2020 HUNTER VALLEY CORRIDOR CAPACITY STRATEGY

July 2020

CONSULTATION DRAFT

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 an annual Hunter Valley Corridor Capacity Strategy (HVCCS), or the 'Strategy', setting out how ARTC planned to ensure that rail corridor capacity in the Hunter Valley would stay ahead of coal demand. This HVCCS is the thirteenth of these annual strategies.

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.

Nearly 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, 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 volumes that have not yet been the subject of a contractual commitment, though these are hypothetical scenarios only and do not imply that such volumes will be contracted.

This 2020 Strategy contemplates 'most likely' and 'prospective' scenarios in addition to the 'contracted' volume scenario. Like the 2019 Strategy, the most likely and prospective scenarios have been directly provided by producers and endorsed by the Rail Capacity Group (RCG).

This Strategy identifies a preliminary scope of work to accommodate contracted plus prospective volumes of up to 246 million tonnes per annum (mtpa). This is a small decrease in the peak volume compared to the 2019 Strategy.

It also identifies a pathway for meeting demand under the most likely scenario, which peaks at 218 mtpa, which is also slightly lower than the equivalent scenario as projected in 2019. Required and recommended projects for contracted volumes are also identified.

For administrative purposes under the HVAU, the network is categorised into three zones, Ports - Bengalla (zone 1), Bengalla - Ulan (zone 2) and Muswellbrook - Narrabri (zone 3). This Strategy sometimes refers to these zones rather than section names, noting that for simplicity Muswellbrook - Bengalla is sometimes treated as being in zone 2 as it is located on the Ulan line.

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, while 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.

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.

HVCCC Master Planning

Capacity analysis in this Strategy takes no account of the capabilities of loading and unloading interfaces, including the capabilities of private rail sidings and balloon 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 coal supply chain capacity analysis is undertaken by the Hunter Valley Coal Chain Coordinator (HVCCC).

The HVCCC is responsible for the co-ordination of coal chain planning on both a day-to-day and long term basis. Its role includes 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, the Declared Inbound Throughput (DIT). This is the lesser of terminal system capacity and rail system capacity. For 2020, the HVCCC has determined a DIT that is less than track system capacity, that is, track system capacity does not represent a constraint on system throughput. HVCCC has forecast that track system capacity will not constrain currently contracted volumes.

Delivering capacity efficiently

Since 2016, the Strategies have included an explicit refocussing of ARTC's forward investment program toward technology and innovation with a view to increasing 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 network control in the Hunter Valley through enhanced dynamic capability to manage variation and streamline network wide train management. ANCO is currently being implemented between Hexham and the port, completing the rollout across the Hunter Valley network.

This could in future be supplemented by the implementation of the Advanced Train Management

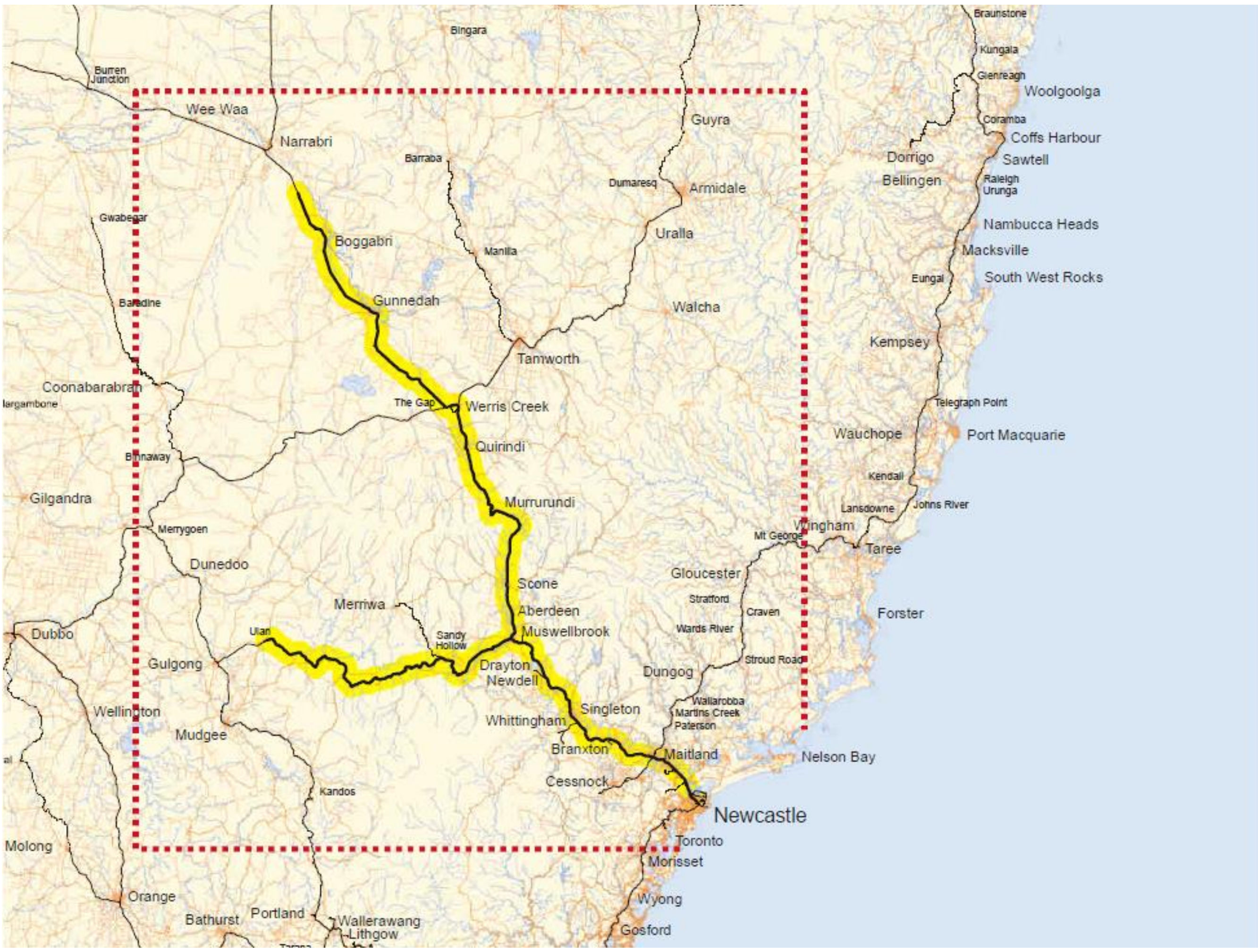

Figure 1-1 - The general location of the Hunter Valley network on the east coast of Australia.

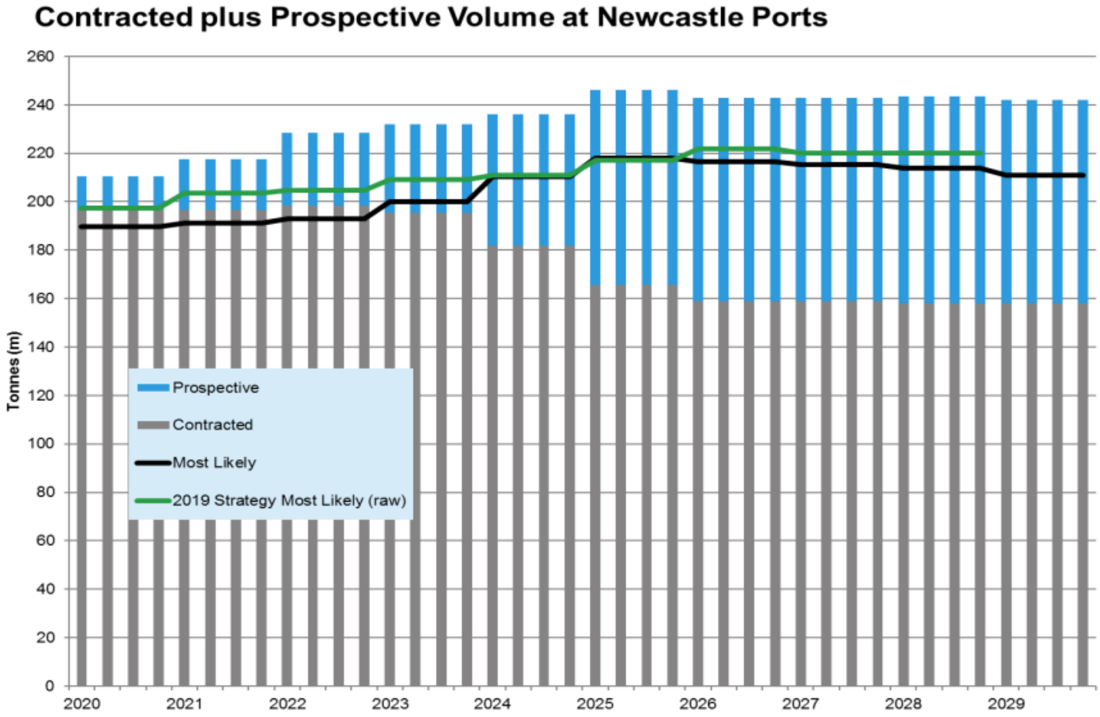

Figure 1-2 - Current Volume Forecasts vs. 2019 Strategy Volume Forecast, Newcastle Terminals (mtpa)

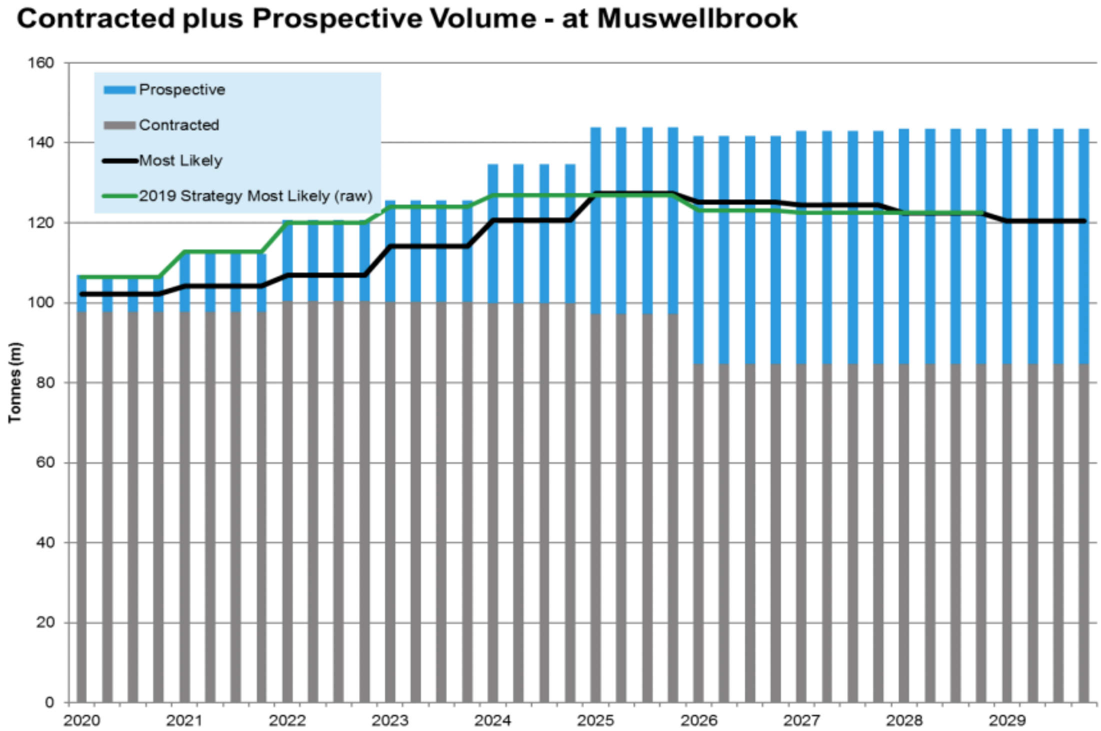

Figure 1-3 - Current Volume Forecasts vs. 2019 Strategy Volume Forecast, Muswellbrook (mtpa)

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.

ARTC believes that industry remains supportive of the approach of delivering capacity at the lowest possible cost.

The focus on technology and innovation therefore continues to align well with a strategy of delivering both increased efficiency and capacity. It recognises though that there remains a level of uncertainty around ATMS and accordingly also documents a pathway based on loop investments.

