Coast line to Stratford is only rated for 25 tonne axle loads (100 tonne wagons). The privately owned railway to Austar can only accommodate 19 tonne axle loads (76 tonne wagons).

Train lengths vary from around 1,250 metres to 1,543 metres, apart from the approximately 600 metre trains servicing the Austar mine. Trains made up of ‘120 tonne’ wagons are generally restricted to 60 km/h loaded and 80 km/h empty.

Weighted average coal capacity per train was approximately 8,091 net tonnes in 2016. This compares to a figure of approximately 8,110 net tonnes in 2015. This is the first time that average actual train size has declined since ARTC took-up the network. It most likely reflects the increase in the proportion of coal coming from the Gunnedah basin and diversion of some coal from the Port Kembla coal terminal to Newcastle. Both of these traffics use a smaller than average train size.

Average train size as contracted with ARTC is 8,060 tonnes in 2017. Figure 2-1 shows the historical growth in average train size and the current contracted train sizes at the Newcastle terminals for the period forecast in the Strategy. While the Strategy is based on the contracted train sizes, ARTC expects that in practice there will be a continuing increase in average train size, though probably not to the same extent as the growth over the past five years.

At 2017 contracted volumes and train sizes, an average of around 66 loaded trains need to be operated each day of the year, or one train every 22 minutes. Capacity planning makes provision for this number of trains to peak at up to 87 per day, though in practice capacity exists for this to peak at even higher rates.

Estimates of the numbers of paths required to carry the forecast coal tonnages are generally based on train consists nominated by producers under the contracting process, and are assumed to be, on average, loaded to 98% of their theoretical capacity.

The coal chain is supported by a captive rail fleet operated by four above-rail operators: Pacific National (PN); Aurizon; Genesee & Wyoming Australia (which acquired the Glencore rail business during the year) and; Southern Shorthaul Railroad (SSR).

While rail operations are dominated by coal arriving from the north, coal also arrives at the terminals from a number of smaller mines to the south of Newcastle, and in recent times in increasing volumes from mines in the Lithgow and Southern Highlands areas. This traffic operates on the Sydney Trains network as far as Broadmeadow. There is also an increasing volume of coal supplied to the Eraring and Vales Point power stations south of Newcastle. There are no identified capacity issues for this coal on the short section of the ARTC network which it traverses outside the port areas, and accordingly this Strategy does not discuss the network between the port terminals and Sydney.

Although there are no identified capacity issues, the timetabling requirements of trains accessing the Sydney network provides operational challenges that have the potential to impact on the Southern coal trains as they work in with the variability of the unloading events at the Newcastle coal terminals.

Domestic coal is also transported over the Hunter Valley network. The largest volume is for AGL Macquarie at Antiene, which receives significant volumes of coal originating from mines on the Ulan line.

Train Length

Train length in the Hunter Valley is limited to 1,543 metres. This length recognises the constraints of departure roads (particularly at KCT), the Hexham Holding Roads, Ulan line loop lengths, balloon loop constraints, and standing distances between signals and level crossings.

Operators continue to be interested in introducing longer trains into the system with a view to increasing operating efficiency and ARTC recognises increasing train length as a potentially effective mechanism to increase capacity when implemented in a systemic manner.

However, ARTC is cautious about permitting the introduction of ‘overlength’ trains on the network. While the individual trains would deliver an increase in capacity per path, the de facto priority it gives these trains, the constraints on where they can cross other overlength trains, and the limitations they place on the system generally, means that they are likely to lead to a net reduction in system capacity. ARTC does not anticipate allowing increased train length on single track lines in the absence of appropriate enhancements.

ATMS will assist in increasing train lengths in some situations. Due to the elimination of some signalling system safety overlaps, ATMS will increase the available standing space in some loops. ATMS also significantly simplifies and reduces the cost of loop extensions.

ARTC will continue to review options for longer (and faster) trains, and will undertake further modelling to validate capacity impacts and opportunities. Subject to support from producers for any engineering

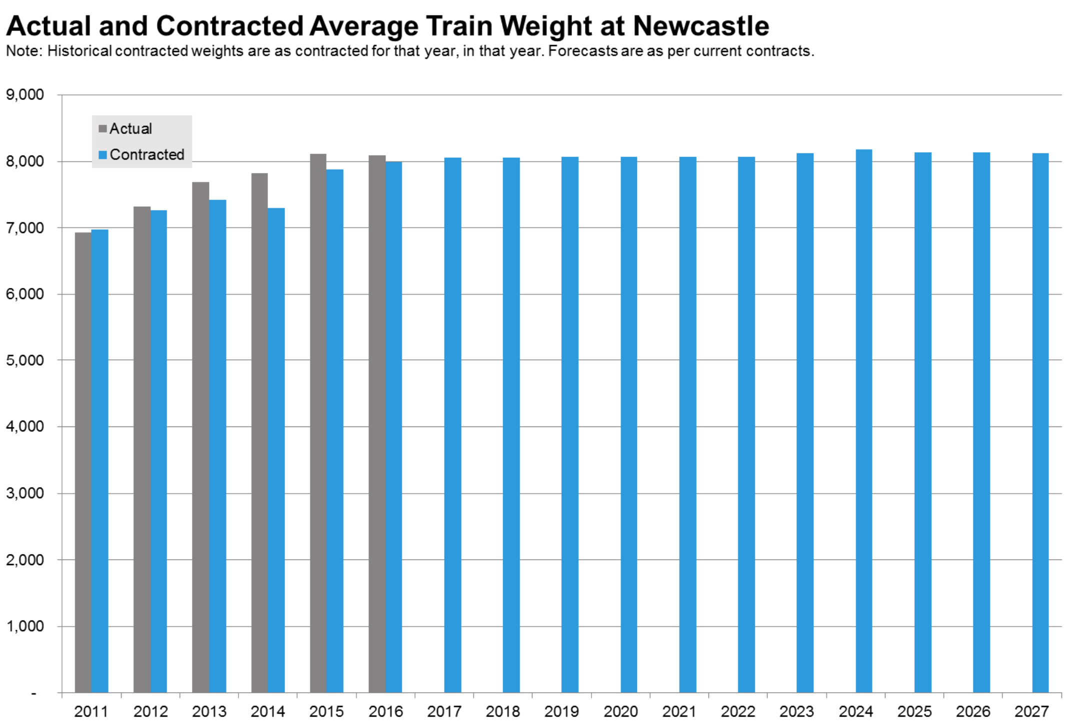

Figure 2-1 -

investigations required, ARTC will develop business case assessments of the costs and benefits of providing necessary infrastructure enhancements.

Operational Improvement Initiatives

ARTC continues to focus on driving an ever increasing value proposition for Hunter Valley customers, supply chain peers and other stakeholders to sustain and grow long term supply chain competitiveness through operational improvement initiatives.

These initiatives currently include a focus on:

- Optimising asset performance through an integrated whole of asset lifecycle strategy and the improved use of reliability and condition monitoring data to improve decision making;
- Increasing synergy between the track maintenance and network control functions through integrated coordination activities, both intra week and day, with the outcome being an increased efficiency in maintenance activities and subsequent train flow on the network. The project focuses on the pre week/day combined planning processes and coordination across multiple teams in live operations to coordinate safe and efficient track access for maintenance activities while improving overall train flow on the day for our customers on a more reliable network.
- Reviewing the Master Train Plan to ensure that section run times and transaction times reflect actual average performance while ensuring that the plan recognises variations from the average.
- Focused monitoring and management of the operational constraints around the Ardglen bank, Bylong tunnel and Muswellbrook areas to ensure that train flow is optimised.
- Effective integration of the coal / non coal train programming with a focus on being able to deliver and implement processes that recognise the different performance characteristics of the traffics and more efficiently assimilate the network tasks to enable increased operational control.
- Increasing real time cooperation and coordination with rail haulage providers to synchronise resourcing and network activities.

in 2016 ARTC installed temporary crew relief structures at designated locations to remove the impact on track capacity from unplanned crew relief stoppages in critical network locations, Hexham, Farley and Branxton. Following the success of the project there may now be a requirement to formalise these structures. This may require some investment to provide facilities of appropriate standard and durability.

ANCO & ATMS

While operational improvement initiatives will enhance ARTC’s ability to provide efficient product delivery and meet customer expectations, the largest improvement opportunities lie in the day to day train control decision making processes. It is a challenge for train control to dynamically consider alternative scenarios and assess the potential flow-on impacts so as to deliver maximum performance for the supply chain as a whole. This arises from limited real time, overall network visibility and a lack of tools to assist with short-term planning. To address this gap and deliver a step change in supply chain performance, ARTC has embarked on two significant projects, ANCO and ATMS.

The ANCO project is ARTC’s initiative to introduce new processes and technology to improve train control in the Hunter Valley. ANCO aims to deliver a more synergistic and coordinated approach to decision making. Underpinning this project will be real time data feeds across organisations (including train forecast times based on live operational information) and the capacity to manage disruption through scenario testing.

An important milestone for the ANCO project was reached in early October 2017 with contracts signed with GE Transportation to obtain their 'Movement Planner' product as the centrepiece of implementation of the ANCO Project.

Movement Planner will allow the introduction of digital train planning in Network Control Centre North (NCCN), replacing the paper-based train graphs currently in use.

The product is in use on other rail networks in both the US and Australia, who have reported increased visibility of network operations, higher speeds, less train dwell time, improved forecasting and increased network capacity. The ANCO project aims to realise similar outcomes.

The 'Network Viewer' and 'Network Optimizer' modules of Movement Planner predict and resolve real time train conflicts respectively. They will be implemented progressively for the Hunter Valley network throughout 2018 and 2019, commencing with the areas west of Muswellbrook.

By increasing the efficiency of both train planning and execution, ANCO will enable improved utilisation of the available track capacity, reduced cycle times and a supply chain which is more responsive to customers’ dynamic needs.

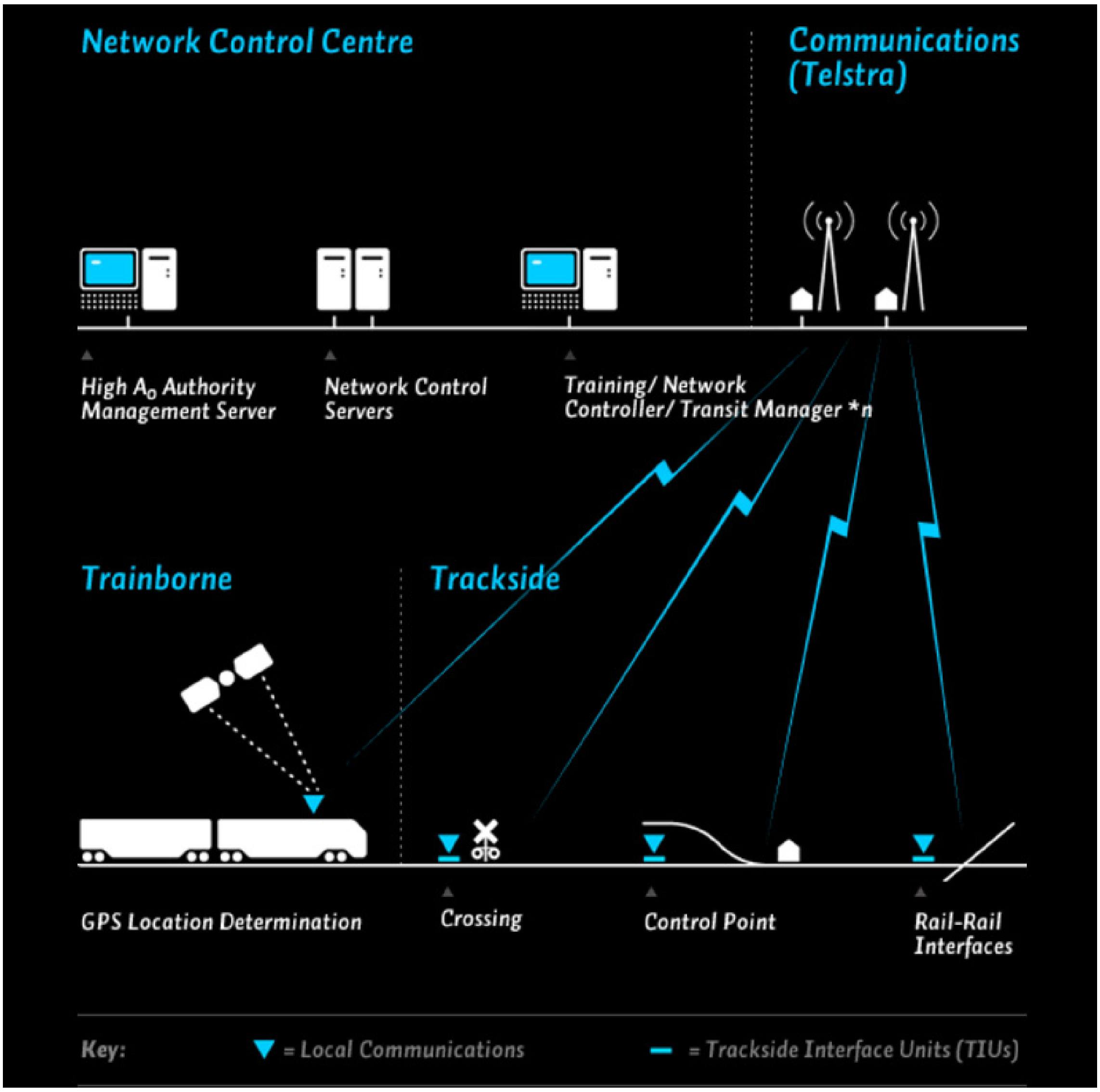

Figure 2-3 - ATMS architecture

The current approved scope will deliver:

- Dynamic pathing: Provision of a detailed daily rail schedule reflecting all occupations, including track maintenance.
- Disruption prediction: Monitoring of potential disruption in live run and using dynamic pathing to adjust the plan to minimise time and throughput losses.

Potential future stages, ANCO Horizon II, will add:

- Train management execution: Automatic route setting and clearing, and issuing of movement authorities, allowing train controllers to focus on train flow.
- Infrastructure monitoring: Continuous monitoring of track infrastructure health to maximise availability.

Dynamic pathing is of particular significance for the determination of track capacity. As discussed elsewhere in this Strategy, ARTC applies principles in determining capacity that make allowance for variations and unknowns. In particular, the 65% utilisation factor on single track is intended to deal with issues like uncertainty around actual train performance, temporary speed restrictions and manual decision making in the execution of crosses as well as the natural constraints on the efficiency with which train crosses can be timetabled. Dynamic pathing will enable these factors to be considered and optimised dynamically, effectively eliminating the need for additional contingency in the train plan. This creates potential for higher utilisation of available track capacity.

Ultimately, the key benefit of ANCO is that it will allow the daily train plan and live run execution to be optimally aligned with system and customer requirements. This alignment, when combined with the capability of the ATMS system, will allow for management of trains to ensure maximisation of efficiency in train flow.

The second initiative, ATMS, is highly synergistic with ANCO.

ATMS is a communications based safeworking system that will allow much of the lineside signalling infrastructure to be removed. It provides the control, location accuracy and intervention ability to allow trains to safely operate at closer headways than is possible today.

The key basic principles that ATMS is built on are:

- A robust, reliable, digital communications backbone;
- Minimal field based infrastructure;
- 'Open' systems architecture;
- Flexibility and scalability; and
- An ability to support the operation of trains at safe braking distance intervals rather than by the traditional fixed block method of train working.

ATMS will provide significantly upgraded capabilities to the ARTC network, including the Hunter Valley. It will support ARTC's objectives of improving rail network capacity, operational flexibility, train service availability, transit times, rail safety and system reliability.

Importantly, it will enforce its track movement authorities through its ability to directly apply the train brakes in the event of any projected breach of permitted operations. This eliminates the risk of trains travelling beyond a safe location or overspeeding. It has a target of less than one safety critical failure per 100 years. This is achieved through a combination of the high safety integrity levels of individual elements and cross-checking of vital information between the elements.

The 'virtual block' system of working adopted by ATMS means that it will be possible to have two or more trains following each other within a section on single track. To the extent that this occurs, it directly increases utilisation. It is a particular benefit where there is a mix of trains with different speed characteristics and frequent instances of trains being overtaken.

ATMS also provides full contextual information to network controllers and train drivers. This will give much greater network visibility and support better decision making.

ATMS provides bidirectional working on all track. This gives flexibility in planning train movements around possessions, allowing track maintenance to happen more quickly with less impact on traffic. Train controllers will also have the ability to allow work on track to commence immediately after the passage of a train and to allow it to continue until shortly before a train arrives at a worksite, thereby giving larger work windows and improving productivity.

The bi-directional capability also gives more options in managing trains of differing priorities or performance, by providing more routing options. This will further increase capacity and reduce delays.

The combination of ANCO and ATMS has the ability to significantly reduce direct human intervention in train operations. This will increase the predictability and reduce the variability of the rail network, while optimising operations both for efficiency of utilisation of the network and to meet customer requirements.

These improvements will materially increase the potential rate of utilisation of the track. On the single track sections in particular, it should be possible to lift the effective rate of utilisation from the current 65%. While the exact utilisation that can be achieved will need to be determined through analysis once the systems are better developed, and refined based on performance following implementation, this Strategy assumes that phase 1 of ANCO will deliver a five percentage point increase in utilisation, and hence adopts 70% utilisation for capacity analysis post ANCO phase 1. It assumes a further five percentage point increase from ATMS giving 75% utilisation with ANCO plus ATMS. It should be noted that as ATMS allows more than one train to be in a section at the same time, the theoretical capacity of the track becomes greater than 100%.

The modelling also assumes that the improved situational awareness and safety overlay will allow trains to operate closer to their theoretical capability and a 5% improvement in average train speed has been assumed to be achieved post-ATMS.

Train Park-up

Train park-up has long been identified as a challenging issue that may have an investment requirement. However, HVCCC and ARTC continue to work together to identify opportunities to park-up trains using existing track assets.

It is expected that ANCO together with the HVCCCs forthcoming automated cargo assembly planning tool, RACE, will support further optimisation and, importantly, smoothing of train flows, reducing pressure for trains to stand. Train park-up remains as a potential investment requirement for prospective volumes, but at this stage there is no apparent requirement for any specific projects.

3

INCREASING CAPACITY BETWEEN NARRABRI AND MUSWELLBROOK

Context

The Gunnedah Basin line extends for 252 km, from the junction for the Narrabri mine to Muswellbrook in the Upper Hunter Valley.

This single-track line is highly complex. In addition to its coal traffic, it carries passenger trains (NSW Trains services to and from Scone and Moree / Armidale) and a proportionately high level of grain, cotton and flour train activity. This non-coal traffic is up to seven trains each way between Narrabri and Scone, and 10 trains each way per day south of Scone.

There are currently four coal origins along the route, at Turrawan, Boggabri, Gunnedah and Werris Creek. The currently closed Dartbrook mine, just north of Muswellbrook, is working toward reopening.

Two major new Gunnedah basin mines are included in the prospective scenario: Vickery South and Watermark. The Caroona mine is no longer considered as prospective following BHP's sale of the mining licence back to the NSW Government. Vickery South is assumed to load from a new balloon loop connecting at approximately 499.3 km, between Emerald Hill and Boggabri. Watermark is assumed to load from a new load point north of Breeza, at approximately 443.5 km.

Liverpool Range

The Ardglen bank, crossing the Liverpool Range, is a particular impediment on this corridor. The severe grades on the short section between Chilcotts Creek and Murrurundi dictate limits for train operations on the whole Werris Creek to Newcastle route. The need to use 'banker' locomotives for loaded coal and grain trains on this section means it carries greater train volumes than the rest of the line.

Operational modelling assumes the following principles for the bank engines:

- There will be two sets of bank engines available at all times. Pacific National and Aurizon currently provide one set each.
- A train requiring banking will not have to wait for a bank engine.
- The attachment process will take 10 minutes to complete before the train will recommence its journey.
- Once the train has cleared Ardglen the bank engine will return to Chilcotts Creek in the shadow of a down train so as not to consume any additional network paths.
- Kankool loop will be used for the crossing of the returning bank engines to avoid any delay to a train in the up direction.

ARTC is working with rail operators to actively manage the banking process so as to optimise utilisation of the network and maximise productivity.

Train Performance and Capacity Utilisation

As described in the 2016 Strategy, ARTC has now adopted actual rather than theoretical performance as a basis for capacity modelling. Section run times developed on this basis were applied to the Gunnedah basin in 2016. For this 2017 Strategy, actual transactions times have also been calculated and applied and the actual section run times have been updated based on a larger data set made possible by automating the calculation process.

As noted in Chapter 1, transaction time was previously a generic five, four or three minutes depending on the loop configuration. Actual transaction times now adopted are shown in figure 3-1. These times have been calculated as the time from when the rear of a train exits the section until the train entering the section from the loop reaches normal actual train speed, less the time that a through train takes to cover the same distance. As such, it combines all elements of signal clearance, driver response and acceleration.

An additional 1 minute has been added to normal loops, and 45 seconds for simultaneous entry loops, to reflect the effect of simultaneous arrival of two trains at the loop, which takes into account both the probability of this occurring and the likely amount of delay when it does.

The transaction times average around 4 minutes in the Down direction and 3.4 minutes in the Up direction,

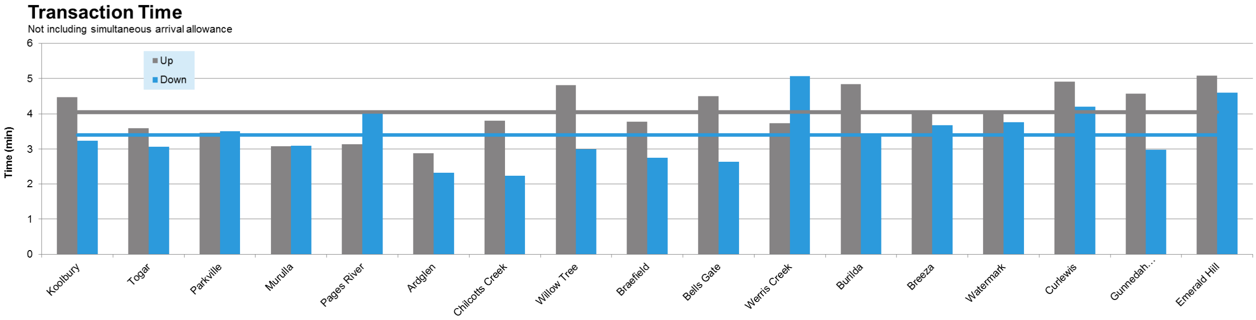

Figure 3-1 - Actual transaction times

both excluding the supplement for simultaneous arrival. As such, they are on average slightly better than previously assumed.

During 2014 ARTC undertook some investigations into changing the way information is transmitted using coded track circuits. Coded track circuits are a key part of the signalling systems and a major factor in transaction time. The work identified potential time savings of 40 seconds per coded track circuit at a cost of around $20,000. Loops generally have two to four circuits, giving potential savings of 80 to 160 seconds in transaction time.

The project was not pursued any further at the time as there were no capacity constraints that warranted further investment. However, changes to the coded track circuit logic may offer some small incremental capacity increases quickly at low cost if producers wish to increase volumes in the near term. There is also potential for a small reduction in cycle times.

Figures 3-2 and 3-3 compare for the Down and Up directions respectively the average speed by section for four data sets:

- Current actual
- Actual as per the 2016 Strategy
- Simulated as per the 2015 Strategy
- Section run times as per the Master Train Plan

Note that these average speeds include transaction time.

As noted last year, there was some variance moving from simulated to actual speeds, primarily in the Up direction between Narrabri and Ardglen. Actual 2017 results have not had much further impact, other than for Down trains north of Chilcotts Creek. This arises from the approach adopted last year of assuming that Aurizon 30 tonne axle load (tal) locomotives would be cleared to operate at 80 km/h. On this basis, PN trains only were used for calculating Down direction speeds.

It has subsequently become apparent that a blanket approval to operate 30 tal locomotives at 80 km/h, while optimal, has a number of complexities to overcome before achieving. The Down average speed has therefore been calculated using actuals for all trains.

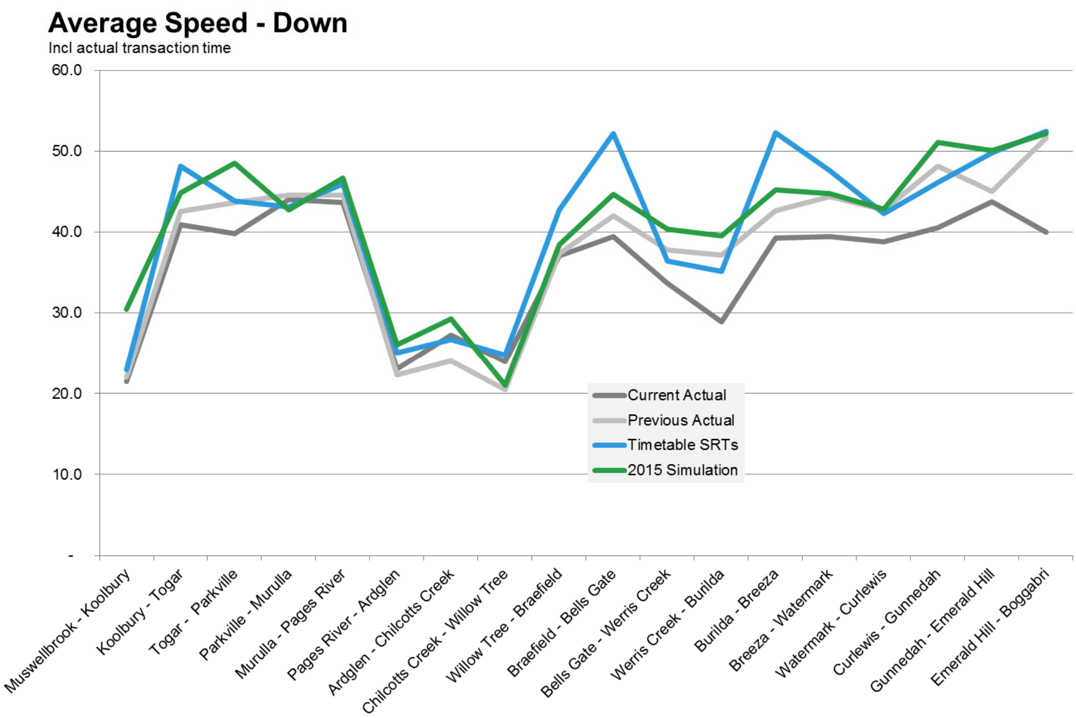

Figure 3-2 - Down direction average speed by section

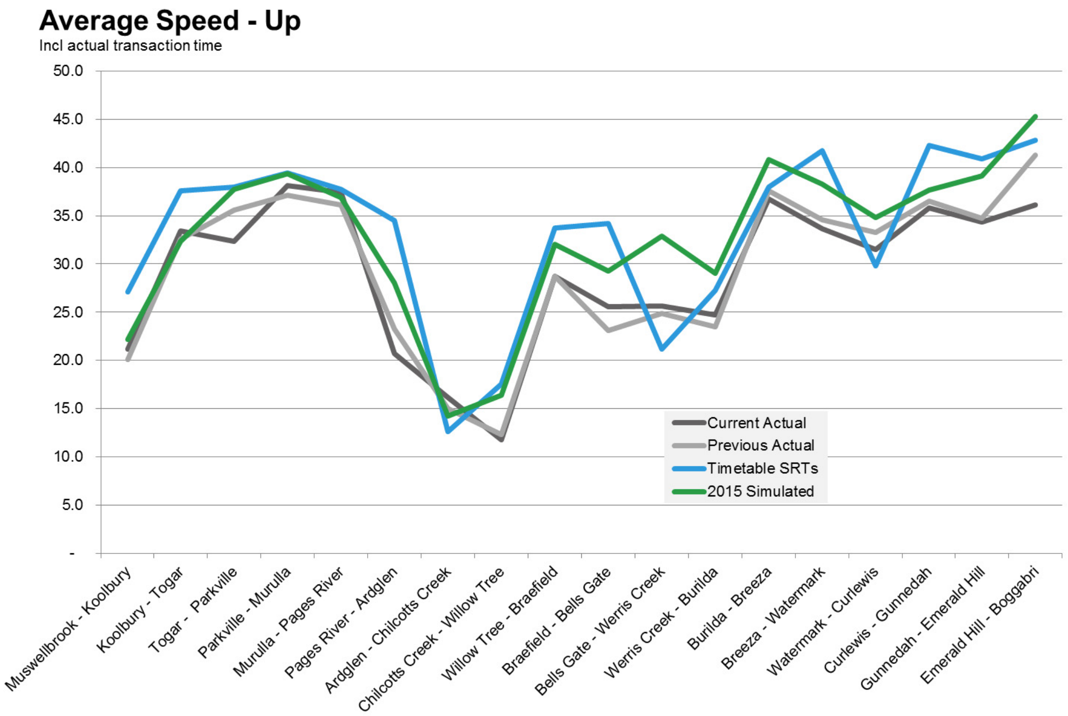

Figure 3-3 - Up direction average speed by section

This has caused a material increase in section times on some sections. The 60 km/h limit appears to have a bigger impact on speed on the undulating grades north of the Liverpool Ranges than it does on the climb up the ranges.

While a blanket approval to operate 30 tal locomotives at 80 km/h is unlikely in the short term, further investigation will be made into opportunities to progressively increase speed, with priority given to the capacity limiting sections.

Actual transaction times are similar to previous assumed values and accordingly the adoption of actual transaction times has not had a noticeable impact on section times and, hence, capacity.

The other notable characteristic of the analysis is that timetabled section run times vary significantly from actual observed performance and on the whole assume a higher average speed than is actually achieved. As discussed in Chapter 2, this has given rise to an initiative to better align timetabled and actual performance.

Target Monthly Tolerance Cap

As discussed in the 2016 Strategy, the adoption of a 10% target monthly tolerance cap effectively drives the construction of sufficient capacity to allow for a peak day of 10% more coal trains than the average day.

While this is conceptually possible across much of the network, the Gunnedah basin may warrant a different approach to peaking. This arises due to the high proportion of agricultural traffic on the Gunnedah line and its associated high levels of variability. At the same time, the Gunnedah's basin's captive coal train fleet and high use of NCIG with its capacity for more even cargo assembly means that coal train variability is relatively low.

The alternative approach would be have a lower TMTC and to use peaking capacity opportunistically on days when non-coal freight was low. The 2016 Strategy noted that, depending on the size of the grain harvest and other factors, the available peaking capacity is likely to be sufficient for two or three additional coal trains per day on a majority of days. This will inevitably mean that there will be days when a coal train set is forced to sit idle due to a lack of paths, but this is potentially a lower cost outcome than additional capacity projects that are only required to meet demand on a minority of days.

Implementing this approach would involve changes to the commercial relationship around ARTC's obligations to provide train paths and is ultimately a matter for negotiation with the Gunnedah Basin producers.

Train Lengths

ARTC has an approved train length of up to 1,329 metres in the Gunnedah basin. This represents a practical limit given current loop lengths and the need to allow a margin at the loop ends. There will be no further increase in train length until the track configuration changes to facilitate it.

In 2015 ARTC undertook an analysis of the option of increasing train length to either 1420 m or the Zone 1 and 2 standard of 1543 m. The 1420 m option would require 10 loop extensions and the 1543 m option 15 extensions. The cost of extensions was estimated at an order of magnitude of $55 m and $90 m respectively.

While the longer trains increase volume per path, the expectation was that the longer trains would retain the same locomotive configurations. As a result, section run times would increase, which approximately offsets the extra capacity per train. Under the prospective scenario at the time, the 1543 m options was estimated to result in an NPV saving of around $5 m in the scope required to achieve the same tonnage throughput.

While it was concluded that extending train lengths was not the most cost effective solution for increasing capacity, to the extent that it results in more efficient train operations there may be a case for going down this path in the future.

In particular, once ATMS is in place, two loops built to a simultaneous entry configuration would no longer need to be extended, while the cost of the loop extensions would reduce as a result of the simpler signalling works.

Loops & Double Tracking

Progressive lengthening of selected existing passing loops, and constructing additional passing loops, has been a key mechanism for accommodating volume growth. The majority of loops are now 1330 m – 1450 m with only a small number of short loops remaining. Of these short loops, Gunnedah, Quirindi, Kankool and Scone have specific challenges that make extension difficult. Only two loops (Aberdeen and Murrurundi) remain for potential extension.