Volume Forecasts

ARTC contracts on a rolling 10 year “evergreen” basis. Contracted export coal volumes were 196.5 mtpa

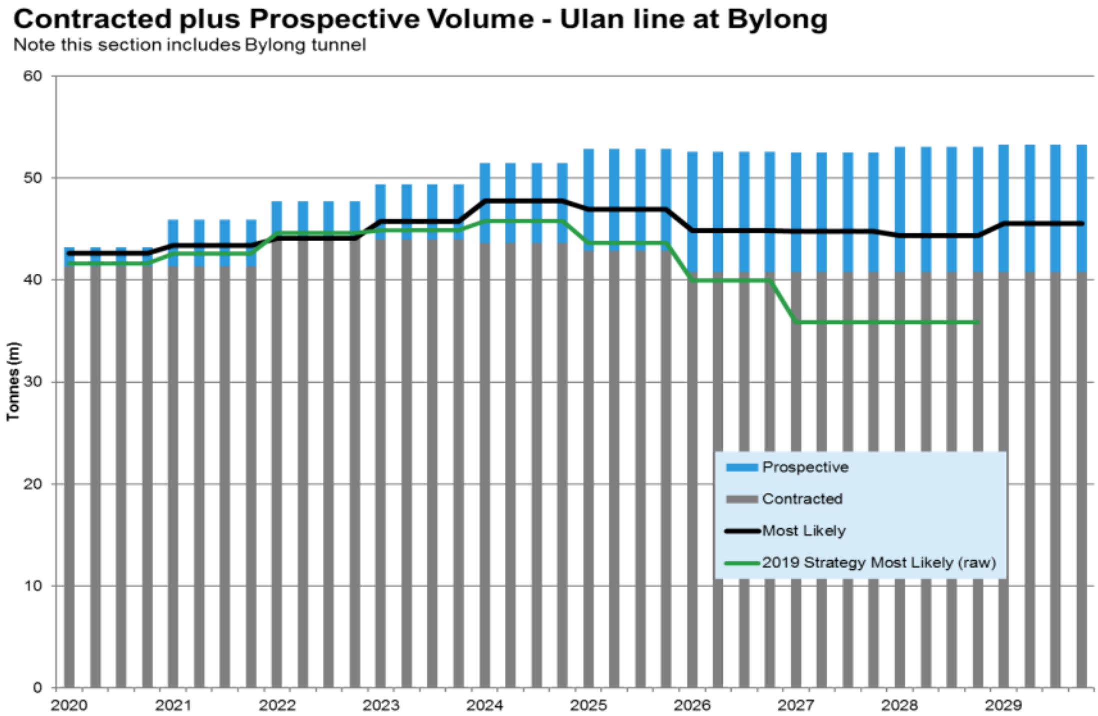

Figure 1-4 - Current Volume Forecasts vs. 2019 Strategy Volume Forecast, Bylong—Mangoola (mtpa)

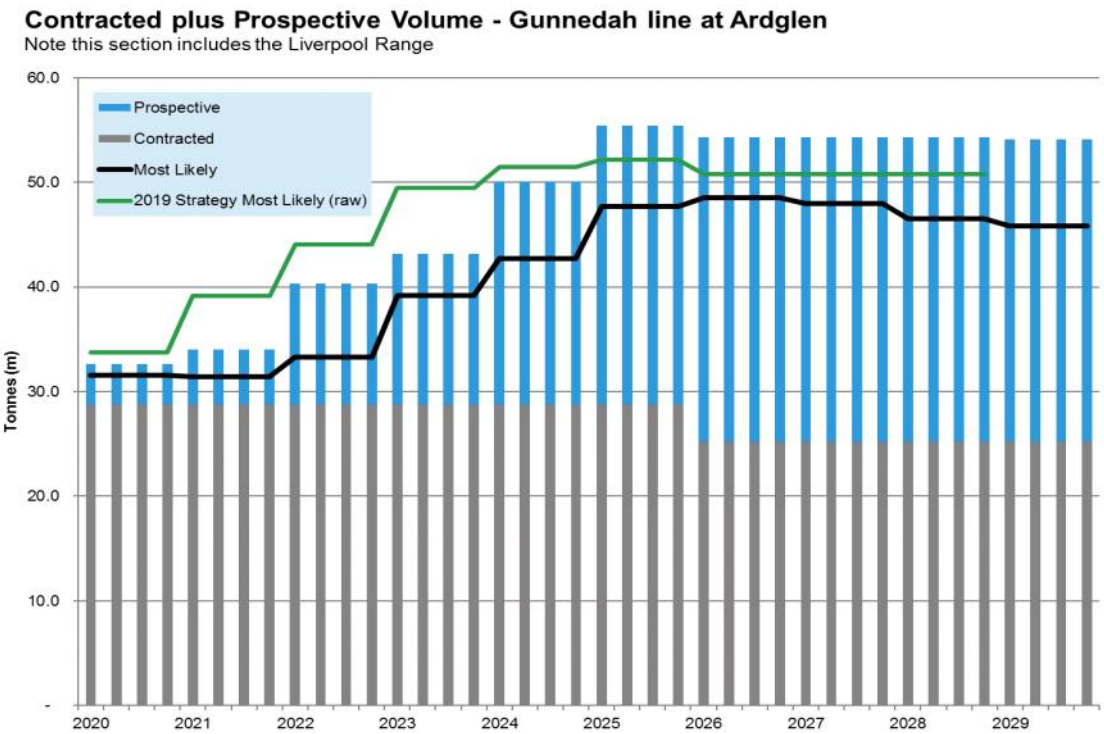

Figure 1-5 - Current Volume Forecast vs. 2019 Strategy Volume Forecast, Werris Creek—Muswellbrook (mtpa)

in Q1 2020. They are essentially stable at approximately this level until they start to decline from Q1 2024, falling to 157.9 mtpa in 2028.

Access holders chose to not roll-over some volume in the 2014-2016 period. This volume has not been replaced by new volume contracts at this point.

Contracted volumes also include up to 9.4 mtpa of domestic coal. This volume is included in all modelling of capacity and utilisation. This volume declines to 8.8 mtpa in 2021 and to 5.0 mtpa in 2026. It includes traffic from the Hunter Valley to Central Coast power stations.

The Strategies have always set out a 'prospective' volume scenario to provide an understanding of the consequences of a high-end volume outcome. This Strategy follows the 2017 and 2019 strategies by including a 'most likely' scenario as a middle ground to help support more detailed capacity planning.

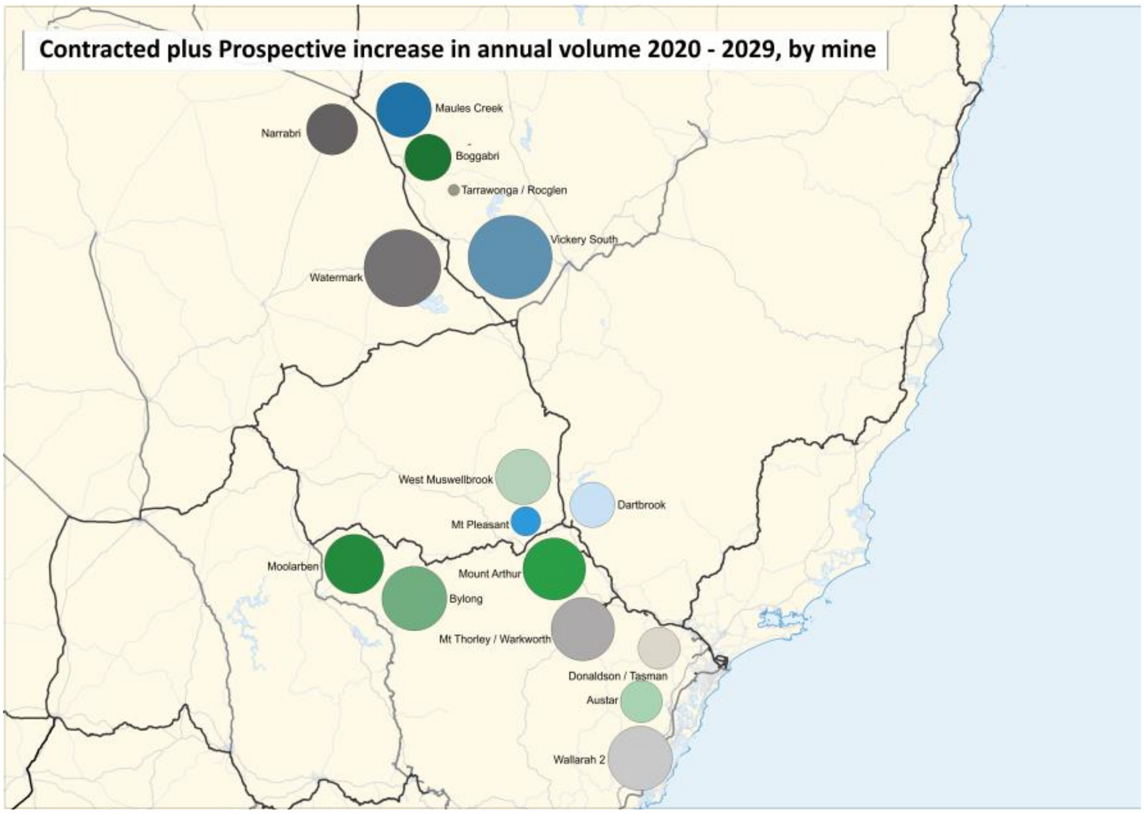

Figure 1-6 - Volume growth forecasts by mine, prospective scenario. Note that growth is represented by diameter

The most likely and prospective scenarios have been sourced from current and potential access holders on the basis that:

- Most likely volume is the volume pathway that access holders consider is their best assessment of future volume; and
- Prospective volume is that which access holders consider is their best assessment of maximum potential volume over and above existing contracts.

Under the provisions of the HVAU, it is a matter for the 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 three volume scenarios have been reviewed and supported by the RCG.

This Strategy continues to calculate capacity directly from the contracted number of paths, using the method first used in the 2019 Strategy, rather than the method used in prior Strategies of calculating paths from contracted volumes and assumed train configuration. The change in methodology resulted in a minor increase in capacity.

Inclusion of a volume in the most likely or prospective scenario does not imply that ARTC believes that the volume will eventuate. Rather, it is used as a guide as to the nature of the projects required in that growth environment.

The most likely and prospective scenarios include some forecasts that sit below currently contracted volumes. This Strategy is based on these raw volumes rather than using the greater of contracted and producer nominated volumes as in the 2019 Strategy. In any case, it is possible that some un-needed contracted volume will be reallocated through the capacity trading system, which will reduce the network capacity requirement.

The most likely scenario in this 2020 Strategy is less bullish than in the 2019 Strategy particularly for volume from the Gunnedah basin. Volumes are also lower at Muswellbrook and at the port, particularly in the first few years. However, volume from the Ulan line is higher than in the 2019 Strategy from 2023.

Prospective volumes from Gunnedah, Muswellbrook and at the port are lower than last year, while volume from the Ulan line remains similar.

Figures 1-2 to 1-5 show the three volume scenarios. The most likely scenario is shown for both this Strategy (black line) and the 2019 Strategy (green line) to allow comparison, noting that the 2019 volumes include forecasts that were both above and below the contracted volumes at the time to allow for a valid comparison with the 2020 volumes. Volume is shown at the Newcastle terminals, at Muswellbrook for the Bylong – Mangoola section (which is the majority of the Ulan line), and 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 the

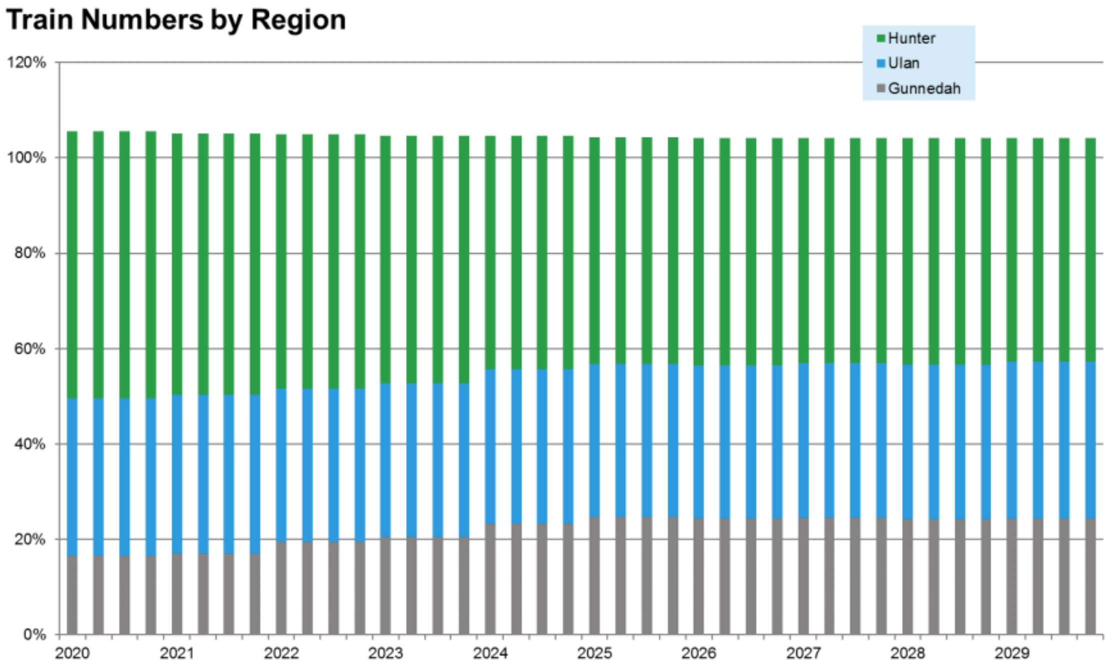

Figure 1-7 - Percentage of Trains by Sub-Network by Year, prospective scenario. Note that total train numbers are calculated as trains from each of the three zones as a proportion of all trains arriving at the port. The total number of trains exceeds 100% due to domestic coal.

proportion of total trains by zone. These figures highlight the ongoing transition of volume from south of Muswellbrook to the north and west.