Opportunities to insert additional mid-section loops are constrained due to the effects of grades and level crossings, while the increasingly short distances

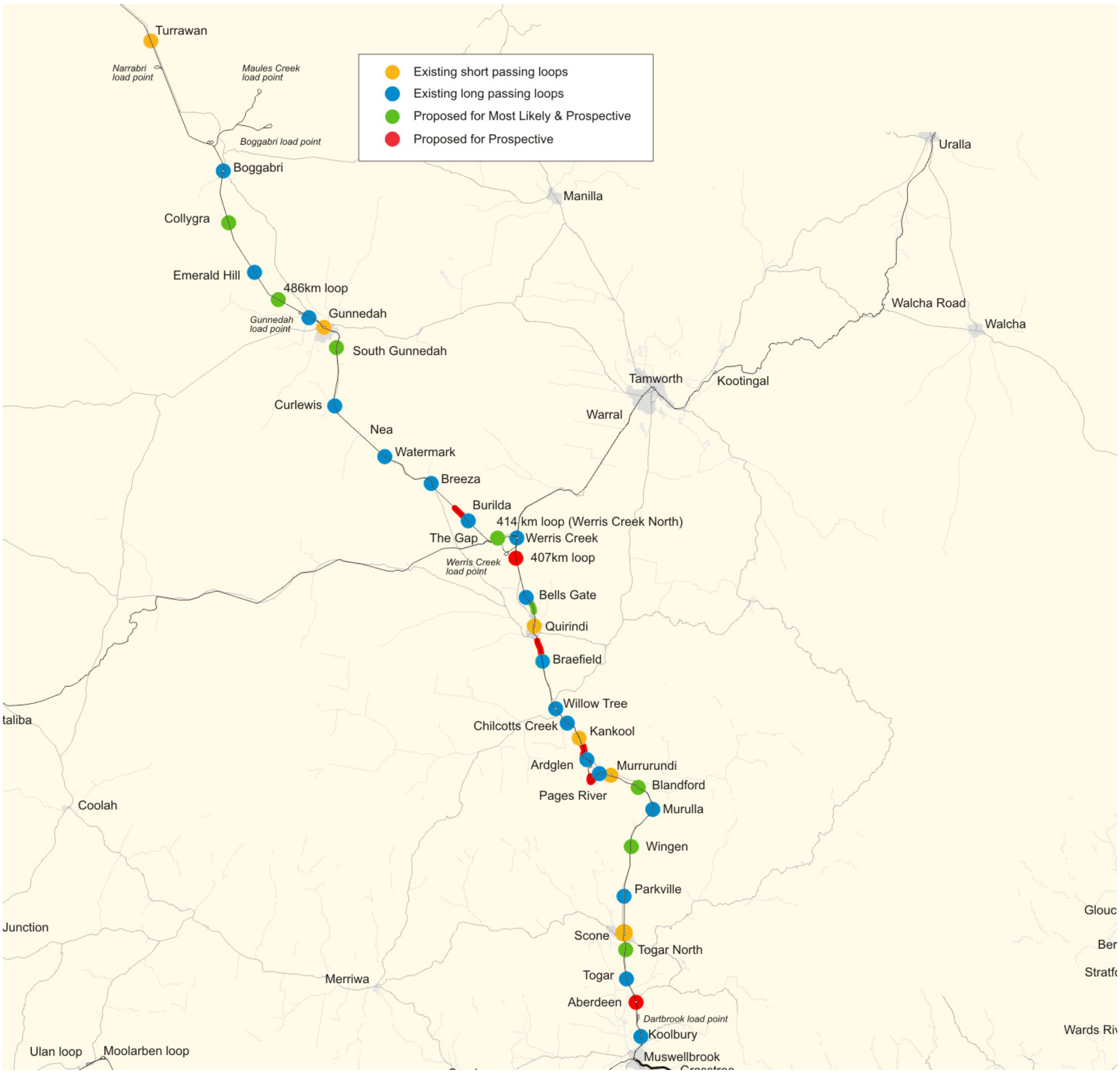

Figure 3-4 - Muswellbrook to Narrabri Loops between loops mean that additional mid-section loops are of declining benefit due to the transaction times at the loop.

Notwithstanding this, concept assessments undertaken in 2012 on projects required to accommodate prospective volumes have tended to conclude that a mid-section loop remains the preferred solution. In some cases these new loops will be quite close to existing loops. However, where it is practical to construct a mid-section loop the additional cost associated with building a passing lane does not justify the additional benefit. As a result, passing lanes have only been recommended where there are physical constraints to a mid-section loop.

Double-track sections remain as the preferred solution on the Liverpool Range as it is not practical to stop trains on either the up or down grade across the range. Bells Gate south extension is preferred to extending Quipolly loop due to the high cost of extending the loop given level crossing and environmental constraints. The length of each of these double track sections is determined by physical constraints.

Investment Pathway

Figure 3-5 shows the preferred investment pathway to meet the most likely volume forecast scenario.

Note that this graph shows volume at Muswellbrook plus the surplus capacity on the most capacity limiting section of the corridor. Hence, capacity can increase independent of investment or other mechanisms to increase capacity if the volume increment is on the port side of the capacity limiting section.

The drop in capacity between Q4 2017 and Q1 2018 reflects the move to actual section times and transaction times.

The signal logic change, being the change to the coded track circuits, is likely to be able to be implemented within a year, giving a modest uplift assumed to be in late 2018. The size of the benefit is location specific and pending a more detailed analysis a generic benefit of 60 seconds has been assumed.

As discussed in Chapter 2, ANCO will offer a range of systemic improvements that should allow the effective utilisation of the track to be increased. A theoretical assessment has suggested that it should allow an increase of around five percentage points, which would lift applied utilisation from 65% to 70%. This is assumed to be able to be realised in around late 2019 consistent with the ANCO delivery plan.

ATMS has also been assessed as having the theoretical potential to lift utilisation by a further five percentage points, which would take utilisation from

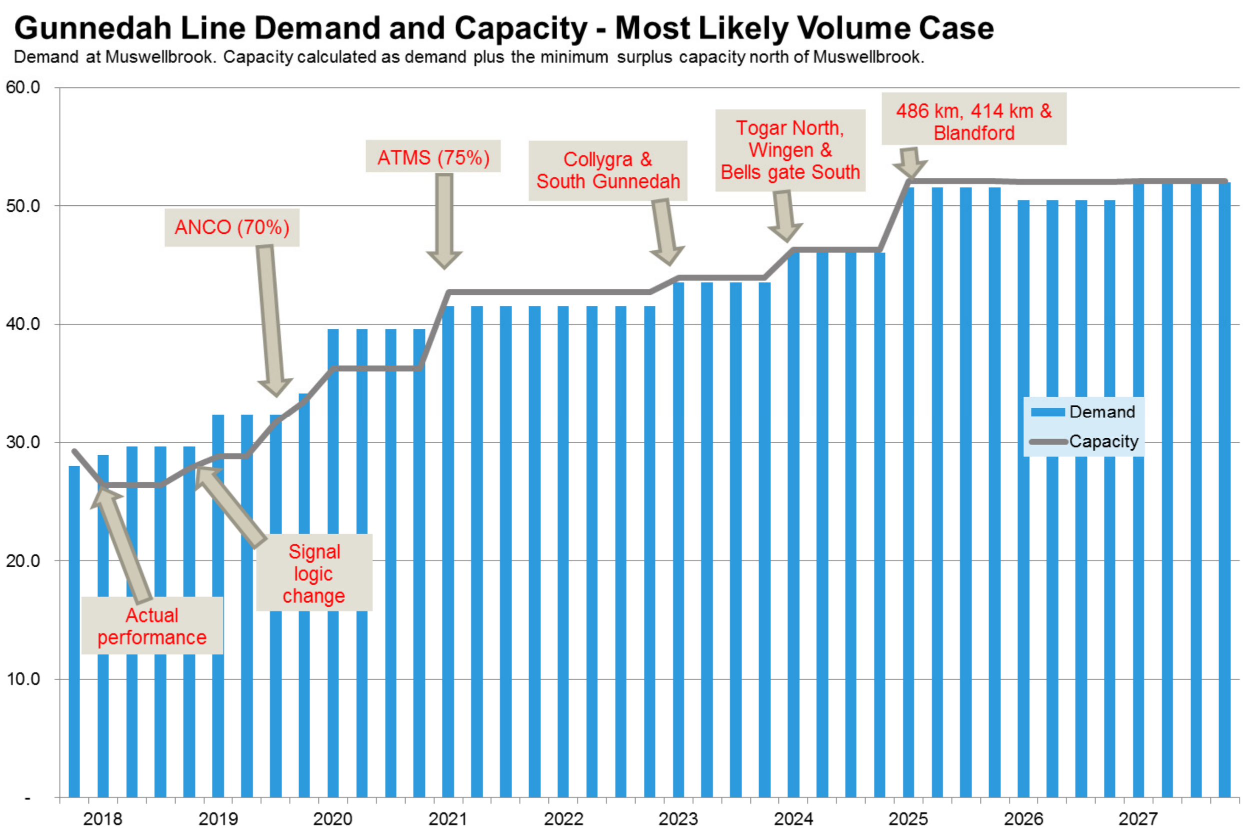

Figure 3-5 - Conceptual pathway for investment to meet Most Likely volume scenario.

70% to 75%. A 5% improvement in average train speed has also been assumed. The strategy and achievable timeframe for rollout of ATMS requires further investigation, but with a focussed approach it is expected that it could be implemented on the Gunnedah basin and Ulan lines by early 2021. This would then deliver sufficient capacity until around 2023 when a program of crossing loop investments would need to recommence.

It is important to emphasise though that the assumed increase in utilisation of both ANCO and ATMS is theoretical and ARTC will need to validate the scale of benefit in practice before being confident that they will deliver the anticipated capacity increase. In addition, the timeframes are somewhat uncertain given the nature of the technology.

Accordingly, if producers wish to ensure certainty around the timeframe for the delivery of additional capacity, work should continue on the design and approvals process for loop projects in parallel with the implementation of the technology projects. This approach minimises risk and given that the design and approvals processes represent a relatively small proportion of the total project expenditure, mitigate risk at modest cost.

In the event that volume grows approximately in line with the forecast, any short term expenditure on loops would ultimately be of value in expediting construction later in the planning period.

Table 3-1 shows the projects required to address the capacity constraint on each local section as demand requires, for each of the most likely and prospective scenarios. The most likely case is shown for both the preferred pathway making maximum use of technology, an ANCO only (no ATMS) scenario, and for the alternative of meeting the capacity through loop projects only. The prospective scenario assumes both ANCO and ATMS.

The location of each of the projects is shown in Figure 3-4

No projects are required for contracted volumes.

The projects identified for the most likely and prospective volume scenarios assume that there is no change to current actual train performance. There may be some scope to increase train speeds around Gunnedah and Scone, both of which have constraints associated with noise. This could potentially allow the deferral of South Gunnedah and Togar North loops.

Project Name	Most Likely without ANCO / ATMS[2]	Most Likely with ANCO only[2]	Most Likely with ANCO / ATMS[2]	Prospective with ANCO / ATMS[2]
Aberdeen	2021	2024	-	2023
Togar North Loop	2020	2020	2024	2020
316 km loop (Parkville South)	2025	-	-	-
Wingen loop	2021	2021	2024	2020
Blandford loop	2021	2021	2025	2022
Pages River North extension	2023	2025	-	2023
Kankool—Ardglen	2024	2025	-	2023
Braefield north extension	2024	2025	-	2023
Bells Gate south extension	2021	2021	2024	2021
407 km loop (Werris Creek South)	2025	2025	-	2023
414 km loop (Werris Creek North)	2021	2023	2025	2022
Burilda north extension	2024	2025	-	2023
Breeza north extension	2025	-	-	-
South Gunnedah loop (Note 1)	2020	2020	2023	2020
486 km loop	2023	2024	2025	2023
Collygra	2021	2021	2023	2023

Table 3-1 - Project timings under various volume scenarios

Note 1 - Empty train speeds through Gunnedah have been limited to 40 km/h to ensure predicted noise levels do not exceed standards. Train speeds could be lifted to 80 km/h either on the basis of actual noise levels being less than predicted, or through additional noise mitigation treatments. Lifting speeds to 80 km/h would increase capacity by approximately 1.9 mtpa.
Note 2—Project timing is based on the later of when the project is required and when the project can be delivered.

4

INCREASING CAPACITY BETWEEN ULAN AND MUSWELLBROOK

Context

The Ulan line extends approximately 170 km, from Ulan, west of the dividing range, to Muswellbrook in the upper Hunter Valley.

Although the line is used mainly by coal trains, it is also used by one or two country ore and grain trains per day and occasionally by interstate freight trains that are bypassing Sydney during possessions. This analysis of the Ulan line assumes that there is no change to this current pattern of limited non-coal trains on this line.

The mines on this sector are clustered either at the start of the line near Muswellbrook (Bengalla, Mangoola) or at the end of the line around Ulan (Ulan, Wilpinjong, Moolarben). This gives rise to a long section in the middle with homogenous demand.

Although six new export coal mines are at various stages of the development and approval process, only the Mt Pleasant, Bylong and West Muswellbrook mines are now assumed to be developed in the timeframe of this Strategy. The Mt Penny, Ferndale and Spur Hill mines are assumed to not be in production during this period.

The Ulan line has some difficult geography which constrains the location of loops. As sections become shorter, the scope to adjust the location of the loop declines. Accordingly, past investigation of nominal sites has found it necessary to consider alternative solutions. Specifically, in some cases it has become necessary to consider "passing lanes", which are effectively short sections of double track. These will necessarily be materially more expensive than straightforward loops.

Train Performance and Capacity Utilisation

As foreshadowed in the 2016 Strategy, and discussed elsewhere in this 2017 Strategy, ARTC has now analysed and adopted actual performance as the basis for calculation of capacity on the Ulan line.

Average actual transaction times are approximately two minutes higher than previously assumed, which leads directly to a reduction in modelled capacity.

The actual transaction times are shown in figure 4-2. The average for both the Up and Down direction is approximately 6 minutes. This doesn't include provision for simultaneous arrival at loops, which in most cases adds an additional minute. The resulting average transaction time of approximately 7 minutes compares to a previously assumed time of five minutes for most loops. The average is approximately 2 minutes higher than the observed average on the Gunnedah line. This is primarily due to differences in the signalling design and specifically the operation of the coded track circuits.

Figures 4-3 and 4-4 show average speeds by section for the Down and Up directions respectively. These two graphs compare:

- The current observed actual performance.
- The simulated train speed with nominal

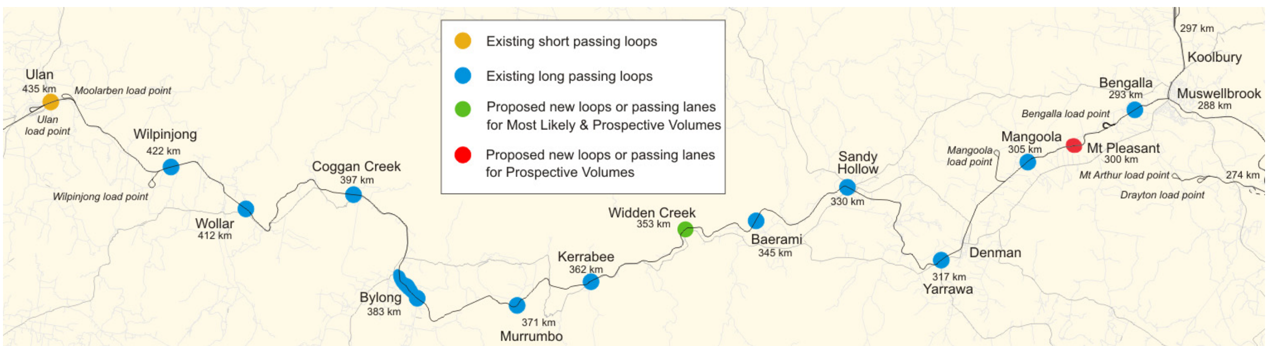

Figure 4-1 - Ulan Loops

transaction times as used in the 2016 Strategy.

- The section run times (SRTs) used in the master train plan, including crossing allowances.

In contrast to the experience with the Gunnedah line, the differential between the previously simulated performance and the current actual performance is significant. This differential has effectively reduced the available track capacity to the extent that the small amount of surplus capacity reported in the 2016 Strategy has been eliminated.

Train Length

Train length on the Ulan line is limited to 1,543 metres, which is the limit for the Hunter Valley as a whole.

Operators continue to be interested in introducing longer trains into the system, including on the Ulan line. This issue is discussed in Section 2.

Bylong Tunnel

Although the Ulan line was only built in 1982, it used works from the original uncompleted construction of the line that commenced in 1915. This included the Bylong tunnel, which was built to a relatively small outline that was consistent with the practices of the day, but which creates ventilation concerns in a modern environment.

Specifically, there are two potential issues: the work health and safety of drivers due to the gasses and particulates from diesel emissions, and; the effect on diesel engines from heat emissions.

Detailed air quality monitoring undertaken in 2011 and 2012 found that the pollution emissions were consistently well below recommended safe thresholds and on this basis the purge time (ie the time between the drivers cab exiting the tunnel and the time the next drivers cab is able to enter the tunnel) was reduced from an arbitrary 30 minutes to 20 minutes.

The results suggested that this purge time was likely to be able to be further reduced. However, as the 20 minute purge time was adequate for the then expected volumes, no further analysis was conducted. In the current demand environment it would now be appropriate to undertake further study.

In regard to the heat issue, past problems that have been experienced have been able to be managed through maintenance and in some cases modification of air intakes. As this is not a safety issue it has been assumed that if any persistent problems appear with a reduced purge time, it is likely that they can be managed, including by real time air temperature monitoring noting that tunnel air temperatures are heavily influenced by ambient air temperature and wind conditions.

The purge time that needs to be achieved depends on the volume and investment scenario. The required time may be as low as 16 minutes, but depending on the outcome of the achievable utilisation rates with ANCO and ATMS it may not need to go this low. Further analysis will provide more clarity around the context for setting an appropriate purge time.

In the event that it is not possible to reduce the purge time with the current tunnel configuration, there are essentially two options—construction of mechanical ventilations systems such as fans and doors, or operating the tunnel section at higher utilisation rates than are tolerated elsewhere, which will mean relatively

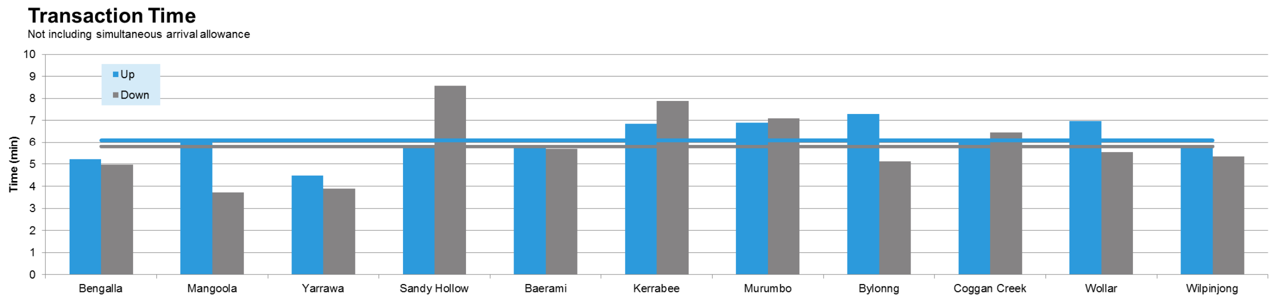

Figure 4-2 - Actual transaction times

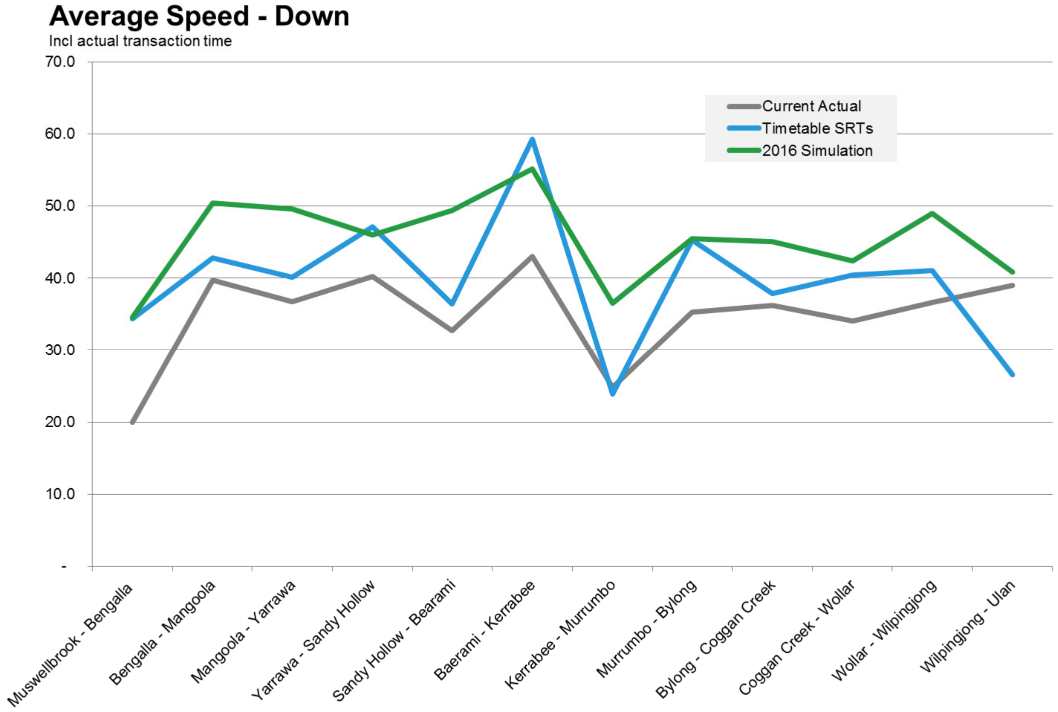

Figure 4-3 - Down direction average speed by section

high levels of congestion, delay and variability, and decreased plan robustness.

Investment Pathway

Figure 4-5 shows the preferred investment pathway to meet the most likely volume forecast scenario.

As already noted, the transaction times on the Ulan line are high, which is largely to do with the way coded track circuits communicate using the rail. Analysis undertaken in 2014 concluded that it was likely that 2.6 minutes could be saved at Kerrabee and 2.0 minutes at each of Bearami, Murrumbo and Bylong by a redesign of the communications logic. These four loops are the ends of the two capacity limiting sections and it is assumed that there is a strong business case for the logic for these loops to be modified, as a minimum. For the higher volume scenarios this is particularly important for Bylong—Murrumbo in conjunction with reduced purge time.

It should be noted that ATMS will achieve this same, or greater, reduction in transaction time. Hence, the

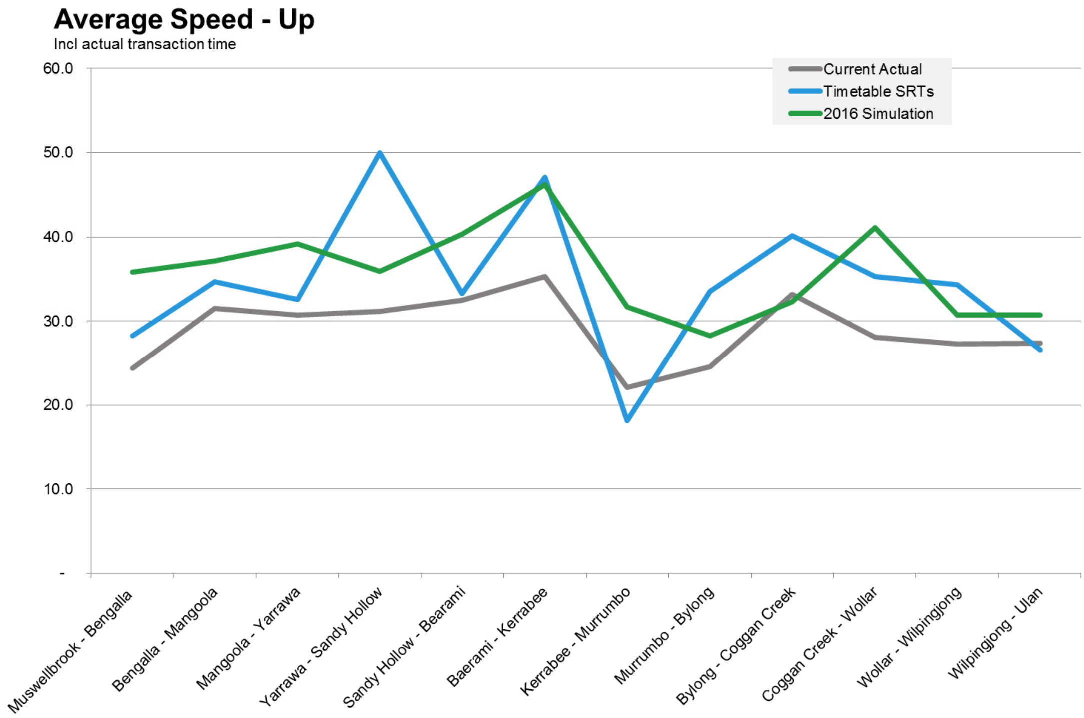

Figure 4-4 - Up direction average speed by section

Project Name	Most Likely without ANCO / ATMS[1]	Most Likely with ANCO only[1]	Most Likely with ANCO / ATMS[1]	Prospective with ANCO / ATMS[1]
Mt Pleasant loop	2021	2023	-	2027
Widden Creek	2021	2021	2021	2021
Murrumbo west extension	-	2021	-	-
Bylong east extension	2021	-	-	-
Coggan Creek west extension	2021	2021	-	-

Note 1—Project timing is based on the later of when the project is required and when the project can be delivered.

Table 4-1 - Project timings under various demand scenarios

investment would need to be justified and recovered over the period between implementing the change to the coded track circuits and roll-out of ATMS, should it proceed.

No projects are assessed as required for contracted volumes beyond the minor investment to change the signal logic to reduce transaction times.

Table 4-1 shows the loop projects required to address the capacity constraint on each local section as demand requires, for the most likely and prospective scenarios. The most likely case is shown for each of the possible combinations of ANCO and ATMS. The prospective scenario assumes ANCO and ATMS.

Under each of these scenarios, construction of Widden Creek loop is necessary. This project has already had Phase 2, feasibility assessment, completed. It has a timeframe for detailed design and construction of approximately 3 years, which would allow it to be delivered by approximately Q1 2021.

Continuing with design now would provide a mitigation against the risk that ANCO and / or ATMS is delayed or does not deliver the required capacity.

In this context, proceeding with Phase 3 of Widden Creek loop, which represents a relatively small financial commitment, makes sense, even if it is then some years between completion of design and proceeding to construction.

Similarly Phase 2 design on Mt Pleasant loop, Bylong East extension, and Coggan Creek west extension provides a mitigation strategy in the event that ANCO and/or ATMS are not able to deliver the required capacity in the necessary timeframe.

With the most likely scenario volumes, it is expected that it will be necessary to make a decision by Q2 2019 as to whether capacity can be delivered by the technology solutions or if the loop projects need to proceed.

The location of each of the loop projects is shown in Figure 4-1.

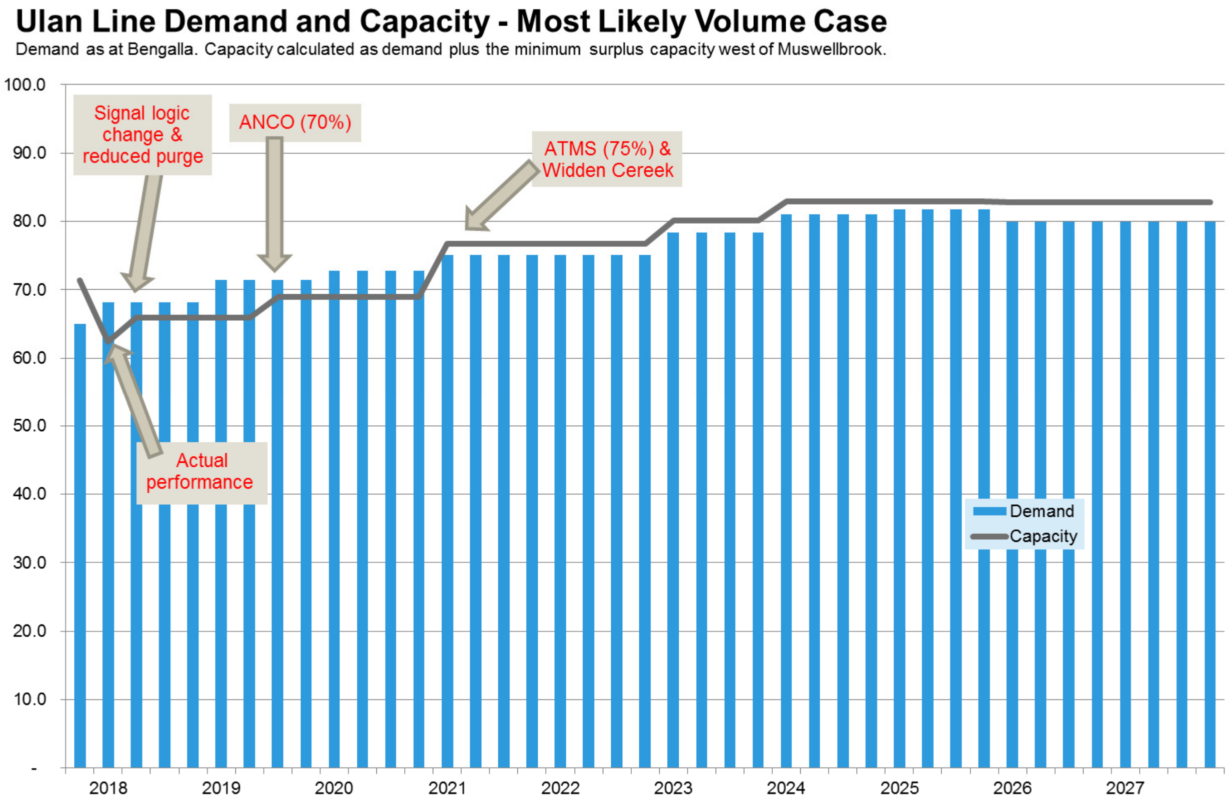

Figure 4-5 - Conceptual pathway for investment to meet Most Likely volume scenario.


5024
5024
64

5

INCREASING CAPACITY BETWEEN MUSWELLBROOK AND THE TERMINALS

Context

The Muswellbrook—Terminals section is the core of the Hunter Valley network. A majority of the coal mines in the Hunter Valley connect to this part of the network, which includes a number of branches of varying length. All of the corridor is at least double track with significant sections of triple track and dedicated double track for coal from Maitland to Hexham.

Although this section has all of the non-coal freight and passenger trains from the Gunnedah and Ulan lines, plus an additional daily Muswellbrook passenger service, the volume of coal means that coal dominates operations across this corridor. The passenger services, which get priority and run down the coal services, do create a disproportionate loss of capacity, particularly in the loaded direction. However, there is sufficient capacity on the corridor and flexibility created by the three track sections, that the shadow effect of the passenger services has a relatively limited effect.

The major issues affecting the line between Muswellbrook and the terminals are headways, junctions, the continuous flow of trains, and efficient flows into the terminals.

Headways

Headways are fundamentally a function of signal spacing and design. Drivers should ideally only ever see a green signal on double track, so that they do not slow down in anticipation of potentially encountering a red signal. To achieve this outcome, a train needs to be at least 4 signals behind the train in front so that the signal a driver encounters, and the next one beyond, are both at green. Signal spacing also needs to take into account train speed and braking capability. Signals need to be spaced such that a train travelling at its maximum speed and with a given braking capability can stop in the distance between a yellow and a red signal. In some cases these constraints start to overlap, in which case it becomes necessary to go to a fifth signal, with a pulsating yellow indication.

Ideally, headways on the whole corridor from Muswellbrook to the terminal should be consistent so that trains can depart at regular intervals, and as additional trains join the network they can slot in to a spare path without impacting a mainline train. This headway target needs to be around 8 minutes[1] once volume exceeds around an average of 84 paths per day, or 245 mtpa at current average train weights.

While this principle has been adopted in the signalling design for new works, there have not as yet been any projects directed specifically at reducing signal spacing. At this stage effective headway is at around 8 minutes south of Minimbah, but increases further up the line. Spacing is as high as 16 minutes in the vicinity of Drayton Junction.

It should also be noted that in a live operating environment, all trains will ideally operate at consistent speeds and achieve the section run time. To the extent that they do not it results in drivers encountering yellow signals, which causes them to slow, creating a cascading effect on following trains that will cause a loss of capacity.

There are three major banks (sections of steep grade) on the Muswellbrook - Maitland section that particularly affect the headways for trains; Nundah Bank, Minimbah Bank and Allandale Bank (Figure 5-1). The steep grades on these banks slow down trains to such an extent that it is not possible to obtain an adequate frequency of trains irrespective of how closely the signals are spaced. This then requires a third track to achieve the required capacity. All three of the major banks are now on three track sections.

Current contracted volumes do not trigger a requirement for any headway projects. In the event that ATMS proceeds it will fundamentally alter the operating environment with trains able to operate at the minimum safe distance in all circumstances. It has been assumed that for the purposes of the scope of work for prospective volumes that ATMS will proceed and negate the need for any signalling projects. ATMS is assumed to be delivered by Q1 2023.

1. Signal clearance times depend on the length and speed of trains, so there is no single absolute number for actual signal spacing.