There is still a small but notable volume of traffic from the Western and Southern coal fields 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 implicitly recognised in the volume forecasts in this Strategy.

How this Strategy has been developed

The development of this Strategy retains the core methodology of the 2019 Strategy. However, as it is a forward looking document it needs to reflect the best understanding of actual current and forecast network performance and as such relevant assumptions have been updated, as discussed later.

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 an homogenous volume section of network defines the capacity limit for that section. A transaction time is also 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. This is then adjusted to reflect practical rather than theoretical capacity using an adjustment factor of 70%. This was previously set at 65%, but with ANCO being implemented across the Hunter Valley, as mentioned earlier and discussed later in this chapter, the capacity threshold has been increased and this is assumed as the starting utilisation for this Strategy.

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.

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

This 2020 Strategy has moved to adopt cancellation losses that align to the true-up test estimates. This is a notable change from previous versions of the strategy, which used the Declared Inbound Throughput, or DIT, estimates from the HVCCC. The cancellation rate was applied uniformly across the Hunter Valley Network. This change in approach provides greater transparency and consistency, and allows for differential rates across the three zones, giving greater accuracy in the calculation of capacity on different sections of the network.

Also, instead of using a train cancellation rate, this Strategy has adopted a rate of actual volume loss incurred during live run, by zone. The live run losses are calculated as the difference between planned and actual tonnes divided by planned tonnes. This percentage is then converted into an escalation to reflect the required uplift in capacity. This approach is considered more reflective of actual live run variance than the cancellations rate, and also picks up short loading. The adopted rates are shown in Table 1-1.

For comparison, a system-wide uplift rate of 8.7% was used in the 2019 Strategy. Assuming the loss rate for 2020 would have been similar if using the same methodology, that rate would have been too high between the Port and Ulan while understating the impact on capacity on the Gunnedah line.

The use of zonal maintenance loss rates is also being considered for use in future strategies. The previous approach, which was derived from the HVCCC DIT calculation process, was not transparent, used a partial maintenance definition and is no longer available due to changes in the DIT process. Moving to a revised approach would better reflect the impact on capacity of differing amounts of maintenance across the different sections of the network and provide and potentially provide better alignment to the true-up test.

More time is needed to consider the appropriateness of the proposed change. Two key issues are whether current actual maintenance loss rates give adequate on-track time, and whether non-aligned maintenance by other service providers leads to a track system loss that should be accounted for.

Consistent with the HVAU, a variability buffer has been formalised in the form of the Target Monthly Tolerance Cap (TMTC). A 10% TMTC has historically applied across all three zones based on the stated preferences from the RCG.

The 2019 Strategy applied a lower TMTC of 8% to zone 3 for 2019, based on consultation with the RCG and preferences from Zone 3 access holders. This 2020 Strategy reverts back to 10% across all zones for all years.

Adjustment factor	2019 Strategy	2020 Strategy
Live run losses	8.7%	Zone 1: 7.0% Zone 2: 9.4% Zone 3: 8.3%
Maintenance	12.3%	All zones: 12.3%
TMTC	Zone 1+2: 10.0% Zone 3: 8%	All zones: 10%
Adjustment Factor	**Zone 1+2: 74.5%** **Zone 3: 75.9%**	**Zone 1: 75.7%** **Zone 2: 74.0%** **Zone 3: 74.7%**

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

The build-up of the Adjustment Factor for this Strategy, and comparison with the assumptions in the 2019 Strategy, is shown in Table 1-1.

The zonal live run loss rates necessarily result in separate adjustment factors for each of the zones. This is an enhancement from previous strategies that had a single adjustment factor across the network.

The adjustment factors for zones 2 and 3 are lower than in the 2019 Strategy and in isolation would result in a reduction in theoretical capacity. However, train performance and transaction times have also been updated and, together with some other minor methodological improvements, the net impact on capacity is varied but mostly a net increase.

This 2020 Strategy continues to use actual train performance derived from the digital train radio system as the basis for calculating section run times.

This approach of using actual rather than simulated performance was applied to the Gunnedah basin in 2016, the Ulan line in 2017, and the Muswellbrook - Ports section for the first time in 2019.

In addition, the train radio system data was used for the first time in 2017 to calculate actual rather than theoretical transaction times, where the transaction time accounts for signal clearance time, driver response and acceleration. These times are 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.

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.

The 2019 Strategy discussed the modelling of an appropriate allowance for this effect, taking into account both the time loss effect of a through train needing to stop and the probability of a simultaneous arrival event occurring. This suggested an appropriate allowance for simultaneous arrival is in the order of one minute and that for a simultaneous entry loop, which has either a longer length or additional signalling, it saves around 15 seconds of this. These values were adopted as supplements to the actual calculated transaction time in 2019 and have been maintained for this Strategy.

The 2019 Strategy held to the previous train performance and transaction time calculations. However, with train configurations continuing to evolve and implementation of the track circuit upgrade program, it is appropriate to now update these.

The capacity methodology has also been modified slightly so that forecast changes in train consist are better reflected. The methodology used in the 2019 and previous strategies used section times calculated as the actual average of all the trains that operated in the period that the train performance was analysed. This approach meant that if the ratio of train types is expected to change over time it wasn't reflected in the calculation of the average section time.

Train performance has now been calculated by train type and section times weighted by the expected proportions of those train types by quarter. The following are the contracted train consists that were captured for the purposes of calculating performance.

Ulan line:

- Pacific National—3 x 92/93/TT class (4400HP AC) locos with 96 wagons - 9,100 net tonnes, 1,541 metres nominal length.
- Pacific National—3 x 90 class (4000HP DC) locos with 92 wagons - 8,500 net tonnes, 1,5529 metres.
- Aurizon—2 x 5000/5020 class (4400HP 30 TAL AC) locos with 88 wagons - 8,600 net tonnes, 1,514 metres.
- One Rail—3 x XRN class (4400HP AC) locos with 96 wagons - 9,100 net tonnes, 1,541 metres.

Gunnedah line:

- Pacific National—3 x 92/93/TT class (4400HP AC) locos with 82 wagons - 7,954 net tonnes, 1,296 metres.
- Aurizon—3 x 6000 class (4400HP AC) locos with 82 wagons - 7,954 net tonnes, 1,296 metres.

To the extent that trains operate with a consist different to the contracted consists, performance, and hence capacity, will be different.

With the implementation of the track circuit upgrading program and changes in train performance, it is has also been appropriate to update the transaction time analysis. In undertaking this work it has become apparent that there is a very large amount of variability in both the time it takes a train in the loop to start, and in the rate at which it accelerates. As such, sample size is important, but due to data issues it is currently challenging to process large numbers of transactions. As a result there is likely to be a degree of variability between the 2017 and 2019 data due to processing limitations rather than underlying changes. This is an opportunity for improvement and refinement in future Strategies. It also highlights an opportunity for operational improvement.

The changes in capacity as a result of the enhancements outlined in this section, including using live run loss and maintenance loss uplift rates for individual zones, updated train performance and transaction time, and weighted forecast train consists, are detailed in the relevant chapters. The impact of each change element has been quantified, which improves the transparency and traceability of changes to the methodology and allows for a comparison of performance in this Strategy with previous strategies.

Saleable & Surplus Capacity

At the time ARTC enters into contracts, capacity is assessed based on a set of assumptions. Previous Strategies have noted that the need to constantly update the cancellation and maintenance loss rates to reflect current actual performance could have the unintended consequence that as these change over time it may infer that there is a shortage of capacity even though the capacity existed at the time contracts were entered into and the changes may be external to ARTC. This is compounded by the inevitability of changes to section run times as the train fleet evolves and operational changes are made. Also, the increase in the accuracy and granularity of train performance information made possible by the digital train radio system has led to the resetting of section run times and transaction times, which also feeds through to changes in capacity.

For the purposes of capacity planning, it is also important to understand likely throughput outcomes compared with the capacity projections at a point in time in the past. ARTC continues to monitor how actual performance compares to underlying assumptions. Where there is a sustainable change in performance, ARTC will consider whether a reset of assumptions is appropriate, noting that recognition of sustainable changes in performance assists to create appropriate incentives to maximise system performance.

Consistent with the 2019 Strategy, the saleable paths and saleable tonnage tables previously included for the contracted and prospective scenarios have also now been supplemented with equivalent tables for the most likely volume scenario. These remain in the Recommended Projects & Network Capacity chapter.

Monthly Tolerance

The Target Monthly Tolerance Cap (TMTC) is designed to enable the contracted pathing to have a degree of flex to align with the supply and demand variations across the respective zone. This target can also be an input into decisions about enhancement investment and contracting of additional volume. The intention is that ARTC will ensure adequate capacity to allow a peaking in train path demand equal to the TMTC, relative to the average across the year. Historically it has been applied as a standard input across all three zones at 10 per cent.

It is also important to note that the methodology that has been applied in the capacity strategies has been to calculate capacity on a daily basis and apply the variance buffer as a daily ability to peak at 10 per cent above average demand.

The 2020 Strategy reverts back to a uniform 10% across all zones in the Hunter Valley, compared with the approach in 2019 whereby in response to requests from access holders in zone 3, ARTC reduced the TMTC to 8% for zone 3 for calendar year 2019 only. Zones 1 and 2 were unchanged.

Transit Times

For any volume and network configuration scenario it is possible to predict a theoretical train transit time between two locations based on the actual train speed and transaction time information and a probability based approach to calculating theoretical loop dwell, escalated by an allowance for congestion delay based on percentage section utilisation.

This 2020 Strategy includes graphs of forecast transit times for each of the contracted, most likely and prospective scenarios calculated on this basis, following on from the 2019 Strategy that introduced these for the first time. These graphs are included in the relevant Chapters and should allow the industry to develop a broad understanding of likely future cycle time outcomes.

It should be noted that adopting higher utilisation rates as with ANCO and proposed with ATMS results in an increase in theoretical dwell and hence transit time as there are more trains for a given population of loops, thus increasing the probability of encountering an opposing movement without any offsetting reduction in the average length of dwell. In the case of ANCO, this is offset by expectations of improved decision making, which was expected to reduce dwell and thereby increase saleable capacity.

Where loops are used to enhance capacity, there is an increase in the probability of encountering an opposing train, but a reduction in the average dwell time at that location, since loops are on average closer together. Whether there is an increase or decrease in transit time in this case will depend on the specific circumstances and balance of these effects.

It should also be noted here that cycle time, including terminal and load point dwell, is a direct function of the number of trains required to move the available coal, divided by the number of train sets available. To the extent that there are surplus train sets in the system, velocity will necessarily slow down. This effect will in many cases be a more important consideration than crossing time on the rail network.

Terminal Capacity

ARTC's understanding of terminal capacity is that nameplate capacity currently sits at 211 mtpa.

Significant growth beyond 211 mtpa had been expected to be met by the PWCS development of Terminal 4 (T4). The T4 project had been on hold since it was granted planning approval on 30 September 2015 and PWCS advised on 31 May 2018 that it would not be proceeding with the development of T4.