Junctions

There are numerous junctions on the Hunter Valley rail network where train conflicts at the at-grade interfaces impact on capacity (figure 5-2).

The low speed, high maintenance turnouts around Maitland have now largely been upgraded, with the last two to be replaced in early 2018. This upgrade was undertaken to reduce the future maintenance task and increase reliability but did not have any significant effect on train speeds through the junction.

Whittingham junction turnout speeds were upgraded to 70 km/h in conjunction with the 80 km/h approach to Minimbah bank project, and the junction has a three track configuration as a result of the Minimbah bank third track project. This allows loaded trains to exit the branch without needing to find a slot between loaded mainline trains. Accordingly this junction is now highly efficient.

Camberwell Junction was upgraded to high speed turnouts in conjunction with the Nundah bank third track project, though the speed on the balloon loop limits the practical speed.

Mt Owen Junction has slow speed turnouts. However, the volume from Mt Owen means that its junction does not have a significant impact on capacity.

Ravensworth loop, which was previously integrated into the Newdell loop, was separated in 2013 and given a new junction with high-speed turnouts and a holding loop.

Newdell and Drayton Junctions have been upgraded with high-speed, low maintenance turnouts. While this was primarily maintenance driven, the speed upgrade means that these junctions are now highly efficient.

In the medium term, prospective volume growth from both the Ulan and Gunnedah basin lines would mean that the capacity of the at-grade junction at Muswellbrook will come under pressure. Muswellbrook stands apart from the other junctions due to the need to sequence trains onto two single track lines and the significant number of trains from both lines, which means a large number of conflicting movements at the junction.

While the level of congestion at Muswellbrook is material under contracted volumes, it is tolerable and the work done to date on potential infrastructure solutions has identified significant construction and environmental challenges that would suggest that any solution is only worth pursuing once volume growth, and hence congestion, approach a level where a solution is unavoidable.

The best physical solution identified is a third track heading east from Muswellbrook, which offers the best operational outcome and value for money given the constraints.

ARTC has previously assessed the threshold where a solution is required at approximately 45 coal paths/day. This threshold is now reached in 2023 under the prospective volume scenario, but doesn't climb above 46 paths per day. ANCO, together with operational discipline, may be able to support even greater throughput with the current configuration, though this will need to be tested.

HVCCC undertook modelling during 2013 that suggested there may be a need for a holding track at Muswellbrook assuming that trains arrive at Muswellbrook off their designated path where there are only a limited number of fixed paths on the Ulan and Gunnedah lines. It was subsequently concluded that in an environment of dynamic management of the network, the need for this investment could be avoided. With ANCO phase 1 now committed, there is reasonable confidence that with dynamic pathing and operational discipline there will be no need for a holding track at this location with current volume forecasts and operational planning assumptions.

This junction will remain a focus for ARTC, both strategically and operationally, to ensure that traffic

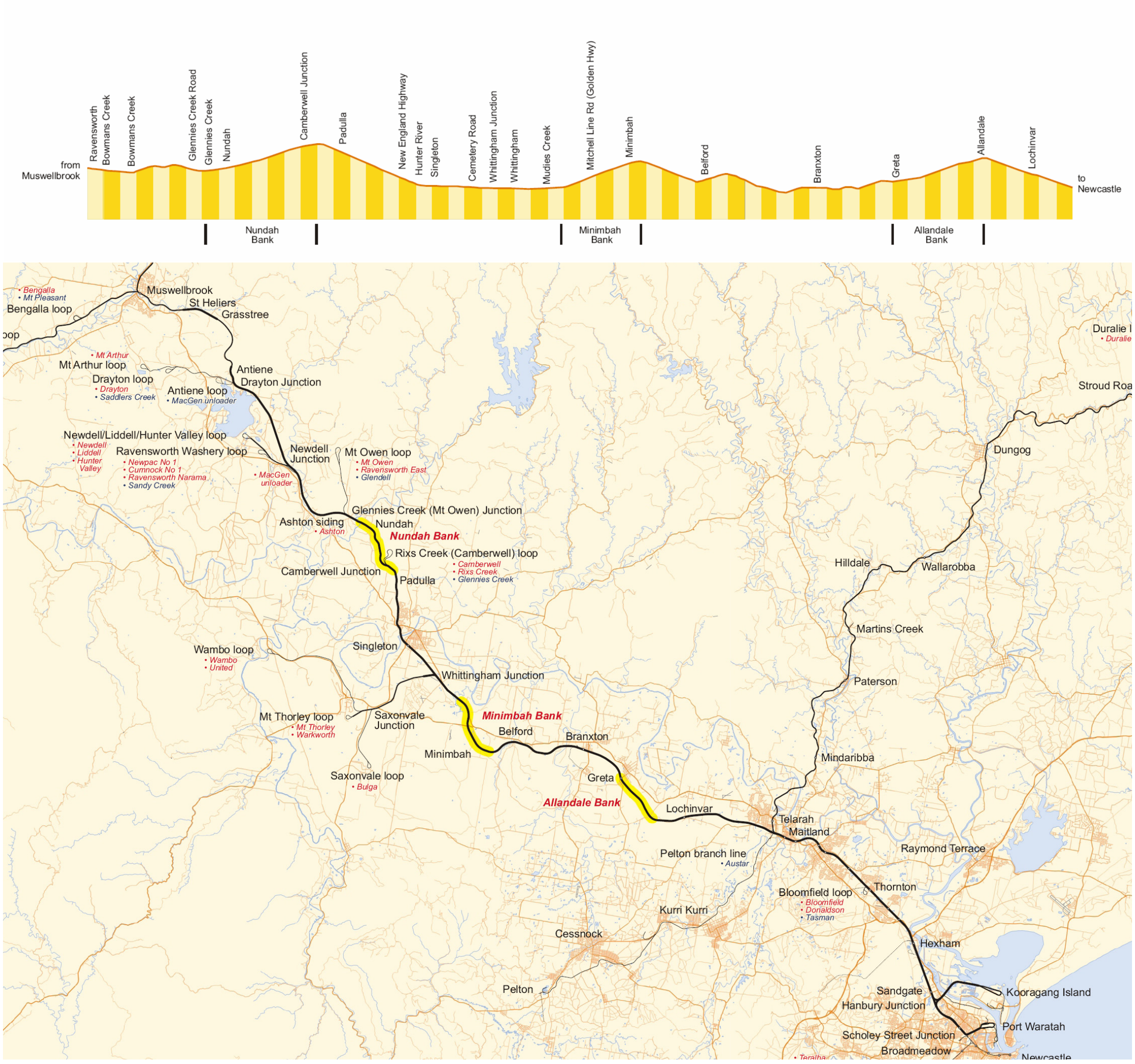

Figure 5-1 - The Nundah, Minimbah and Allandale Banks.

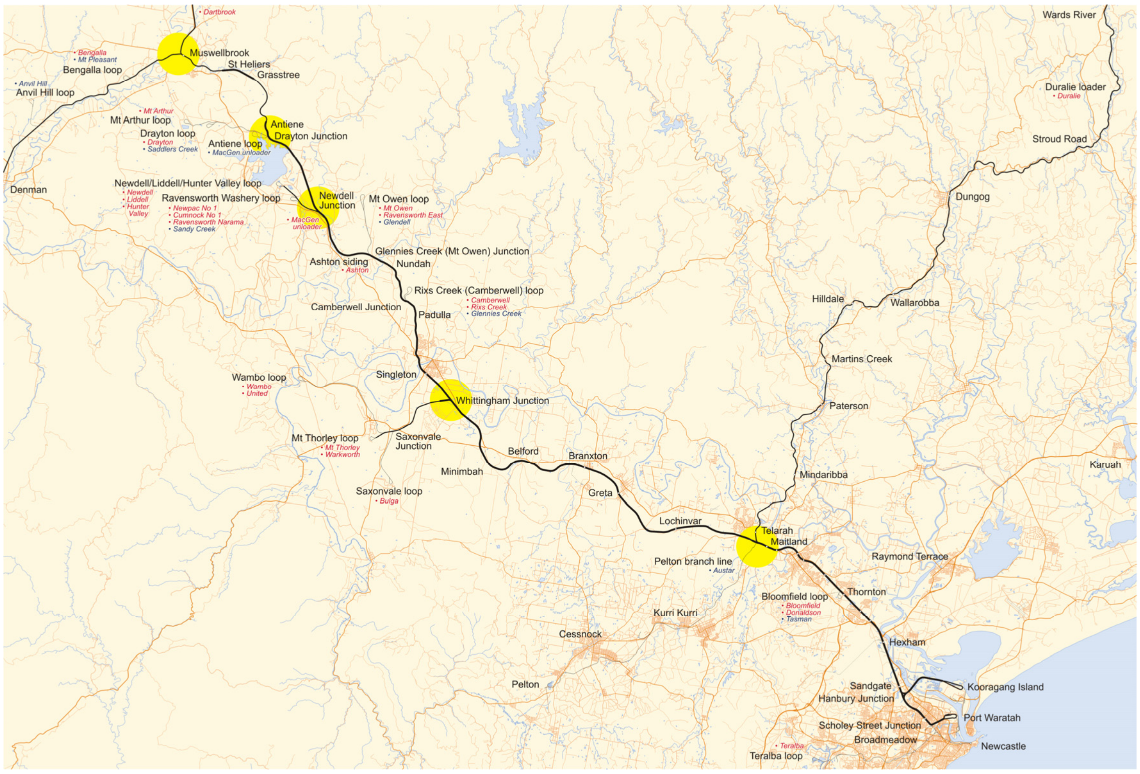

Figure 5-2 - Maitland, Whittingham, Newdell, Drayton and Muswellbrook Junctions flows from the two single lines are integrated efficiently onto the double track spine south of Muswellbrook.

Continuous Train Flow

A key issue for efficiency at the terminal is the need for the dump stations to receive a continuous flow of trains. When the flow of trains at the dump station is interrupted, this creates a direct unrecoverable loss of coal chain capacity, except to the extent that maintenance downtime of the terminal infrastructure can be aligned to the rail side disruption. A critical consideration for the coal chain as a whole is therefore maximising the continuity of trains rather than simply total track capacity.

This was the primary driver of the decision to build the Minimbah—Maitland third track, and flexibility to achieve continuous flow has also been enhanced by the construction of the Hexham holding roads.

No further tightening of train flow requirements has been identified as necessary to support current volume forecasts. However, ANCO is expected to provide significantly enhanced ability to plan and control the arrival pattern of trains, which will give greater confidence around the ability of the system to optimise utilisation of the dump stations.

Terminals

The Hunter Valley coal industry is serviced by three coal loader terminals, PWCS Carrington (CCT), PWCS Kooragang Island (KCT) and NCIG Kooragang Island. While the coal loaders are owned by Port Waratah Coal Services (PWCS) and the Newcastle Coal Infrastructure Group (NCIG), much of the track in and around the terminals is leased by ARTC and all train operations are controlled by ARTC.

The Carrington loader is the oldest of the facilities and is located in the highly developed Port Waratah precinct, with extensive rail facilities servicing a variety of activities. This includes steel products, containerised product for both third party logistics and mineral concentrate export in addition to bulk export grain for both GrainCorp and Newcastle Agri Terminal loader. There are also locomotive and wagon servicing and maintenance facilities.

The Carrington coal facilities include 3 arrival roads and 2 unloaders. While there are nominally 10 departure roads, these range in length from 414 metres to 863 metres, all of which are shorter than all coal trains, other than the short trains used for Austar services. Only two of the three arrival roads can accommodate 80 wagon and longer trains.

The Carrington facility has an environmental approval limit of 25 mtpa. There is some opportunity to expand this slightly, though there may be environmental challenges in doing so.

PWCS Kooragang Island is better configured for modern rail operations. It now has 9 departure roads for its four dump stations and four fully signalled arrival roads.

Provisioning and inspection activity, which had historically contributed to congestion, has been moved out of the departure roads. Locomotives continue to shuttle between Kooragang and Port Waratah but this has a relatively minor impact on capacity.

PWCS nameplate capacity as a whole is 143 mtpa, while NCIG has nameplate capacity of 66 mtpa. NCIG has three arrival roads for its two dump stations.

All previously identified rail network investments to support current terminal capability have been completed.

Any scope of work required for prospective volumes will be dependent on the details of any incremental enhancements to capacity at KCT or NCIG. In the event that T4 proceeds, all of the necessary terminal track is assumed to be provided within the scope of that project.

Train flow between Hexham and the terminals continues to perform well and is meeting the required benchmarks to support throughput.

6

MAINTENANCE STRATEGY

Context

In this section ARTC aims to provide high level insight into improving the customer value proposition of the existing asset through transparency to the underlying asset management process and expected cost exposure for maintenance in the Hunter Valley. It reflects ARTC's major focus on long-term asset reliability improvement.

Changes from Previous Year

There are no significant changes in terms of the published spend profiles for the maintenance program compared to the 2016 Strategy. This is expected given the sustaining maintenance strategy approach of ARTC. Looking forward, the spend profile may need to change to reflect ATMS and steel bridge integrity considerations, as well as any new loop projects that proceed.

Since the 2016 Strategy, ARTC has committed to the delivery of various improvement projects which are aimed at improving understanding of condition and risk to the network. The notable projects are discussed below.

Technology Initiatives

ARTC is at various stages of assessing and implementing a number of technological improvements to support efficient maintenance delivery. These include:

- High speed grinding
- High speed ultrasonic testing
- Real time bridge monitoring
- Use of lidar for corridor monitoring
- Deployment of instrumented coal wagons onto the Ulan line for continuous track condition monitoring
- Implementation of point monitoring devices
- Continuous monitoring of track infrastructure health to maximise availability under ANCO Horizon II

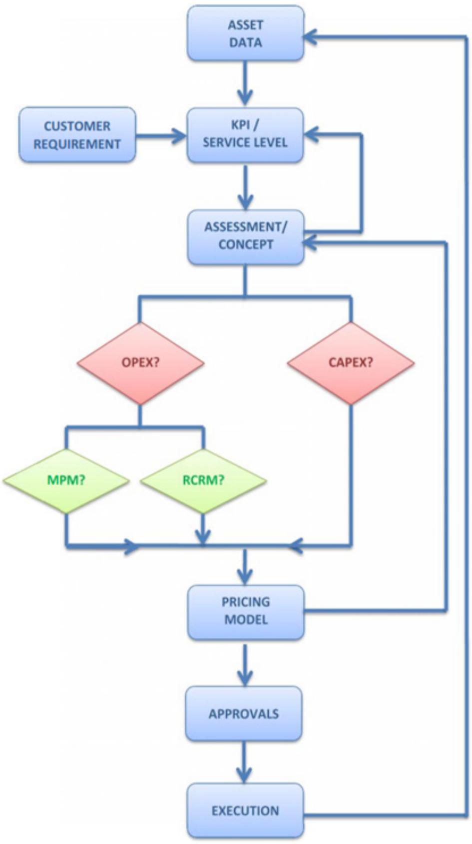

Figure 6-1 - Maintenance Development Process

Maintenance Planning System

The development of the Hunter Valley Corridor Maintenance program is an iterative process using various asset data inputs and analysis methods to arrive at a program of works that is considered to deliver ARTC's customer requirements in the most efficient manner. Figure 6-1 outlines the basics of the process.

ARTC has recently committed to a review of the system used to develop the annual maintenance program with a view to transforming the fundamental processes used to derive the maintenance strategy. The targeted processes are aimed at extracting further value

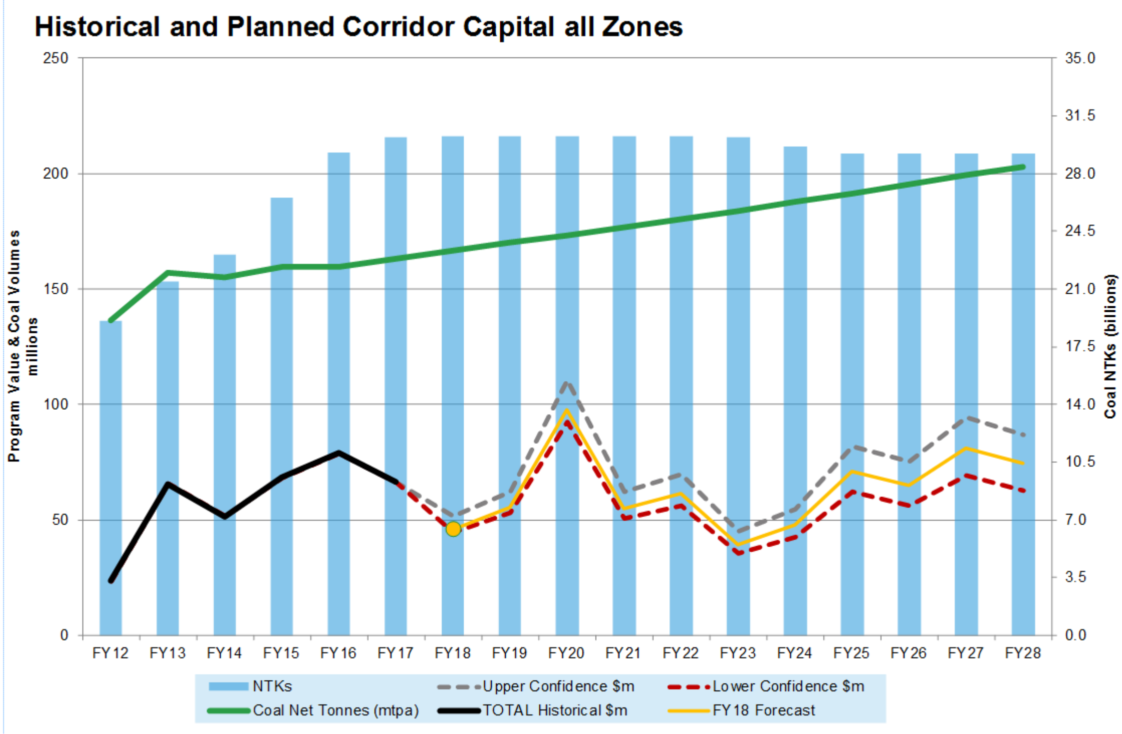

Figure 6-2 - Historical and Planned Corridor Capital

for money for our customers. Most notably these changes have involved:

- Rationalisation of the systems used to manage the asset through the Asset Management Improvement Project (AMIP).
- Challenging the underlying standards and process that generate work on the asset.
- Maturing the focus and capability of our internal staff from a compliance approach to an assurance approach.

ASSET MANAGEMENT IMPROVEMENT PROGRAM

To meet the service delivery and strategic objectives of the rail network, infrastructure assets are required to be safe, reliable and cost effective. Asset management systems and processes that optimise maintenance activities and deliver an accurate understanding of asset health, risk and cost provide customers with confidence that their business is supported.

The Asset Management Improvement Project will build this foundation and deliver value through improved asset assurance function, resource optimisation and defect management on the rail assets. This will provide a more sophisticated asset management framework for ARTC to build customer focussed plans and enable a deeper level of discussion on risk.

MAINTENANCE STANDARDS

The majority of the maintenance standards used to manage the asset have been derived using a tonnage or time basis. This time/tonnes basis has historically managed the safety risk across many rail operations worldwide. For example, a turnout will be inspected at a certain interval regardless of other mitigating factors such as age, condition or recent performance.

ARTC is currently undertaking work that challenges these maintenance standards, ultimately bringing about greater balance between efficient operating cost and risk. The aim of this work is to intervene and maintain the asset only after a safety, reliability or condition trigger to optimise customer outcomes.

The changes to standards will be implemented in stages over a medium to longer term time horizon. However, recently ARTC has reviewed the frequency at which turnouts are visually inspected across the network. This review has used an approach that ranks turnouts against elements such as condition, age, criticality and failure history to derive an inspection frequency that better addresses the risk at each particular location on the network.

ARTC will work with the industry safety regulator and other subject matter experts as required to ensure that any changes to inspection intervals are done in a proper risk controlled manner that does not compromise the safety of the asset.

FUTURE WORK

Work continues on testing the prudence and efficiency of the maintenance spend. This program will enable improvements to the understanding of the asset condition and behaviour of the asset in response to the current maintenance strategy.

ARTC has committed funds in the 2017/18 financial year for the purchase and implementation of a Decision Support Platform (DSP) as foreshadowed in the 2016 Strategy. The goal of the DSP is to rationalise the many models and data sources on the asset into a single system that will enable an efficient review of asset data (from a single source) and the use of contemporary analysis techniques on data to ensure that reliable and robust decisions are made on the asset.

Maintenance Works Summary

The annual maintenance program is divided into three main areas of expenditure; Routine Corrective and Reactive Maintenance (RCRM), Major Periodic Maintenance (MPM) and Corridor Capital (capital). The RCRM and MPM programs are considered an operating expense and as such these programs are not subject to the Regulated Asset Base (RAB) treatment, whereas the capital program of works is subject to this treatment in accordance with the Hunter Valley Access Undertaking (HVAU).

The current forecast program of works for both MPM and capital is presented in the following sections. The graphs highlight an upper and lower confidence limit in terms of the forecast expenditure. This limit diverges over time in line with confidence around the requirement for the works and the cost estimate associated with the works. The graphs include the total Net Tonne Kilometres (NTK's) and the total coal volumes. The trend in maintenance expenditure can be compared to the trend of both historic and future NTK's and coal tonnes.

To provide further context to this forward maintenance spending profile, the previous five years of maintenance expenditure is also shown.

Corridor Capital

The current forecast of the ten-year corridor capital program for all zones is shown in Figure 6-2.

This spend profile includes the 30 tonne axle load program of works being delivered in Zone 3 which concluded at the end of 2017. At the conclusion of this program, the corridor capital spending profile shows a modest sustaining program across all zones with a few of the departures to this trend being significant asset replacements (e.g. bridges).

The significant activities under the corridor capital program of works and a brief description of the development and asset risk are provided below. These activities typically represent over 50% of the annual corridor capital spend in any given year.

BRIDGE RENEWALS

Most structures on the coal network are of concrete construction. However, there are also 47 steel structures and 1 masonry structure which whilst they are adequate for the current operating requirements of the coal network, do provide a different risk profile due to age, condition and location on the network.

The bridge renewal program is primarily driven from a safety and risk perspective. Structures are a long life asset with modern day designs allowing for 100+ year life. A small proportion of significant steel structures in the Hunter Valley are approaching the end of their expected life with maintenance plans for each of these structures reflecting the treatment of safety risks as opposed to significant life extension.

Whilst historical strengthening work on the older bridges, many over 100 years old, has allowed ARTC to keep pace with the expected load profiles, ARTC is reviewing and revising its long term structures life and replacement program to ensure an appropriate trade-off between risk and program cost.

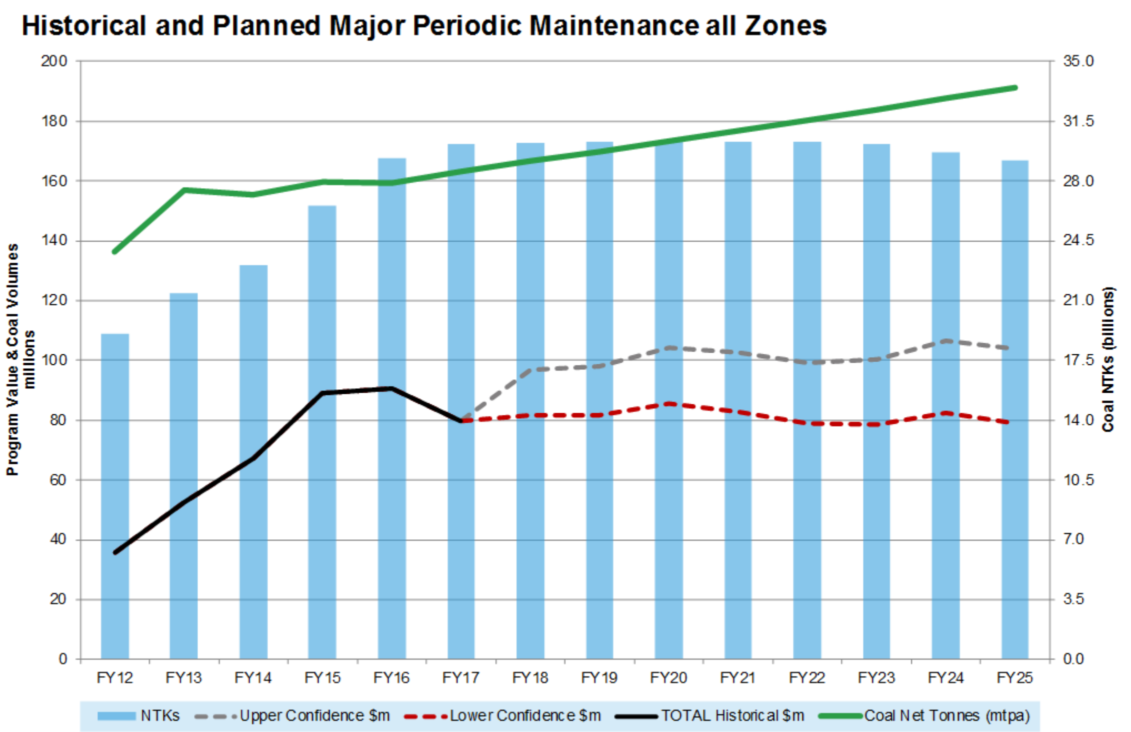

Figure 6-3 - Historical and Planned Major Periodic Maintenance

RERAILING

The rerailing program is calculated using a model which uses the historical observed rail wear rates for each section of track. By correlating the actual tonnage history over these sections, the model then estimates the amount of rerailing required on the network through the use of forecast volumes to predict future life of the rail.

Rerailing is essential both to ensure that the rail has adequate structural capacity to carry the specified axle loads and to reduce the risk of rail breaks as defects in the rail propagate over time.

TRACK STRENGTHENING

The track strengthening program generally consists of track reconditioning (removal of all ballast and subgrade) where the work extends over a distance of greater than 200m. The identification and development of the scope utilises various sources of information including temporary speed restrictions, amount of tamping effort, geotechnical investigations and local team knowledge. Work scope and method is developed with a view to achieving permanent solutions that can be delivered in a 72 hour closedown.

The majority of the Hunter Valley rail network is built on an earthworks formation which was constructed during the early 1900's. The running of 30 tonne axle load rolling stock would not have been envisaged by design work done during this period. Due to the age and engineering design of these earthworks, some sections do progressively fail and the renewal is performed with a contemporary formation design .

TURNOUT RENEWAL

The turnout renewal program is derived through an assessment of turnout performance, age, location risk and current maintenance effort. The scope of works under this activity generally delivers an upgrading of the existing turnout and underlying formation with any design optimisation performed in the investigation phase of the project.

Turnouts constructed with timber bearers and older style steel work are considered an operational risk to the coal network as this style of turnout is prone to failure and a high maintenance effort. The majority of turnout replacements performed in the Hunter Valley are replacing turnouts of this design with turnouts designed to withstand the demands required of the asset in moving the volumes forecast, and achieving standardised turnout types across the network.

Major Periodic Maintenance

The forecast spend profile of the MPM program for all zones is shown in Figure 6-3.

The significant activities under the MPM program of works and a brief description of the development and asset risk are provided below. These activities typically represent over 50% of the annual MPM spend in any given year.

BALLAST CLEANING

The ballast underneath the sleepers must be free draining for the track asset to function properly. Over time the free draining nature of ballast reduces through the degradation of the ballast and the development of fines throughout the track profile. This degradation is due to many factors including tonnage, the amount of tamping effort, coal debris and formation failures.

Ballast cleaning is performed to remove these fines that build up over time and reduce the efficacy of the drainage system. This process involves major track plant which screens the in-situ ballast and returns good ballast to the track, with fines removed to spoil. As the ballast degradation is highly correlated to tonnage, the ballast cleaning program is cyclic in nature and sensitive to future coal volumes, noting that in the next few years there is a legacy that ARTC is continuing to work on rectifying.

RAIL GRINDING

The rail grinding programme is a cyclic program based on tonnage, track curvature and rail performance (internal/external defects). The process of rail grinding involves grinding the surface of the rail to reinstate the rail shape to a profile which best suits the rollingstock wheel profiles. If there is a mismatch in these profiles, excess stresses are transferred into the rail section, creating defects which may lead to temporary speed restrictions (TSRs) or broken rails.

It is an essential part of any rail operation to maintain the rails through rail grinding. This program of works is correlated to tonnage and track curvature (with the sharper curves getting ground more often than straight track).

RESURFACING (TAMPING)

Resurfacing (or tamping) is a process where the track geometry is reinstated to a standard at which trains can travel through a track section at full design track speed. Over time track geometry deteriorates, mainly due to tonnage across the line, weather conditions and the underlying track formation.

The resurfacing programme is a cyclic program based on tonnage and track performance.

DRAINAGE AND MUDHOLE RECTIFICATION

The Drainage and Mudhole rectification activity is considered to be an essential part of the maintenance program. This scope of works is variable from site to site (mud hole dig outs, surface drain cleaning, subsurface drain installation etc) however the maintenance of an effective drainage system is critical to ensuring that track geometry faults and the development of TSRs is kept to an acceptable level.

7

RECOMMENDED PROJECTS AND NETWORK CAPACITY

Recommended Projects

A summary of the recommended projects for contracted volumes comparing previous and new proposed delivery timeframes, together with estimated costs at a P75[2] level, is shown in Table 7-1.

Table 7-2 shows the same detail as Table 7-1, for the scope of work required for prospective volumes. In Table 7-2 costs are shown as both un-escalated and escalated based on the 'proposed by' delivery dates. Costs are generally orders of magnitude only unless a project is in or close to construction. Costs are not ARTC's anticipated outturn costs as there are too many unknowns at the strategy phase to attach any reliability to the estimates. Scope and construction conditions are progressively better defined until a project cost is established for approval by the RCG in accordance with the HVAU.

Chapter 2 includes a discussion around the development of the ANCO and ATMS projects and notes the potential for these projects to deliver a higher rate of single track utilisation than the 65% adopted for the purposes of determining capacity in this Strategy.

Table 7-2 varies from the approach adopted in previous Strategies in that it now adopts ATMS and ANCO as the base case assumption, with a final utilisation rate of 75%.

However, it is important to emphasise that until these projects are delivered and the sustainable level of utilisation is validated there is some uncertainty around

Contracted Volume	2016 Strategy – Proposed by	2017 Strategy – Required by	2017 Strategy – Proposed by	Change 2016 to 2017	Estimated Cost ($m)
Port—Muswellbrook					
Nil					
Ulan Line					
Coded track circuit upgrade	-	ASAP	Late 2018	-	<$1 m
Gunnedah Line					
Coded track circuit upgrade	-	ASAP	Late 2019	-	<$2 m
Productivity Projects					
ARTC Network Control Optimisation (ANCO)[3]	n/a	n/a	Q4 2019	see note 1	$36
Advanced Train Management System (ATMS)	Q1 2020	n/a	Q1 2021 / Q1 2023[4]	see note 2	$260

Table 7-1 - Recommended Projects, Delivery Schedule and Costs for Contracted Volumes

General Notes: All projects (including scope, timing, and funding arrangements) are subject to consultation with and endorsement by the industry.

Dollar estimates are based on current known: Scope; survey and geotechnical knowledge; legislation and tax regimes. Project dollars are order of magnitude estimates only and do not represent concluded project dollars.

Note 1 - ANCO will be a phased roll out with the Gunnedah line targeted for Q4 2018, Ulan line Q2 2019 and the Muswellbrook—Ports network in Q4 2019.

Note 2—The cost estimate for ATMS includes the roll out for the whole of the Hunter Valley. There are options to implement the project partially and incrementally over a longer period of time reducing this estimate significantly.

Note 3—The proposed ANCO scope assumes funding for a phase 2 study into Horizon II scope, cost and benefits.

Note 4—Single track sections assumed to be completed by Q! 2021 and Muswellbrook—Ports by Q1 2023.

2 A P75 value indicates the project has been assessed as having a 75% probability of being delivered for the identified cost, or less.

Contracted plus Prospective Volume	2016 Strategy – Required by (Note 1)	2017Strategy - Required by (Note 2)	Estimated Cost ($m) un-escalated 2017, order-of-magnitude	Estimated Cost ($m) escalated, order-of-magnitude
Port—Maitland				
Nil				
Maitland - Muswellbrook				
Nil				
Ulan Line				
Coded track circuit upgrade	-	ASAP	<$1	<$1
Mt Pleasant	2024	2027	$29	$36
Widden Creek	-	2021	$38	$47
Gunnedah Basin Line				
Coded track circuit upgrade	-	ASAP	<$1	<$1
Aberdeen	2019	2023	$18	$20
Togar North Loop	2017	2020	$21	$23
316 km loop (Parkville South)	2022	-	$42	-
Wingen loop	2017	2020	$21	$23
Blandford loop	2019	2022	$35	$39
Pages River North extension	2022	2023	$90	$103
Kankool—Ardglen	2019	2023	$85	$98
Braefield north extension	2022	2023	$51	$59
Bells Gate south extension	2017	2021	$42	$46
407 km loop (Werris Creek South)	2022	2023	$30	$34
414 km loop (Werris Creek North)	2020	2022	$27	$30
Burilda north extension	-	2023	$81	$100
Breeza north extension	2023	-	$40	-
South Gunnedah loop	2017	2020	$23	$25
486 km loop	-	2023	$26	$32
Collygra	2017	2023	$23	$26
Congestion Projects				
Train Parkup	See Note 3	TBD		

Table 7-2 - Recommended Projects, Delivery Schedule and Costs for Prospective Volumes

General Notes:

All the above projects (including scope, timing, and funding arrangements) are subject to consultation with and endorsement by the industry.