In April 2020, NCIG submitted a development application to modify their planning approval to increase approved throughput capacity of the terminal from 66 mtpa to 79 mtpa. The increase reflects the benefit of a

number of already completed incremental initiatives within the existing footprint of the terminal. If approved, it would boost overall terminal nameplate capacity to 224 mtpa.

It should be noted that the NCIG push-based assembly model has had a positive impact on the network and terminal operations by smoothing intra-day and intra-week train flows and enhancing network robustness, particularly for trains from the western coalfields. This incremental expansion is therefore consistent with and complementary to improving rail network performance.

The HVCCS has for some years assumed that it would be possible to achieve some incremental capacity through enhancement of existing terminals, up to a nameplate throughput in the order of 235 mtpa. For the purposes of this Strategy it has been assumed that incremental terminal capacity could be available progressively from Q1 2022 if required.

There is no requirement for additional terminal capacity for ARTC contracted volumes.

The most likely scenario would theoretically require incremental enhancement from late 2023. However, in practice it is likely that some contracted volume will not be realised and that capacity trading could facilitate demand being met.

The prospective scenario would potentially exceed the capacity of the terminals even with incremental enhancements. However, it is again likely that trading would allow volumes to be satisfied. The relationship between contracted, most likely and prospective volumes, and potential terminal capacity as assumed for this Strategy, is shown in Figure 1-8.

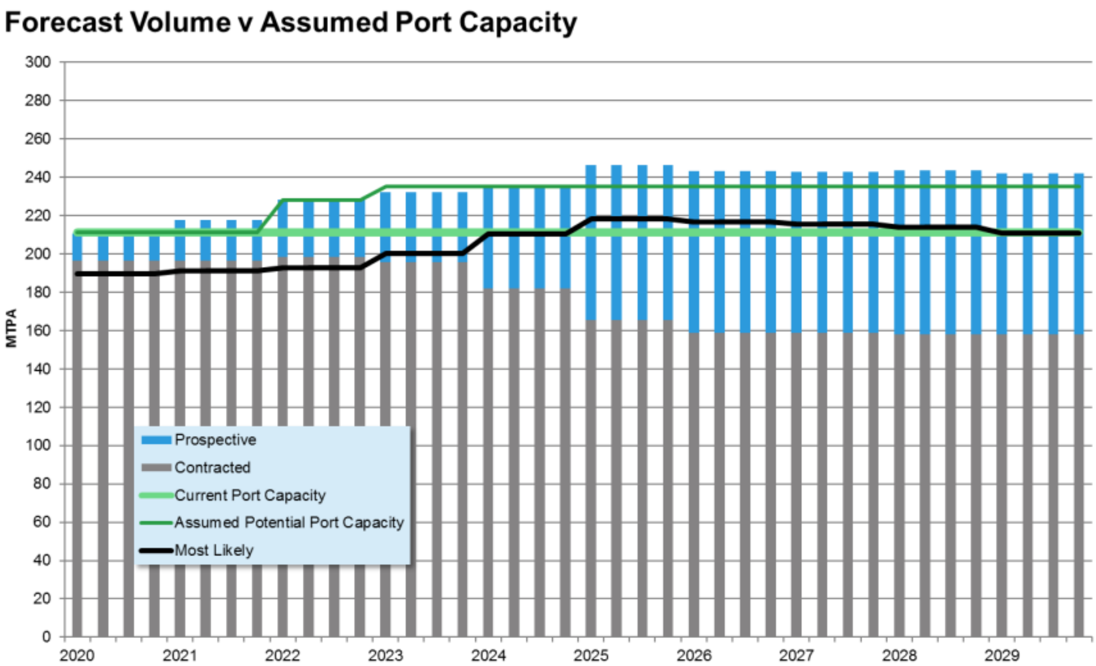

Figure 1-8 - Forecast volume at Newcastle Port compared to assumed port capacity (mtpa)


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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

At 2020 contracted volumes and train sizes, an average of around 68 loaded trains need to be operated each day of the year, or one train every 21 minutes. Capacity planning makes provision for this number of trains to peak at up to 97 per day, though in practice capacity exists for this to peak at even higher rates.

The coal chain is supported by a captive rail fleet operated by four above-rail operators: Pacific National (PN); Aurizon; One Rail (previously Genesee & Wyoming Australia (GWA)) 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 from mines in the Lithgow area. This traffic operates on the Sydney Trains network as far as Broadmeadow. There is also a 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 Islington Junction (where the Hunter Valley adjoins the Sydney Trains network).

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.

Train size

ARTC contracts on the basis of a contractual entitlement to paths known as Base Path Usage (BPU). Tranches of paths are associated with a nominated train configuration, giving an implied contractual volume.

Average train size as contracted with ARTC in 2019 was 8,281 tonnes.

Weighted average delivered coal volume per train was approximately 8,091 net tonnes in 2016, 7,860 in 2017, 8,254 in 2018 and 8,197 in 2019.

The decline in average actual train size from 2016 to 2017 reflected the continued increase in the proportion of coal coming from the Gunnedah basin, diversion of some coal from the Port Kembla coal terminal to Newcastle and a temporary increase in the number of trains from the Austar colliery. These traffics use a smaller than average train size, in particular the Austar coal trains. The subsequent changes in train size reflect natural variation rather than any major underlying trend.

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 trend of increasing average train size, though probably not to the same extent as the growth achieved in earlier years. The move by Aurizon to a 96 wagon train will, if widely contracted, support this trend.

Train Length

Train length in the Hunter Valley and along the Ulan line 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.

The length limit to the Gunnedah basin is 1,329 m, with North Coast line trains operating to a similar length. Trains to the Austar mine and to locations south of Newcastle operate with substantially shorter consists.

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 systematic manner.

However, ARTC is cautious about permitting the introduction of ‘overlength’ trains on the network (i.e. trains that are longer than the corridor standard) without thorough assessment and change management being enacted which may include infrastructure and supporting systems alterations. A longer individual train would deliver an increase in capacity per path, but without other supporting infrastructure investment, 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.

Longer trains also potentially require greater braking distance. This can trigger a requirement for signalling alterations or impose speed restrictions, which can have significant cost and / or capacity implications.

ARTC is continuing to review options for longer trains, and is currently undertaking engineering investigations between Ulan and Newcastle Port to potentially support longer trains on the Ulan line. Further modelling will be required to validate capacity impacts and opportunities. Subject to the findings of the

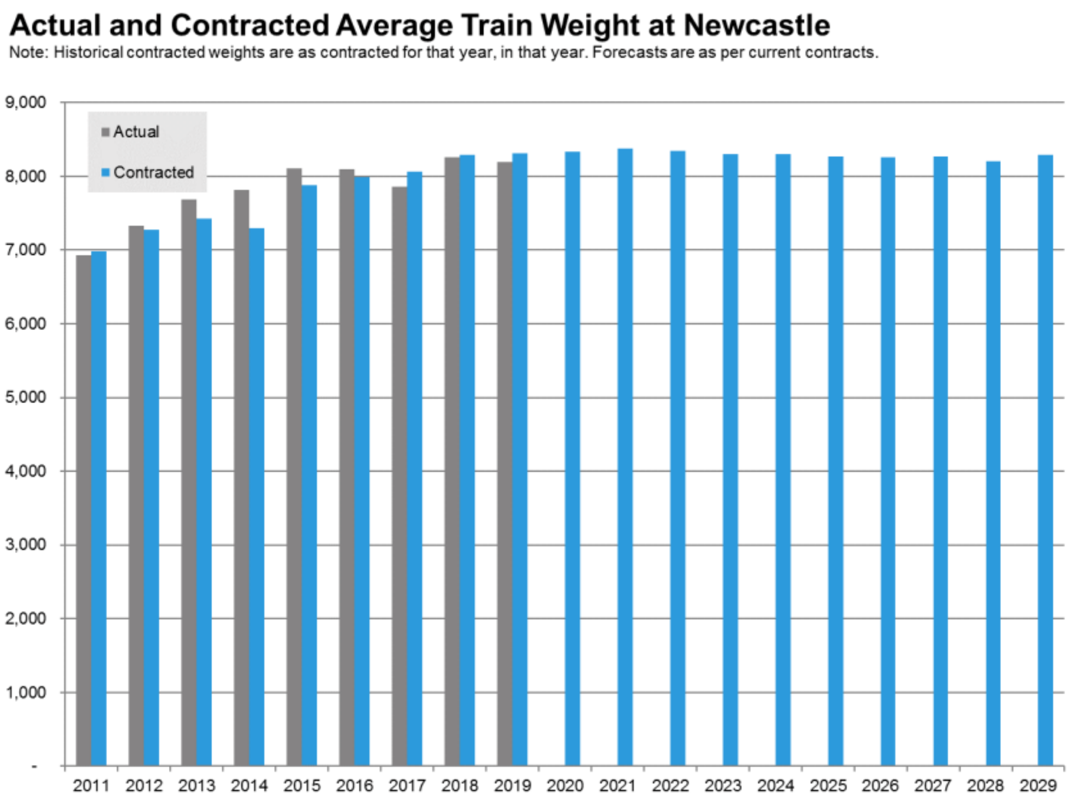


Figure 2-1 - Average Train Capacity under Contracted Volumes (tonnes) engineering investigations, ARTC will develop business case assessments of the costs and benefits of providing necessary infrastructure enhancements.

ATMS would 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.

Axle load

Most of the Hunter Valley coal network is capable of handling rolling stock with 30 tonne axle loadings (TAL) (i.e. 120 gross tonne wagons), but the North Coast line to Stratford and the lines south of Vales Point are 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).

From time to time the question of going to higher axle loads, such as 32.5 tonnes, arises. There is no engineering constraint on running such higher axle loads on the existing track structure, and indeed some wagons operate at above 30 TAL when the coal is particularly dense. Individual axles can also be significantly above 30 TAL when the coal is distributed unevenly within the wagon.

From a system capacity perspective though, an increase in axle load offers limited benefit unless the outline gauge is increased, since there is no significant improvement in tonnes per metre of train length. There would be a small benefit from being able to build slightly longer wagons with less capacity lost due to bogies, but this would be offset by the longer wagon needing to be slightly narrower to remain within the structure clearance.

At the same time, assuming operators built longer wagons to take advantage of the higher axle load, maintenance costs would increase. Risk would also increase as dense coal and unevenly loaded wagons would bring the maximum actual axle loads closer to the theoretical limits of the track. Higher axle loads could also potentially increase track failures, such as rail breaks, and formation failures, increasing the frequency of disruption in the absence of increased maintenance intervention. Formation issues would require detailed consideration.

Given these considerations the position adopted in the past has been to retain 30 TAL as the nominal axle load limit. However, ARTC is open to reviewing this if the industry supports the work to analyse a higher axle load.

Train speed

Trains made up of ‘120 tonne’ (30 TAL) wagons are generally restricted to 60 km/h loaded and 80 km/h empty, though locomotives of up to 30 tonne axle load are permitted to run at 80 km/h.

However, engineering analysis has identified that due to formation issues it is not possible to give a blanket approval to operate higher axle load locomotives, such as 30TAL locomotives, above 60 km/h to the Gunnedah basin. Accordingly, trains with locomotives weighing more than 134 tonnes are limited to 60 km/h north of Muswellbrook. This, however, has declined as an issue as heavier locomotives have not generally been operating on the Gunnedah line since mid 2019.

There is potential to improve cycle times, and to improve capacity on the single-track sections by increasing empty train speeds to 100 km/h. A transition to 100km/h in in the Down direction is now underway in the Gunnedah basin. This is discussed in more detail in the relevant sections.

Clearances

The Hunter Valley generally conforms to rollingstock outline plate B, which allows up to 3050 mm width and 4270 mm height.

A detailed study was undertaken in 2002 that looked at the option of introducing a North American rollingstock outline to the Hunter Valley, which would allow a higher weight per metre of train length thereby increasing network capacity. However, this study identified that aside from a large number of location specific impediments (including the Ulan line and Ardglen tunnels), a major impediment was the track centres on the multiple track sections. These were mostly built to 3430 mm or 3660 mm, and despite more generous standards being adopted over time, the majority of the main lines remained at around 3660 mm to 3740 mm track centres. A typical North American vehicle would require a minimum of 3940 mm.

While new works are built to a horizontal clearance standard that is consistent with the wider rollingstock, a large proportion of the network remains below this standard and it would require extensive works to accommodate it. Prima facie this does not, therefore, represent a cost-effective pathway to higher volume.