Dollar estimates are based on current known: Scope; Survey and geotechnical knowledge; legislation and tax regimes. Project dollars are order of magnitude estimates only and do not represent concluded project dollars.

Note 1: The 2016 Strategy assumed ANCO and ATMS but did not make any adjustment to the utilisation rate. Also, project timing were based solely on capacity requirements and did not take into account practical timeframes for project delivery.

Note 2: This Strategy includes ANCO and ATMS and assumes that utilisation will be increased to 75%. Project timing is the earlier of when the project is required for capacity and when it can realistically be delivered.

it. For this reason, and to highlight the investment requirements were the projects to not proceed, table 7-3 shows the effect on the scope under a utilisation rate of 65% as well as 75%. This is shown for the most likely scenario outlined in this Strategy which gives the most realistic view of the potential investment requirement.

Demand and capacity by sector, based on the project timings recommended in this Strategy, and using the calculation methodology set out in Chapter 1, is shown in figures 7-1, 7-2 and 7-3. These charts show both contracted and prospective volumes.

Saleable coal train capacity and coal tonnage capacity by sector for the contracted volume scenario is shown in tables 7-5 and 7-6 respectively. Tables 7-7 and 7-8 show the equivalent information for prospective volumes, for train numbers and tonnage respectively.

The HVAU also requires that the Capacity Strategy provide details of net capacity - that is, total capacity less contracted coal and non-coal volumes. This is shown in general in figures 7-1, 7-2 and 7-3.

It is not possible to provide both total capacity and net capacity by line section as this would allow volume by load point to be back solved, breaching ARTC's confidentiality obligations To give an indication of net capacity table 7-4 provides net capacity for three key line sections for contracted volumes and is intended to complement figures 7-1, 7-2 and 7-3.

Projects required for Most Likely scenario	Current assumption (65% utilisation)	ATMS / ANCO (75% utilisation)
Ulan Line		
Mt Pleasant loop	2021	-
Widden Creek	2021	2021
Bylong east extension	2021	-
Coggan Creek west extension	2021	-
Gunnedah Basin Line		
Aberdeen	2021	-
Togar North Loop	2020	2024
316 km loop (Parkville South)	2025	-
Wingen loop	2021	2024
Blandford loop	2021	2025
Pages River North extension	2023	-
Kankool—Ardglen	2024	-
Braefield north extension	2024	-
Bells Gate south extension	2021	2024
407 km loop (Werris Creek South)	2025	-
414 km loop (Werris Creek North)	2021	2025
Burilda north extension	2024	-
Breeza north extension	2025	-
South Gunnedah loop	2020	2023
486 km loop	2023	2025
Collygra	2021	2023

Table 7-3 —Scope for prospective volumes under current and potential future single track utilisation rates.

Net Capacity (paths)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Pricing Zone 3 (at Werris Creek)	0.2	0.9	2.1	4.0	4.0	4.0	4.0	4.0	5.3	5.3
Pricing Zone 2 (at Bylong)	-0.3 [1]	0.9	0.9	2.2	2.2	2.3	2.4	2.6	4.9	4.9
Pricing Zone 1 (at Whittingham)	33.6	33.7	33.7	33.7	34.0	136.7	139.8	144.8	147.1	147.1

Table 7-4 - Surplus coal path availability (total capacity less contracted volume) for indicative line sectors for each zone.

Note 1—Due to the increase in system cancellation and maintenance loss rates compared to prior assumptions, together with adoption of actual train performance, there is technically a small shortfall in paths under contracted volumes on the Ulan line in 2018. ARTC is confident though that contracted volumes can be achieved.

	2018				2019				2020	2021	2022	2023	2024	2025	2026	2027
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
Narrabri - Boggabri	4.2	4.2	4.2	4.5	4.5	4.5	5.2	5.2	5.2	6.4	6.4	6.4	6.4	6.4	6.4	6.4
Boggabri - Vickery	7.9	7.9	7.9	8.3	8.3	8.3	9.3	9.3	9.3	11.0	11.0	11.0	11.0	11.0	11.0	11.0
Vickery - Gunnedah	10.4	10.4	10.4	11.1	11.1	11.1	12.3	12.3	12.3	14.3	14.3	14.3	14.3	14.3	14.4	14.4
Gunnedah - Watermark Jct	8.1	8.1	8.1	8.6	8.6	8.6	9.7	9.7	9.7	11.4	11.4	11.4	11.4	11.4	11.4	11.4
Watermark Jct - Werris Creek	10.7	10.7	10.7	11.4	11.4	11.4	12.7	12.7	12.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7
Werris Creek - Scone	10.1	10.1	10.1	10.8	10.8	10.8	12.0	12.0	12.0	13.9	13.9	13.9	13.9	13.9	13.9	13.9
Scone - Dartbrook	9.8	9.8	9.8	10.4	10.4	10.4	11.6	11.6	11.6	13.5	13.5	13.5	13.5	13.5	13.4	13.4
Dartbrook - Musw ellbrook	17.7	17.7	17.7	19.6	19.6	19.6	21.6	21.6	21.6	24.7	24.7	24.7	24.7	24.7	24.7	24.7
Ulan - Moolarben	11.3	11.3	11.3	13.2	13.2	13.2	14.8	14.8	14.8	17.2	17.2	17.2	17.2	17.3	18.2	18.2
Moolarben - Wilpinjong	16.0	16.0	16.0	17.9	18.0	18.0	19.6	19.6	19.6	22.0	22.0	22.0	21.9	22.1	23.0	23.0
Wilpinjong - Bylong	12.7	12.7	12.7	13.9	13.9	13.9	15.0	15.0	15.0	16.8	16.8	16.8	16.8	16.8	16.8	16.8
Bylong - Ferndale	11.3	11.3	11.3	12.4	12.4	12.4	13.4	13.4	13.4	14.6	14.6	14.6	14.6	14.6	14.6	14.6
Ferndale - Mangoola	15.3	15.3	15.3	16.9	16.9	16.9	18.3	18.3	18.3	20.6	20.6	20.6	20.6	20.8	20.9	20.9
Mangoola - Mt Pleasant	21.7	21.7	21.7	25.0	25.0	25.0	27.0	27.0	27.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Mt Pleasant - Bengalla	17.9	17.9	17.9	19.4	19.4	19.4	20.9	20.9	20.9	23.1	23.1	23.1	23.1	23.0	22.7	22.7
Bengalla - Musw ellbrook	23.6	23.6	23.6	27.5	27.5	27.5	29.7	29.7	29.7	33.0	33.0	33.0	33.0	33.0	33.0	33.0
Musw ellbrook -Drayton	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	194.7	194.7	194.7	194.7	194.7
Drayton - New dell	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7	194.7	194.7	194.7	194.7	194.7
New dell - Mt Ow en	114.4	114.4	114.4	114.4	114.4	114.4	114.4	114.4	114.4	114.4	114.4	194.7	194.7	194.7	194.7	194.7
Mt Ow en - Camberw ell	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	194.7	194.7	194.7	194.7	194.7
Camberw ell - Whittingham	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	194.7	194.7	194.7	194.7	194.7
Whittingham - Maitland	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	194.7	194.7	194.7	194.7	194.7
Maitland - Bloomfield	148.6	148.6	148.6	148.6	148.6	148.6	148.6	148.6	148.6	148.6	148.6	214.0	214.0	214.0	214.0	214.0
Bloomfield - Hexham	148.6	148.6	148.6	148.6	148.6	148.6	148.6	148.6	148.6	148.6	148.6	214.0	214.0	214.0	214.0	214.0

Table 7-5 - Saleable capacity in coal train numbers (round-trips per day) assuming volumes and the recommended scope of work as per the contracted volume scenario.

	2018				2019				2020	2021	2022	2023	2024	2025	2026	2027
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
Narrabri - Boggabri	12.1	12.1	12.1	12.8	12.8	12.8	14.9	14.9	14.9	18.4	18.4	18.4	18.4	18.4	18.4	18.4
Boggabri - Vickery	22.0	22.0	22.0	23.4	23.4	23.4	26.2	26.2	26.2	30.9	30.9	30.9	30.9	30.9	30.9	30.9
Vickery - Gunnedah	29.1	29.1	29.1	31.1	31.1	31.1	34.5	34.5	34.5	40.2	40.2	40.2	40.2	40.2	40.4	40.4
Gunnedah - Watermark Jct	22.8	22.8	22.8	24.3	24.3	24.3	27.1	27.1	27.1	31.9	31.9	31.9	31.9	31.9	31.9	31.9
Watermark Jct - Werris Creek	30.0	30.0	30.0	32.1	32.1	32.1	35.6	35.6	35.6	41.2	41.2	41.2	41.2	41.2	41.2	41.2
Werris Creek - Scone	28.4	28.4	28.4	30.3	30.3	30.3	33.7	33.7	33.7	39.2	39.2	39.2	39.2	39.2	39.1	39.1
Scone - Dartbrook	27.5	27.5	27.5	29.3	29.3	29.3	32.6	32.6	32.6	38.0	38.0	38.0	38.0	38.0	37.7	37.7
Dartbrook - Musw ellbrook	49.7	49.7	49.7	55.0	55.0	55.0	60.7	60.7	60.7	69.5	69.5	69.5	69.5	69.5	69.4	69.4
Ulan - Moolarben	35.6	35.6	35.6	41.7	41.9	41.9	46.9	46.9	46.9	54.6	54.6	54.5	54.5	54.8	57.6	57.6
Moolarben - Wilpinjong	49.7	49.7	49.7	55.6	55.8	55.8	60.7	60.7	60.7	68.2	68.2	68.2	68.1	68.4	71.2	71.2
Wilpinjong - Bylong	39.4	39.4	39.4	42.9	42.9	42.9	46.4	46.4	46.4	52.0	52.0	52.0	52.0	52.0	52.1	52.1
Bylong - Ferndale	34.8	34.8	34.8	38.3	38.3	38.3	41.5	41.5	41.5	45.3	45.3	45.3	45.3	45.3	45.3	45.3
Ferndale - Mangoola	47.3	47.3	47.3	52.3	52.3	52.3	56.7	56.7	56.7	63.8	63.8	63.7	63.7	64.2	64.6	64.6
Mangoola - Mt Pleasant	67.8	67.8	67.8	78.1	78.2	78.2	84.3	84.3	84.3	93.7	93.7	93.7	93.7	93.5	93.8	93.8
Mt Pleasant - Bengalla	55.9	55.9	55.9	60.8	60.7	60.7	65.3	65.3	65.3	72.2	72.2	72.2	72.2	71.8	71.0	71.0
Bengalla - Musw ellbrook	73.9	73.9	73.9	86.2	86.2	86.2	93.0	93.0	93.0	103.3	103.3	103.3	103.3	103.2	103.5	103.5
Musw ellbrook -Drayton	279.4	279.4	279.4	279.4	279.4	279.4	279.4	279.4	279.4	279.4	279.4	590.2	590.1	589.0	589.5	589.5
Drayton - New dell	245.0	245.0	245.0	245.0	245.0	245.0	245.0	245.0	245.0	245.0	245.0	591.1	591.0	590.1	591.2	591.2
New dell - Mt Ow en	350.8	350.8	350.8	350.8	350.7	350.7	350.7	350.7	350.7	350.7	350.7	596.6	596.6	596.1	597.4	597.4
Mt Ow en - Camberw ell	269.9	269.9	269.9	269.9	269.9	269.9	269.9	269.9	269.8	269.8	269.8	599.1	598.5	596.1	597.4	597.4
Camberw ell - Whittingham	270.3	270.3	270.3	270.3	270.3	270.3	270.3	270.3	270.3	270.3	270.3	600.1	599.2	596.9	598.2	598.2
Whittingham - Maitland	285.6	285.6	285.6	285.6	285.6	285.6	285.6	285.6	285.6	285.6	285.6	603.3	602.5	600.5	601.2	601.2
Maitland - Bloomfield	455.2	455.2	455.2	455.2	455.2	455.2	455.2	455.2	455.2	455.2	455.2	655.4	662.1	659.8	660.6	660.6
Bloomfield - Hexham	455.2	455.2	455.2	455.2	455.2	455.2	455.2	455.2	455.2	455.2	455.1	655.4	662.0	659.8	660.6	660.6

Table 7-6 - Saleable capacity in million tonnes assuming volumes and the recommended scope of work as per the contracted volume scenario. This tonnage capacity is equal to table 7-5 times average train size times 365.

	2018				2019				2020	2021	2022	2023	2024	2025	2026	2027
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
Narrabri - Boggabri	3.6	3.6	3.6	3.8	3.8	3.8	4.5	4.5	4.5	5.6	5.6	5.8	5.8	5.8	5.8	5.8
Boggabri - Vickery	7.9	7.9	7.9	8.3	8.3	8.3	9.3	9.3	9.3	10.8	10.8	21.0	21.0	21.0	21.0	21.0
Vickery - Gunnedah	10.3	10.3	10.3	11.0	11.0	11.0	12.3	12.3	12.3	14.3	14.3	24.1	24.1	24.1	24.3	24.5
Gunnedah - Watermark Jct	8.1	8.1	8.1	8.6	8.6	8.6	9.7	16.8	16.8	19.0	18.5	18.7	18.7	18.7	18.7	18.7
Watermark Jct - Werris Creek	10.7	10.7	10.7	11.4	11.4	11.4	12.7	12.7	12.7	14.7	17.7	24.6	24.6	24.6	24.6	24.6
Werris Creek - Scone	10.1	10.1	10.1	10.8	10.8	10.8	12.0	12.0	12.6	15.0	17.0	19.1	19.1	19.1	19.1	19.1
Scone - Dartbrook	9.6	9.6	9.6	10.2	10.3	10.3	11.5	11.7	14.2	16.6	16.7	18.9	18.9	18.9	18.9	18.9
Dartbrook - Musw ellbrook	17.7	17.7	17.7	19.6	19.6	19.6	21.6	21.6	21.6	24.7	24.7	24.7	24.7	24.7	24.7	24.7
Ulan - Moolarben	10.9	10.9	10.9	12.7	12.1	12.1	13.7	13.7	13.3	15.0	15.0	15.0	14.9	15.0	15.0	15.0
Moolarben - Wilpinjong	16.1	16.1	16.1	17.9	18.2	18.2	19.7	19.7	19.8	22.2	22.2	22.2	22.1	22.2	22.2	22.2
Wilpinjong - Bylong	12.7	12.7	12.7	13.9	13.9	13.9	15.0	15.0	15.0	16.8	16.8	16.8	16.8	16.8	16.8	16.8
Bylong - Ferndale	11.3	11.3	11.3	12.4	12.4	12.4	13.4	13.4	13.4	18.8	18.8	18.8	18.8	18.8	18.8	18.8
Ferndale - Mangoola	15.3	15.3	15.3	16.9	17.0	17.0	18.4	18.5	18.5	20.9	20.9	20.8	20.8	20.7	20.6	20.4
Mangoola - Mt Pleasant	21.7	21.7	21.7	25.0	25.0	25.0	27.0	27.0	27.0	30.0	30.0	30.0	30.0	30.0	30.0	40.1
Mt Pleasant - Bengalla	17.9	17.9	17.9	19.5	19.6	19.6	21.0	21.1	21.2	23.5	23.5	23.5	23.5	23.6	23.6	33.0
Bengalla - Musw ellbrook	23.6	23.6	23.6	27.5	27.5	27.5	29.7	29.7	29.7	33.0	33.0	33.0	33.0	33.0	33.0	33.0
Musw ellbrook -Drayton	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	194.7	194.7	194.7	194.7	194.7
Drayton - New dell	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7	80.7	194.7	194.7	194.7	194.7	194.7
New dell - Mt Ow en	114.4	114.4	114.4	114.4	114.4	114.4	114.4	114.4	114.4	114.4	114.4	194.7	194.7	194.7	194.7	194.7
Mt Ow en - Camberw ell	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	194.7	194.7	194.7	194.7	194.7
Camberw ell - Whittingham	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	194.7	194.7	194.7	194.7	194.7
Whittingham - Maitland	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	92.1	194.7	194.7	194.7	194.7	194.7
Maitland - Bloomfield	148.6	148.6	148.6	148.6	148.6	148.6	148.6	148.6	148.6	148.6	148.6	214.0	214.0	214.0	214.0	214.0
Bloomfield - Hexham	148.6	148.6	148.6	148.6	148.6	148.6	148.6	148.6	148.6	148.6	148.6	214.0	214.0	214.0	214.0	214.0

Table 7-7 - Saleable capacity in coal train numbers (round-trips per day) assuming volumes and the recommended scope of work as per the prospective volume scenario.

	2018				2019				2020	2021	2022	2023	2024	2025	2026	2027
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
Narrabri - Boggabri	10.4	10.4	10.4	11.0	10.8	10.8	13.0	13.0	12.8	15.9	15.9	16.5	16.5	16.5	16.5	16.5
Boggabri - Vickery	22.0	22.0	22.0	23.4	23.4	23.4	26.3	26.3	26.0	30.3	30.3	59.3	59.3	59.3	59.3	59.3
Vickery - Gunnedah	29.0	29.0	29.0	31.0	31.0	31.0	34.5	34.5	34.6	40.4	40.4	68.2	68.2	68.2	68.6	69.3
Gunnedah - Watermark Jct	22.8	22.8	22.8	24.3	24.3	24.3	27.2	47.2	47.3	53.6	52.3	53.0	53.0	53.0	52.9	52.9
Watermark Jct - Werris Creek	30.0	30.0	30.0	32.1	32.1	32.1	35.6	35.7	35.7	41.4	50.0	69.8	69.8	69.8	69.8	69.8
Werris Creek - Scone	28.4	28.4	28.4	30.4	30.4	30.4	33.7	33.8	35.6	42.4	48.2	54.1	54.1	54.1	54.1	54.1
Scone - Dartbrook	27.1	27.1	27.1	28.8	28.9	28.9	32.3	32.9	40.1	47.1	47.2	53.7	53.7	53.7	53.5	53.5
Dartbrook - Musw ellbrook	49.9	49.9	49.9	55.3	55.5	55.5	61.2	61.2	61.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7
Ulan - Moolarben	34.4	34.4	34.4	40.2	38.5	38.5	43.4	43.4	42.2	47.5	47.5	47.4	47.3	47.5	47.5	47.5
Moolarben - Wilpinjong	49.9	49.9	49.9	55.6	56.3	56.3	61.2	61.2	61.2	68.7	68.7	68.6	68.5	68.7	68.7	68.7
Wilpinjong - Bylong	39.4	39.4	39.4	42.9	42.9	42.9	46.4	46.4	46.4	51.9	51.9	51.9	51.9	51.9	51.9	51.9
Bylong - Ferndale	34.8	34.8	34.8	38.3	38.3	38.3	41.4	41.4	41.4	58.0	58.0	58.0	58.0	58.0	58.0	58.0
Ferndale - Mangoola	47.4	47.4	47.4	52.4	52.6	52.6	57.0	57.1	57.2	64.4	64.4	64.4	64.4	64.0	63.7	62.9
Mangoola - Mt Pleasant	67.7	67.7	67.7	78.1	78.1	78.1	84.2	84.2	84.2	93.4	93.4	93.4	93.4	93.2	93.3	124.8
Mt Pleasant - Bengalla	56.1	56.1	56.1	60.9	61.2	61.2	65.8	66.0	66.1	73.5	73.5	73.5	73.4	73.4	73.5	102.7
Bengalla - Musw ellbrook	73.8	73.8	73.8	86.2	86.1	86.1	92.9	92.9	92.8	103.0	103.0	103.0	103.0	102.9	102.9	102.9
Musw ellbrook -Drayton	279.0	279.0	279.0	279.0	279.2	279.2	279.2	279.0	278.9	278.4	278.0	585.4	585.4	585.0	586.0	586.5
Drayton - New dell	244.8	244.8	244.8	244.8	244.9	244.9	244.9	244.7	244.7	244.2	243.9	586.7	586.7	586.2	587.7	588.0
New dell - Mt Ow en	350.3	350.3	350.3	350.3	350.3	350.3	350.3	350.1	349.9	349.2	348.7	591.5	591.4	591.1	592.3	592.5
Mt Ow en - Camberw ell	269.5	269.5	269.5	269.5	269.5	269.5	269.5	269.3	269.0	268.5	268.2	593.6	592.9	591.1	592.3	592.5
Camberw ell - Whittingham	269.9	269.9	269.9	269.9	269.9	269.9	269.9	269.7	269.5	268.9	268.6	594.5	593.5	591.7	592.9	593.1
Whittingham - Maitland	285.2	285.2	285.2	285.2	285.1	285.1	285.1	284.9	284.6	284.0	283.7	597.7	596.8	595.0	595.6	595.7
Maitland - Bloomfield	448.4	448.4	448.4	448.4	446.6	446.6	446.6	446.6	446.6	446.3	445.9	640.9	645.0	642.4	643.2	643.5
Bloomfield - Hexham	448.4	448.4	448.4	448.4	446.7	446.7	446.7	446.6	446.6	446.3	446.0	641.1	645.1	642.5	643.3	643.6

Table 7-8 - Saleable capacity in tonnes assuming volumes and the recommended scope of work as per the prospective volume scenario. This tonnage capacity is equal to table 7-7 times average train size times 365.

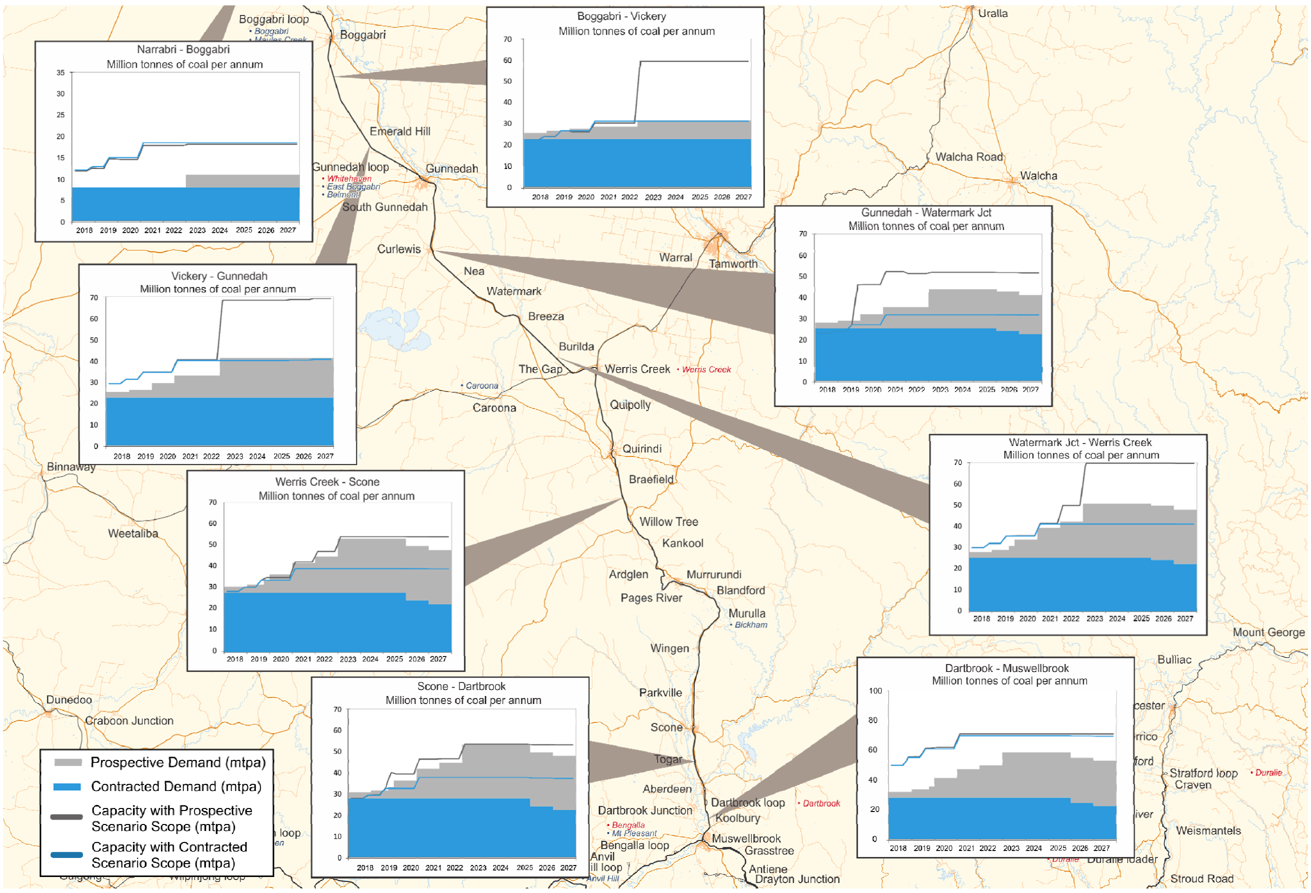

Figure 7-1 - Volume and capacity on the Gunnedah basin line.

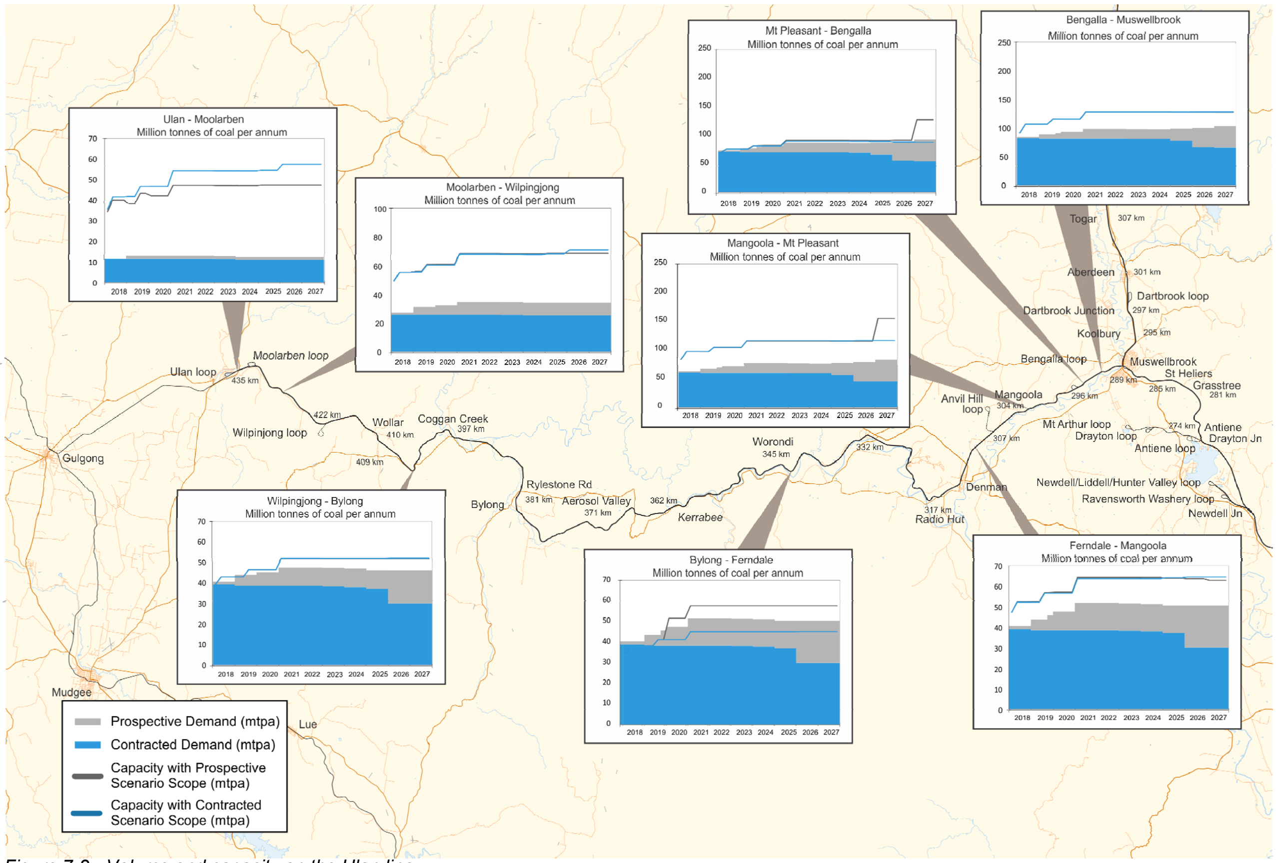

Figure 7-2 - Volume and capacity on the Ulan line

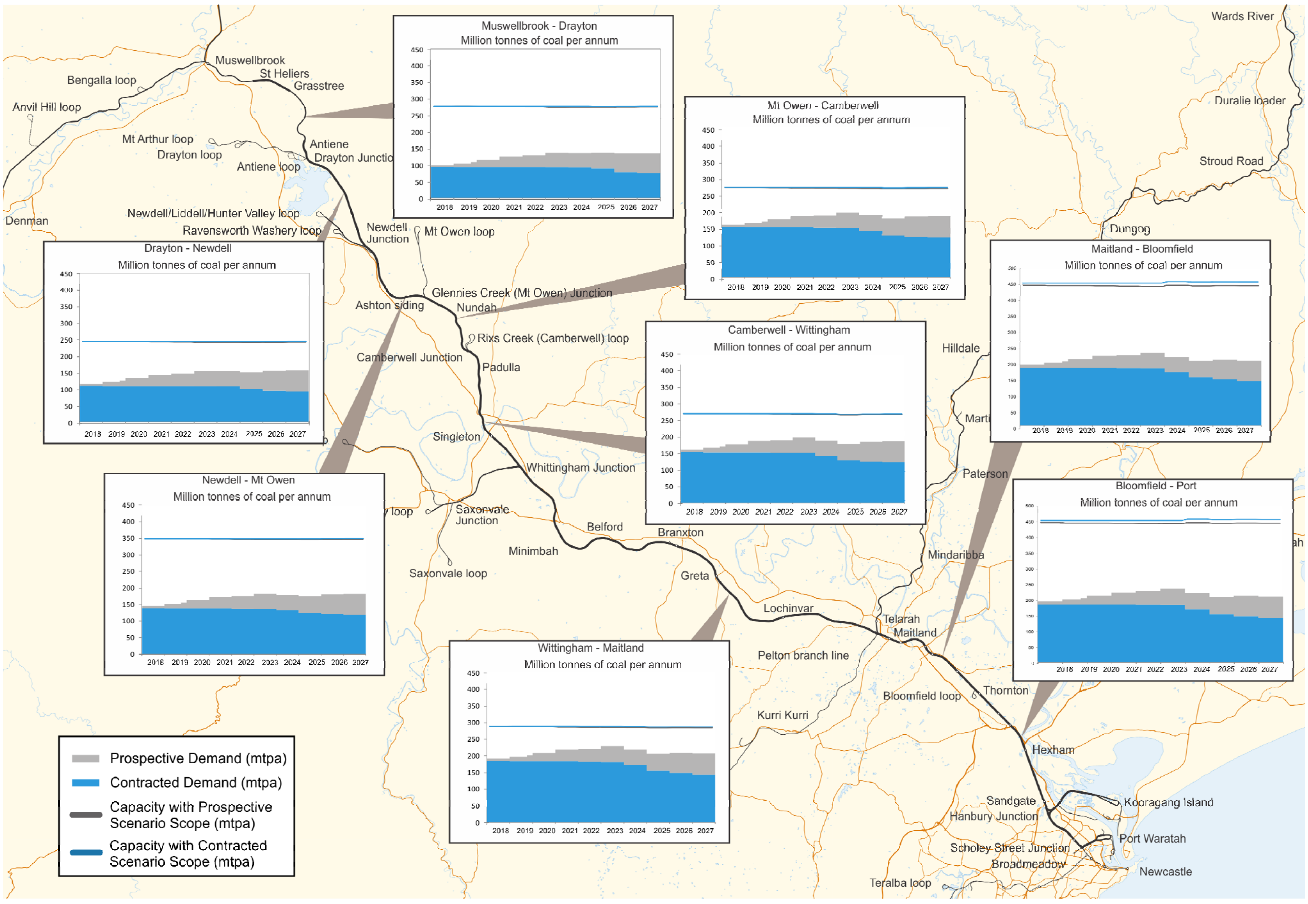

Figure 7-3 - Volume and capacity Muswellbrook—Newcastle

Refer to ARTC's website for more information on ARTC.

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