The other strategic clearance issue is horizontal clearances for container double stacking. As a general principle ARTC aspires to achieve double stack clearances, which requires a horizontal structure clearance of 7100 mm. ARTC’s default position is to require any new structures to be built to this clearance.

However, the double stack requirement is directed at interstate container operations. Interstate container trains do not operate across the Hunter Valley network, other than the short section between Broadmeadow and Maitland. This section is precluded from double-stack operations by the overhead wiring south of Broadmeadow. Accordingly, ARTC exempts the Hunter Valley, extending to Narrabri and Narromine, and the NSW North Coast line, from its double stack clearance requirement.

Operational Improvement Initiatives

The 2019 Strategy outlined a number of operational initiatives that aimed to improve the performance of the Hunter Valley Network aligned with capacity assumptions. Several of the initiatives have since been delivered while others are still being planned.

These initiatives included:

- Improved response to failures on the network—ARTC has worked with above-rail operators to improve the recovery time of failed assets on the network. Initiatives include working with operators to develop and implement a standardised communications process to support the fastest possible response time, allowing operators to locate 'rescue locomotives' and critical spare parts at strategic points on the network, while ARTC has undertaken a review into whether the Muswellbrook provisioning centre can respond to the demands placed on the performance of the Ulan line by its geography and topography.

- Minor network enhancements—ARTC identified minor works that could quickly deliver improved train running times through key sections of the network, including: installation of repeater signals at key locations, trackside flora maintenance to improve sighting visibility, completion of Coded Track Circuit installations on the Ulan and Gunnedah lines and installation of speedboards to enable higher speeds at turnouts that currently have no signage. These initiatives were delivered via the ARTC 2019/20 Corridor Capital program or within Customer enhancement projects after business cases for operating expenditure were approved. This approach from ARTC creates a mechanism whereby these ideas can be collected, consolidated and assessed for benefits, resulting in increased input from rail operators and Network Control staff into the drive for enhanced network performance, particularly in zones 2 and 3.

- Improving train flows through Muswellbrook junction—Before ANCO, peaking and troughing in train flow resulted in this junction at times becoming a bottleneck. Opportunities to reduce train dwell and improve performance were to be investigated. However, since the 2019 Strategy, ANCO has been implemented across the Ulan and Gunnedah lines and will be shortly operational between Hexham and Newcastle port, completing the ANCO rollout. ARTC will review the impact of ANCO on train performance through Muswellbrook junction once fully implemented.

The following are in the process of being planned or implemented.

- 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 increased effectiveness in maintenance activities and with improved train flow on the network. The integration 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.

ANCO & ATMS

While there is much benefit in pursuing operational initiatives, the biggest opportunities to increase throughput in the absence of capacity-enhancing capital projects is in the day to day train control decision-making processes. Historically, the biggest challenge for train control was 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 arose from limited real-time, overall network visibility and a lack of tools to assist with short-term planning. To

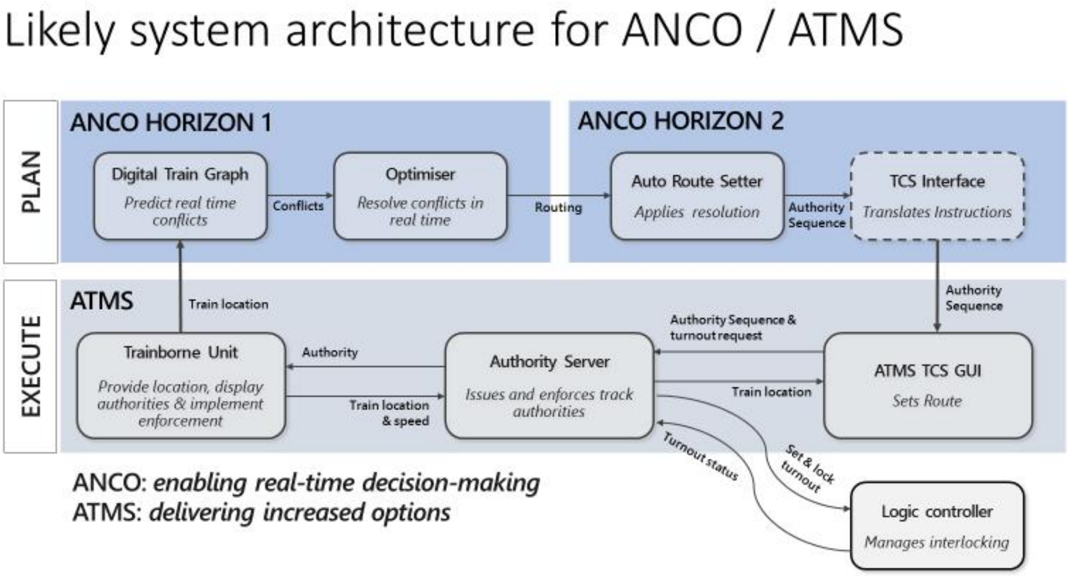


Figure 2-2 - Likely system architecture for ANCO / ATMS

address this gap and deliver a step change in supply chain performance, ARTC has embarked on two significant projects, ANCO and ATMS.

The ANCO, or ARTC Network Control Optimisation, project is ARTC's initiative to introduce new processes and technology to improve train control in the Hunter Valley spanning three horizons of work for enhanced capability. Horizon 1 is nearing completion with the implementation of the digital train planning product around 80% complete, providing digital train planning in Network Control Centre North (NCCN) for train movements west of Maitland to Narrabri and Ulan. The system has replaced the previously used paper-based train graphs.

Digital train planning, coupled with near real-time data integration with supply chain partners, enables a rapid response to network disruptions and any changes to supply chain asset availability, with train plans dynamically adjusted to minimise potential flow-on impacts and deliver maximum performance for the supply chain as a whole.

The scope being delivered includes:

- Dynamic pathing: Provision of a detailed rail plan reflecting all occupations, including track maintenance and dynamically responding to any variation resulting from actual train movements;
- Disruption and conflict resolution: Rapid and automatic response to resolve train conflicts and/or replan around asset breakdowns to minimise throughput losses;
- Supply Chain Integration: A 'whole of supply chain' end-to-end view enabled through data integration with Customers and supply chain partners, including train loading and unloading at end-points, and the capability to continuously plan for efficient train flow; and
- Network Visibility for Decision-making: Train arrival forecast information is being published across the supply chain, for key locations, directly from the Movement Planner tool onto 'Train Information Boards' as well as via direct feeds into Customer and supply chain partners' own systems.

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, on single track it accommodates 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 enables these factors to be considered and optimised dynamically, effectively eliminating the need for additional contingency in the train plan.

This manifests itself in an improvement in crossing decision making, leading to reduced dwell. Analysis to date of normalised levels of dwell in a pre and post ANCO environment compared to theoretical efficient dwell have validated the expected level of benefit and the application of higher utilisation of available track capacity. Accordingly, the utilisation rate adopted in the Strategy has been lifted from the previous 65% to 70%.

The targeted outcomes from ANCO are now being realised, including increased visibility of network operations, less train dwell time, improved forecasting and improved utilisation of available track capacity. With testing for the final component of the network, the coal terminals at the Port of Newcastle, now in progress, completion of Horizon 1 is on-track to deliver a supply chain which is more responsive to customers' dynamic needs.

Preparations for planning for Horizon 2 of ANCO is now underway with scope development to consider:

- Advanced Network Flow Management: Further increasing the capability for network flow and performance through the utilisation of advanced analytics to target areas of improvement and set the foundation for further advancement in optimisation and future machine learning;

- Integrated Rail Maintenance Schedule: An integrated asset maintenance and operations schedule feed into Movement Planner to enable seamless and continuous combined planning of all ARTC activities to satisfy both throughput and reliability requirements; and

- Performance Monitoring and Improvement: Leveraging the comprehensive ANCO data-set for enhanced reporting capability and identification of improvement opportunities.

Potential future horizons are expected to further build on this capability, including a pathway to advanced optimisation for decision support, the introduction automatic route setting of movement authorities within the train control system, to allow controllers to focus on train flow, and continuous monitoring of track infrastructure health to maximise availability.

The second prospective initiative for the Hunter Valley, ATMS, would be highly synergistic with ANCO.

ATMS, or Advanced Train Management System, 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.

ATMS testing and documentation is now largely complete for it to be the accredited safeworking system on Port Augusta to Whyalla.

The next ATMS project will be to deploy the system from Tarcoola to Kalgoorlie. This has completed Phase 1 Concept, Phase 2 Feasibility, and has now been granted funding to commence Phase 3 Assessment. Commissioning of ATMS on a large scale from Tarcoola to Kalgoorlie will proceed from 2021.

The rollout schedule of ATMS across the ARTC network is now the subject of detailed analysis and engagement with rail operators. The three key limits to the speed of rollout have been identified as:

- Availability of suitable resources to undertake the trackside works.

- Manufacturing and fitment of trainborne units.
- Training of drivers and train controllers, and associated organisational change.

As such, there are extensive trade-offs to be resolved in determining a network-wide deployment plan.

Current planning provides for (subject to RCG support) the Ulan line to be equipped by mid-2024 and the Gunnedah line by late 2024. However, this remains subject to refinement and there may be potential to bring the timing forward if operators can support a faster roll-out, or giving these lines a higher priority delivers an overall benefit.

As noted, trainborne unit manufacture and fitment will be a key limit to the speed of roll-out and it is likely that the fleet of locomotives that travel on these lines will need to be equipped progressively with the ATMS in-cab equipment. This will mean that there will be a transitionary period where some locomotives will need to be captive to Ulan and Gunnedah traffic. The practical limit of this will also be a key issue in determining the roll-out timing.

As discussed earlier in this chapter, Muswellbrook Junction can be a bottleneck as a result of uneven train flows. Extension of ATMS through Muswellbrook would improve delays caused by latency in the signalling and control systems. The improved granularity of location position would also feed into greater responsiveness and precision for Movement Planner, which is currently constrained by the limitations of track circuiting.

Initial consideration is now being given to the need to replace life-expired CTC equipment at Newdell and Drayton Junctions to ensure ongoing reliability of the signalling system. While some elements of the renewal may be re-usable for ATMS installation, there is likely to be efficiencies in incorporating the renewal into the ATMS implementation. Given these considerations, extension of ATMS from the single line sections to Singleton has also been given a high priority in the current implementation planning, with a target of mid-2026.

Completion of ATMS implementation in the Hunter Valley has a higher relative cost and hence lower commercial benefit and is likely to be toward the back-end of the program, with a target of 2029/30.

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.

Figure 2-2 shows diagrammatically the likely future architecture of the ANCO (horizon 1 & 2) and ATMS systems and how they would relate to automation of the train driving function.

Following on from the lift in utilisation to 70% with ANCO, the Strategy assumes a further five percentage point increase from ATMS, allowing 75% utilisation. 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 single track becomes greater than 100%.

The modelling also assumes that the improved situational awareness and safety overlay of ATMS will allow trains to operate closer to their theoretical capability and a 2.5% 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.

It is expected that ANCO will facilitate greater smoothing of train flows, reducing pressure for trains to stand. This may be further supported by some features of the HVCCC's forthcoming automated cargo assembly planning tool, RACE.

However, as HVCCC highlights in the 2019 System Assumptions document, there is currently a higher number of train sets in use than the theoretical efficient fleet. This leads to an increased requirement for trains to be parked-up over and above the normal train park-up challenges in live run operations and track outages.

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 and export container 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, though grain movements have been significantly lower over the past couple of years given the poor growing conditions in northern NSW.

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. Only Aurizon and Pacific National operate coal trains from the mines along this line.

Two major new Gunnedah basin mines are included in the most likely and prospective scenarios: Vickery South being developed by Whitehaven, and Watermark being developed by Shenhua. 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. Coal from these mines is not expected to be transported until the middle of this decade.

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:

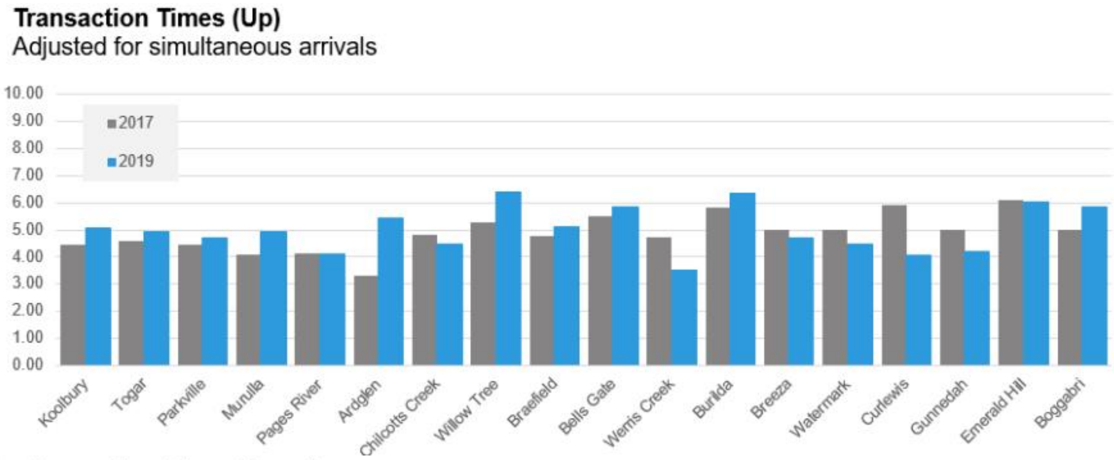
- There will be two sets of bank engines available at all times. Pacific National and Aurizon currently provide one set each.
- A train requiring banking will not have to wait for a bank engine.
- The attachment process will take 10 minutes to complete before the train will recommence its journey.
- 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 if necessary to avoid delay to a train in the up direction.

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

Train Performance

ARTC has been using actual rather than theoretical performance as a basis for capacity modelling between Muswellbrook and Narrabri since the 2016 Strategy and further refined the process by calculating and applying actual transactions times in 2017

In the second half of 2019 Aurizon adopted a functionally identical consist to the PN train. While PN has been using this consist for a number of years, Aurizon switched from its previous consist comprising two heavier 30TAL 5000/5020 class locomotives. The 5000/5020 class locomotives were restricted to 60km/h in both directions compared with 80km/h for the 6000



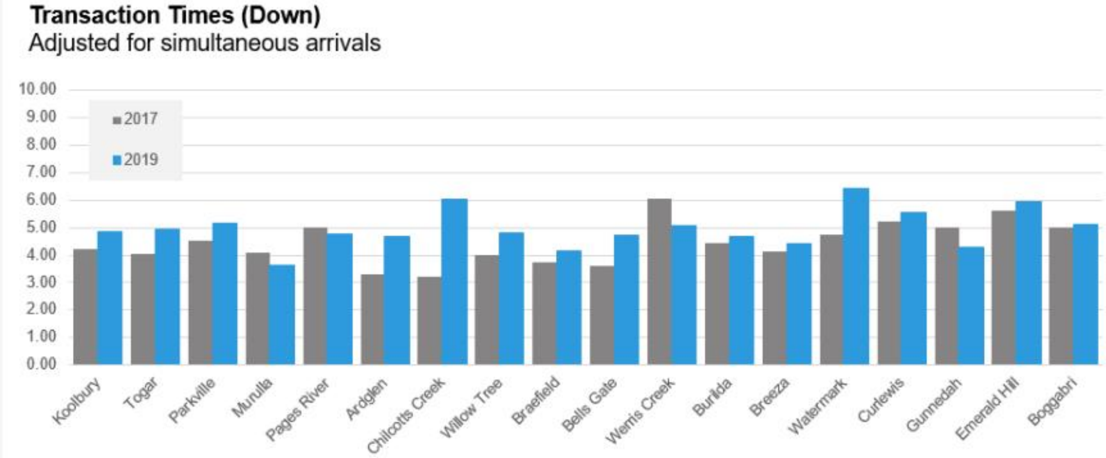


Figure 3-1 - Transaction times

class locomotives. Both operators can now operate empty coal trains at up to 80km/h on the Gunnedah line. The change also gives a higher power to weight ratio, which has improved uphill loaded train performance in some areas.

Given that this is a material and sustainable change in train performance, the train performance analysis used for the Gunnedah basin capacity calculations has been rebased. The consists, as also noted in Chapter 1, are now assumed to be:

- Pacific National—3 x 92/93/TT class (AC 4400HP) locos with 82 wagons - 7,954 net tonnes, 1,296 metres in length.
- Aurizon—3 x 6000 class (AC 4400HP) locos with 82 wagons - 7,954 net tonnes, 1,296 metres.

As expected, the 2019 train performance used in this 2020 strategy shows an improvement compared with the 2019 strategy.

The completion of the Microlok upgrade program on loops north of Werris Creek has also resulted in a material and sustainable change in the operating environment for the purposes of calculating transaction times. In addition, the change in the Aurizon train consist also has transaction time effects. Accordingly, transaction times have been recalculated for the purposes of the capacity modelling.

The updated transaction times, compared with those used in the previous Strategy, are shown in Figure 3-1 (including adjustment for the effect of simultaneous arrivals).

With the increase in average Down train speed, there is a systemic increase in transaction times, as Down

Section capacity Q1 2025 (mtpa) - without projects

	Gunnedah to Curlewis	Burilda to Werris Creek	Bells Gate to Braefield	Ardglen to Pages River	Pages River to Murulla	Murulla to Parkville	Parkville to Togar
Capacity as per 2019 Strategy (with ATMS)	37.26	48.00	45.93	50.88	47.18	44.72	41.19
Capacity as per 2019 Strategy (w/o ATMS)	29.25	36.90	34.39	40.00	36.88	34.32	32.82
Add 2020 contract paths	29.25	36.90	34.39	40.00	36.88	34.32	32.90
Add updated transaction times	29.02	34.04	34.13	39.85	36.97	33.12	31.45
Live run losses (8.7% to 8.3%)	29.13	34.17	34.26	39.99	37.10	33.24	31.56
Add updated train performance	29.76	35.06	34.83	44.24	39.72	36.04	34.14
Add forecast train proportions	29.76	35.13	34.81	44.25	39.75	36.06	34.16
Add ATMS	38.21	49.64	46.88	56.73	50.85	47.70	45.04

Table 3-1 - Changes in capacity of key line sections as a result of methodological and input adjustments.

trains take longer to accelerate to the higher through train speed.

As already noted in Chapter 1, there are data challenges with the transaction time analysis that may cause greater variability in the results than is ideal. This may be an opportunity for future improvement.

As also noted in Chapter 1, this 2020 Strategy:

- Uses a new architecture to calculate future average train performance, rather than the previous approach of assuming a constant share of train types. However, as both operators now use an all but identical train consist this does not have a material effect.

- Has applied live run loss rates based on the true-up test methodology rather than HVCCC assumptions and has applied them on zonal basis to better reflect the impact on capacity.

Table 3-1 shows the incremental change in capacity across seven key sections of the Gunnedah line from the changes above compared with the methodology and inputs used in the 2019 Strategy. The capacities are for the year 2025 and assume no capacity enhancement projects are delivered so that the result reflects the raw change in capacity, though it is structured to make the starting and ending point with and without ATMS also clear.

The combination of the effects results in mostly increased capacity across the different sections, but varied in their magnitude. Capacity is slightly higher on the current capacity-limiting Gunnedah to Curlewis section, but is significantly higher on the Ardglen to Pages River section.

For reasons previously noted, the updated transaction times are generally higher than the predicted times following completion of the Microlok upgrade. This is particularly the case in the down direction while transaction times in the up direction compared to previous are more mixed. This contributes to a small decrease in capacity compared with 2019 across four of the key sections of the Gunnedah line.

The adoption of a live run rate of 8.3% for the Gunnedah line, which is slightly lower than the 8.7% applied across the Hunter Valley in the 2019 Strategy, results in a minor increase in capacity across all line sections.

The use of 2019 average train performance has a significant impact on sections south of Ardglen with capacity increasing by between 2.5 and 4 million tonnes a year. The increases are smaller north of Werris Creek. The use of consist-specific averaging of train performance does not materially impact capacity as both operators are now effectively using the equivalent trains.

Performance Improvement Initiatives

ARTC has been pursuing a number of smaller scale initiatives aimed at incrementally increasing capacity between Narrabri and Muswellbrook at reduced cost compared to loop projects. Relevant initiatives identified as potentially viable options are as follows:

- 100km/h running of down trains:

Down trains have been permitted to operate at a maximum 100km/h on some sections since early 2020, allowing empty coal trains to complete a cycle quicker, improving asset utilisation, as well as potentially enhancing capacity.

The train performance used in this Strategy does not capture the benefits of the higher speeds but is expected to be reflected in future editions.

Analysis undertaken by ARTC indicated that the higher permitted speed is estimated to increase capacity on specific sections by between 2.4 and 3.5 million tonnes a year and a number of new crossing loops would either be delayed or not required. There have been some upgrades undertaken on some level crossings and bridges to accommodate the higher speeds while operators are currently in the process of obtaining accreditation for their fleets to operate at the higher speed.

- Higher speeds for Up trains approaching grades at Werris Creek—Bells Gate, Bells Gate—Braefield and Pages River—Murulla:

Increasing the permitted speed of loaded coal trains to 80km/h on the approach to certain grades has been analysed on the basis that higher speeds would give trains additional momentum allowing them to ascend the grade faster, reducing section time. Loaded coal trains at 30 TAL are currently limited to 60km/h across the Hunter Valley Network except for the approaches to the Minimbah and Nundah banks, where 80 km/h is permitted to improve headways. Allowing them to operate to 80km/h approaching selected grades was found to increase capacity in the order of 3.2 mtpa to 4.4 mtpa though this will vary depending on specific circumstances.

Higher approach speeds would also give a transit time reduction, but producers have not been supportive of introducing the change in advance of a capacity trigger, noting that there will be higher track maintenance costs and increased fuel consumption.

- Werris Creek configuration:

Increasing the permitted speed over the turnout (105 points) immediately south of Werris Creek station on the main line from 25km/h to its capability of 35km/h is estimated to increase capacity by 0.7 and 1.6 mtpa on the sections to Bells Gate and Burilda respectively. Additional capacity of between 3.9 and 4.6 mtpa could be achieved on those sections by realigning tracks at Werris Creek station to reduce curvature and removing a little used crossover in Werris Creek yard (104A and B points). These works could delay the need for both the 414km and 407km loops.

- Increased speed through Scone:

Trains are limited to 50km/h passing through Scone to manage noise. An increase in permitted speed to 70km/h would increase capacity by around 2.5 mtpa, but this would require additional noise attenuation to be provided for nearby affected properties. Investigations on whether this is feasible is currently underway.

- Speed boards at all turnouts rated higher than 25km/h:

The turnouts for Boggabri, Emerald Hill, Curlewis and Breeza crossing loops are designed for 50km/h operation but were limited to 25km/h because speed boards were not in place. Potential time savings flow into reduced transaction times. Savings of between one and two minutes were estimated at each of these loops between Muswellbrook and Narrabri.

A program of works to reinstate these speed boards was completed in early 2020. The benefits of this program have not been captured in the train performance data used in this Strategy but will be reflected in future editions.

- Intermediate signals:

An intermediate signal permits a single train to follow another train already in the section, but its benefit is a function of how frequently trains present as a following rather than opposing movement. It also assumes that the following train is less than the section length behind the train in front. The probability of this scenario was analysed in detail for the purposes of establishing the theoretical benefit of ATMS. The benefit is a function of section utilisation, the number of trains operating in a following pattern, and the extent to which there was a conscious decision to take advantage of the following capability. The benefit is equivalent to increasing the section utilisation threshold beyond the post–ANCO threshold of 70% to 74%.

Assuming the above, investigations of potential intermediate signals on the Gunnedah to Curlewis and Emerald Hill to Gunnedah sections estimated that capacity could be increased by around 2.5 mtpa. While beneficial as a stand-alone investment to deliver a marginal capacity uplift, there is a risk of redundancy if it is still necessary to construct a loop to meet demand, as may be the case with South Gunnedah. The benefit is also redundant if ATMS is implemented.

- Increasing permitted speed of Down trains through Gunnedah to above 40km/h:

There is the potential to lift train speed in the Down direction through Gunnedah from the current limit of 40 km/h that was set to meet noise requirements. The Down limit was determined in advance of the yard reconfiguration project and was set with a view to optimising the scope of noise walls. The option remains to extend the noise walls. As a first step noise monitoring could be undertaken to confirm actual noise levels compared to the predictions, which will help inform a solution. Lifting the speed limit to 60 km/h, and assuming that Down trains achieve an average of 54 km/h, would add 1.7 mtpa on this capacity limiting section. Lifting the speed to 70km/h would increase capacity by 2.6 mtpa, or a further 0.9mtpa. An engineering assessment indicated that 70km/h would be the maximum permissible speed for down trains through Gunnedah.

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 in the absence of 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 option 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, is the default option for accommodating volume growth beyond that provided by the proposed technology projects. The majority of loops are now 1330 m – 1450 m with only a small number of short loops remaining. Of these short loops, Gunnedah, Quipolly, Quirindi, Kankool and Scone have specific challenges that make

Figure 3-2 - Muswellbrook to Narrabri Loops

extension difficult. Only two loops (Aberdeen and Murrurundi) remain for potential extension. The location of these, and other existing and potential loops, is shown in Figure 3-2.

Opportunities to insert additional mid-section loops are constrained due to the effects of grades and level crossings, while the increasingly short distances 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 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, though this would be tested again before a final decision on a solution if and when required. The length of each of these double track sections is determined by physical constraints.

Chapter 6 provides more detail on those projects that would be required in the prospective scenario.

Required by timing[1]	Most Likely with ANCO (no ATMS)	Most Likely with ANCO / ATMS	Prospective with ANCO (no ATMS)	Prospective with ANCO / ATMS
South Gunnedah loop	Q3 2022	Q3 2022	Q3 2022	Q3 2022
Burilda north extension			Q1 2025	
414 km loop (Werris Creek North)	Q3 2024		Q3 2024	Q3 2024
407 km loop (Werris Creek South)	Q1 2025		Q1 2025	
Bells Gate south extension	Q3 2023	Q3 2023	Q3 2023	Q3 2023
Braefield north extension	Q1 2025		Q1 2025	
Kankool—Ardglen	Q1 2025		Q1 2025	
Pages River North extension	Q1 2025		Q1 2025	
Blandford loop	Q1 2025		Q3 2023	Q3 2023
Wingen loop	Q3 2023	Q3 2023	Q3 2023	Q3 2023
316 km loop (Parkville South)			Q1 2025	
Togar North Loop	Q3 2023	Q3 2023	Q3 2023	Q3 2023
Aberdeen	Q1 2025		Q1 2025	Q1 2025

Table 3-2 - Project timings under various volume scenarios

Note 1 - Project timing is based on the later of when the project is required, when the project can be delivered and when it adds to capacity given other capacity bottlenecks.

Investment Pathway

Table 3-2 shows the projects required to address the capacity constraint on each local section to meet demand, for the most likely and prospective scenarios and with and without ATMS. No loop projects are required or proposed for contracted volumes.

The benefits of ANCO and Microlok upgrades are fully captured following their implementation in 2019. As discussed in Chapter 2, ANCO is assumed to have increased utilisation from 65% to 70%. It should be noted that some loops would not be required if the Performance Improvement Initiatives outlined earlier in this chapter, particularly the 100km/h running in the Down direction in some sections and 80km/h approach to some grades in the Up direction, are implemented.

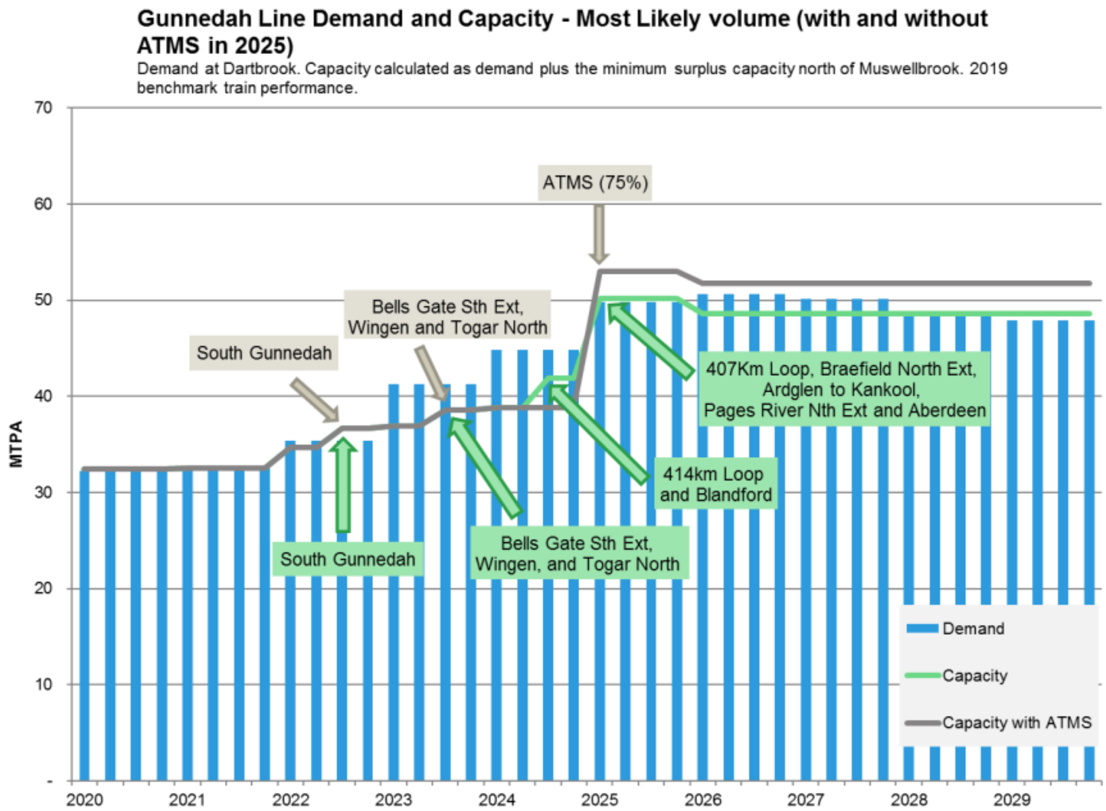


Figure 3-3 - Conceptual pathway for investment to meet the most likely volume scenario.

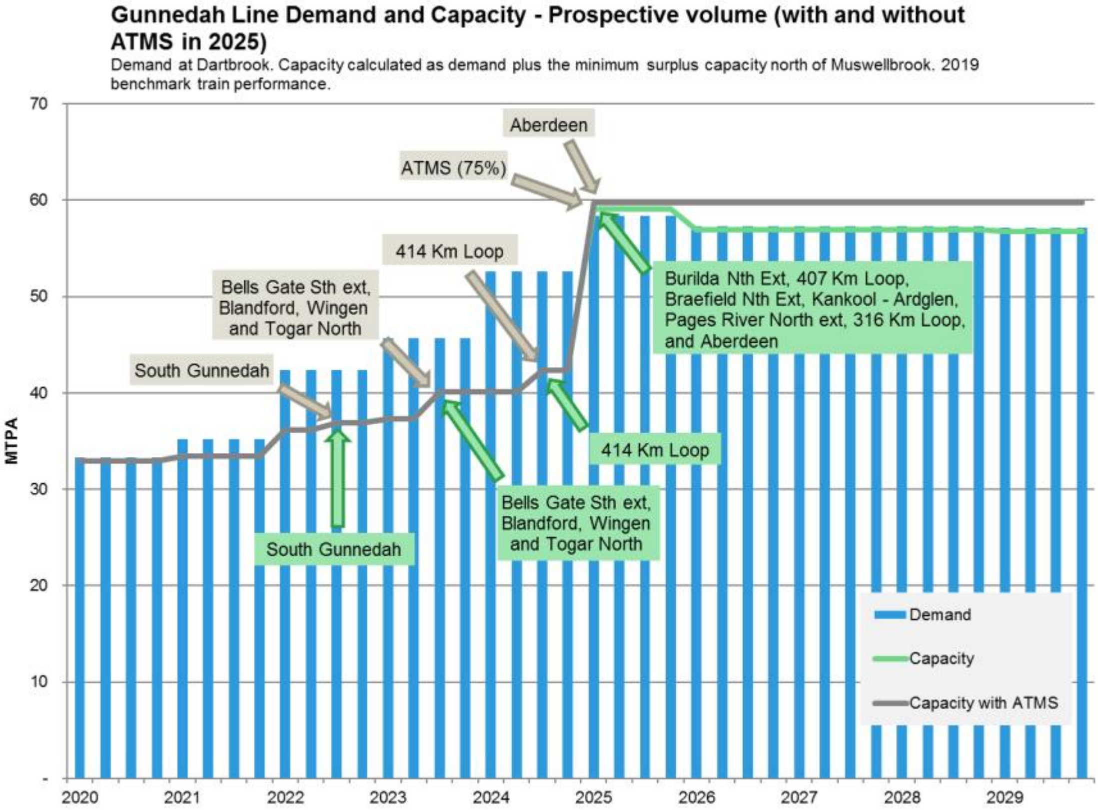


Figure 3-4 - Conceptual pathway for investment to meet the prospective volume scenario.

Note 1—Unlabelled changes in capacity reflect changes in volume on the port side of the capacity limiting section.

The location of each of the projects is shown in Figure 3-2.

The timing of projects is the later of when they are required, when they can be delivered and when they will deliver a capacity benefit given constraints elsewhere on the corridor, and the earliest projects can be delivered to address those constraints.

It is also important to note that the current best assessment is that ATMS provides the single biggest capacity increment and is equivalent to many of the projects in Table 3-1. As such the ATMS pathway helps to delivers the required capacity at a lower cost than the no-ATMS pathway.

Figure 3-3 shows the preferred investment pathway to meet the most likely volume forecast scenario, graphically. Figure 3-4 shows the investment pathway to meet the prospective volume forecast scenario. Both figures show pathways with and without ATMS.

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 capacity enhancement projects if the volume increment is on the port side of the capacity limiting section.

ATMS has also been assessed as having the theoretical potential to lift utilisation by a further five percentage points, from 70% to 75%. A 2.5% improvement in average train speed has also been assumed. The strategy and achievable timeframe for rollout of ATMS is subject to ongoing review informed by progress in the finalisation of the system safety case and the priority rollout of the system as part of Inland Rail delivery. The current judgement is that Q1 2024 is a plausible target for implementation of ATMS in the Hunter Valley and it has been assumed that full deployment across the Gunnedah basin line would be complete by Q1 2025.

It is important to emphasise that the scale of benefit from ATMS, and the timeframes for implementation, are somewhat uncertain given the nature of the technology.

Accordingly, if access holders wish to ensure certainty around the delivery of additional capacity, it remains preferable to continue with 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, mitigates 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.

Volume & Capacity

Demand and capacity by sector, based on the project timings recommended in this Chapter, and using the calculation methodology set out in Chapter 1, is shown in Figure 3-5. This chart shows both contracted and

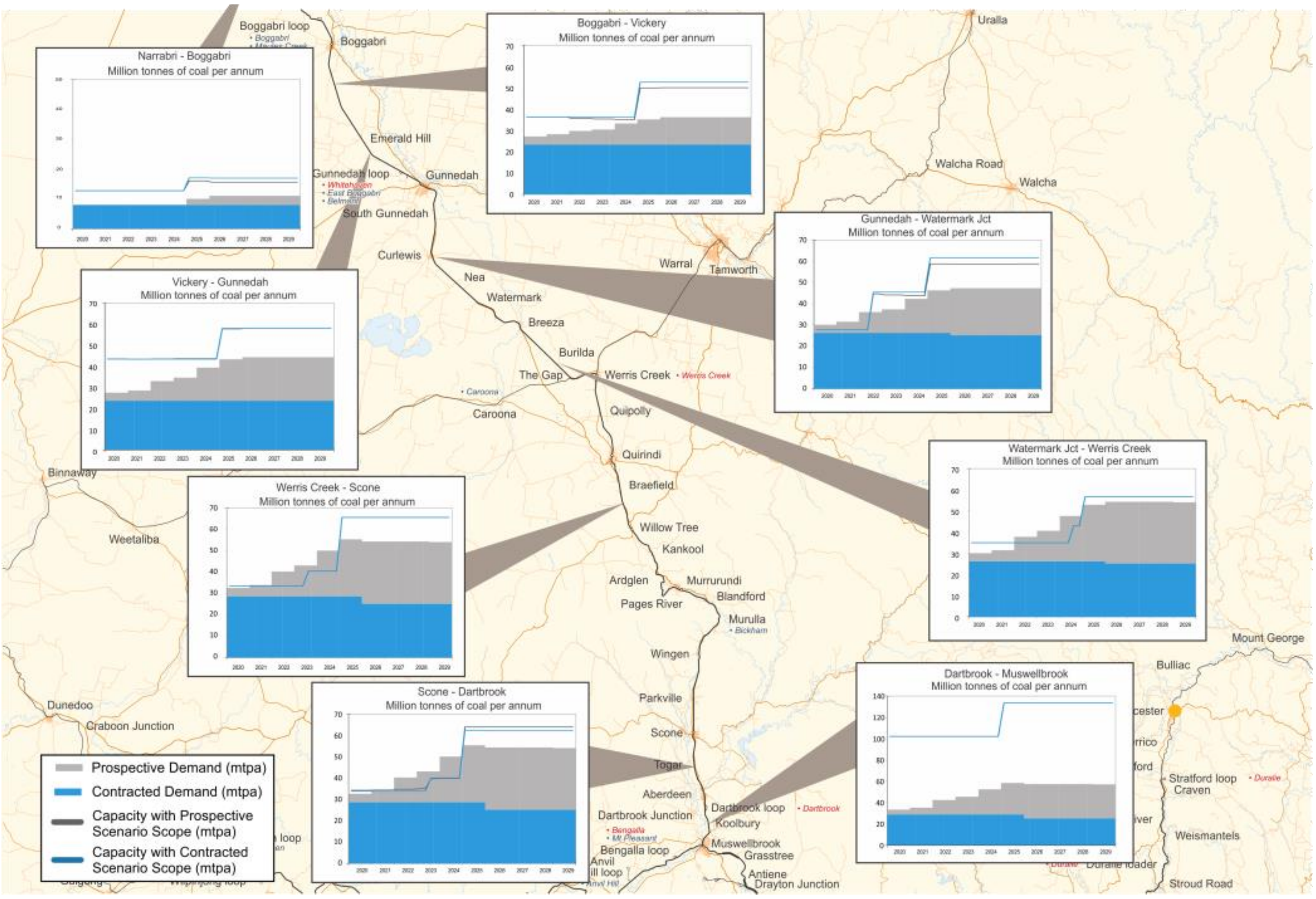


Figure 3-5- Volume and capacity on the Gunnedah basin line.

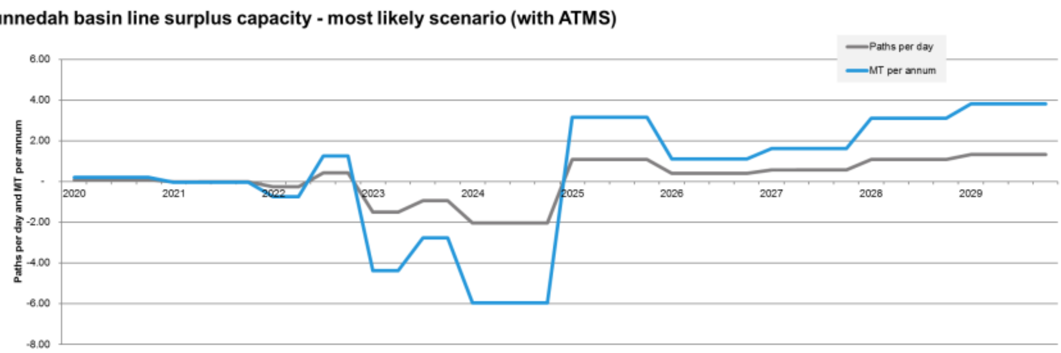


Figure 3-6 - Saleable surplus capacity in paths and tonnes for Zone 3 under the most likely volume and recommended projects scenario with ATMS

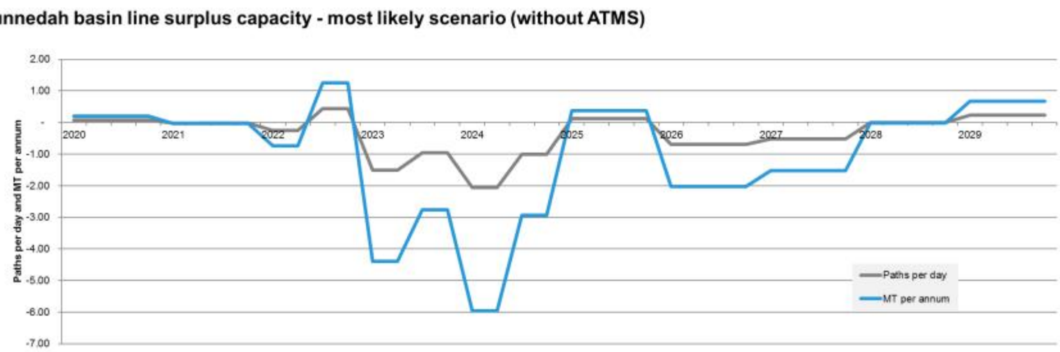


Figure 3-7 - Saleable surplus capacity in paths and tonnes for Zone 3 under the most likely volume and recommended projects without prospective volumes for the proposed infrastructure scope including ATMS.

Forecast surplus capacity in both paths and tonnes under the most likely volume and infrastructure scenario with ATMS as shown in Figure 3-6. A scenario without ATMS is presented in Figure 3-7.

This is calculated as the surplus capacity on the most capacity constrained section, assuming a 10% TMTC, and is effectively the difference between the volume and capacity pathways shown in figures 3-3 and 3-4.

The most likely volume scenario identified by producers has volume growing faster than capacity enhancement projects can be delivered. Accordingly the 'surplus capacity' chart shows a capacity shortfall until the last required project is delivered, which in this case is ATMS under the ATMS scenario, or the final loops in the non-ATMS scenario.

Transit Times

As discussed in Chapter 1, the capacity modelling tools were enhanced for the 2019 Strategy to include a transit time calculator. This uses actual train performance and transaction times, together with a probabilistic tool for calculating loop dwell frequency and duration, to forecast the likely average transit time with ATMS.

This is shown in Figure 3-8 for the three volume / infrastructure scenarios, in the with ATMS case. The predicted Muswellbrook - Narrabri mine transit time has been adopted as being illustrative of the likely performance for all load points. The no-ATMS scenario is shown in Figure 3-9. Overall transit time is forecast to reduce as the increase in infrastructure more than offsets the increase in train numbers.

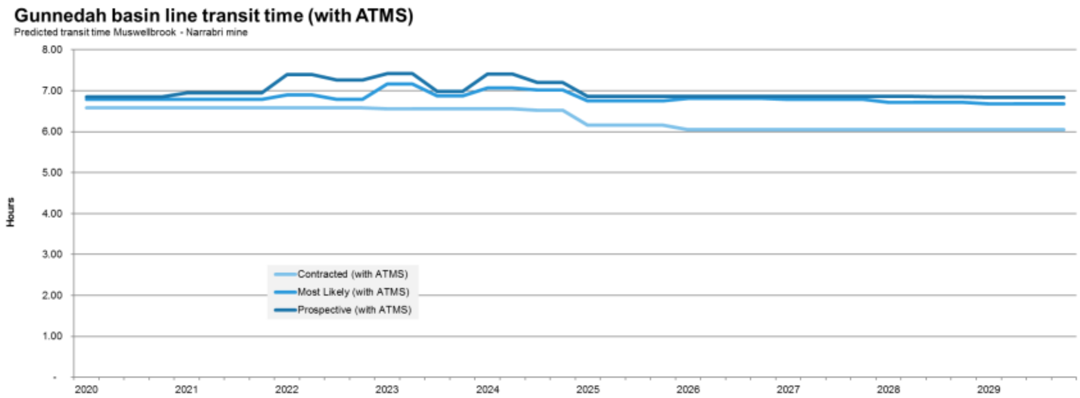


Figure 3-8 - Forecast transit time Muswellbrook - Narrabri mine under contracted, most likely and prospective volume scenarios and works as per Table 3-1 with ATMS

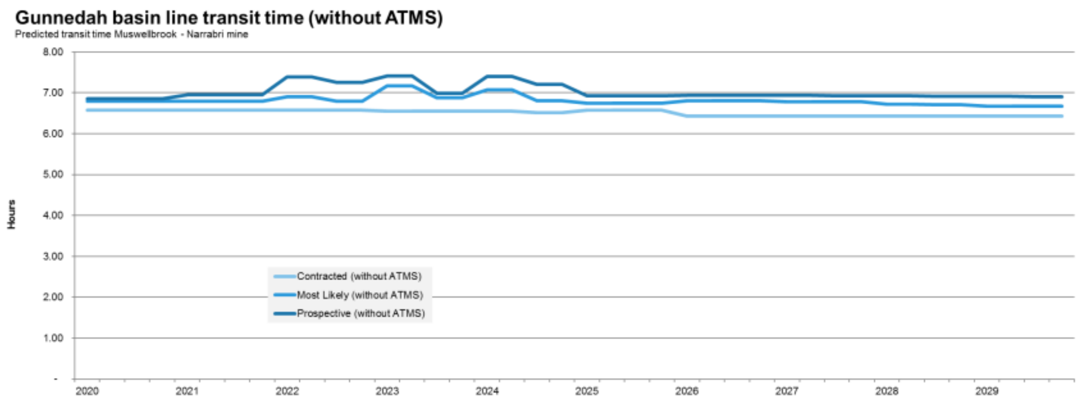


Figure 3-9 - Forecast transit time Muswellbrook - Narrabri mine under contracted, most likely and prospective volume scenarios and works as per Table 3-1 without ATMS.

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, Mt Pleasant, 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.

Four new export coal mines are at various stages of the development and approval process, but only the Bylong and West Muswellbrook mines are assumed to be developed in the timeframe of this Strategy. The Mt Penny and Ferndale mines are assumed to not be in production during this period. The Spur Hill mine, which was previously identified as a potential mine connecting to this line, is now considered to be more likely to load through the Drayton load point if it were to go ahead.

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

As noted in Chapter 1, train performance has been updated to 2019 train performance, and a new methodology has been applied that uses section times weighted by the expected proportions of each train type.

Four coal train consists are contracted for use on the Ulan line. The consists, as noted in Chapter 1, are:

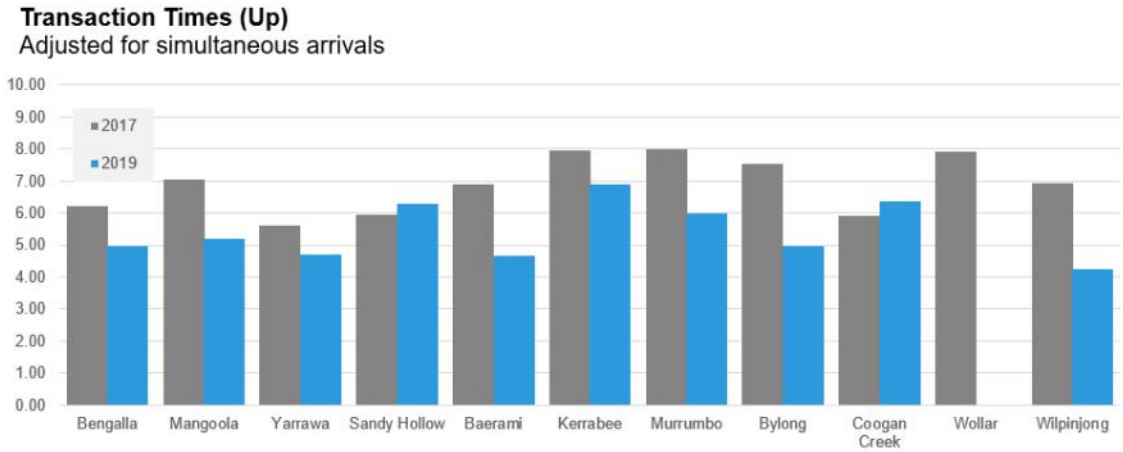
- Pacific National—3 x 92/93/TT class (4400HP AC) locos with 96 wagons - 9,100 net tonnes, 1,541 metres nominal length.
- Pacific National—3 x 90 class (4000HP DC) locos with 92 wagons - 8,500 net tonnes, 1,5529 metres.
- Aurizon—2 x 5000/5020 class (4400HP 30 TAL AC) locos with 88 wagons - 8,600 net tonnes, 1,514 metres.
- One Rail—3 x XRN class (4400HP AC) locos with 96 wagons - 9,100 net tonnes, 1,541 metres.

Similar to the Gunnedah line, the 2019 train performance used in this strategy shows a general improvement compared with the performance used in the 2019 strategy.

It should be noted that Aurizon are moving towards adoption of a consist comprising 3 x 5000/5020/6000 class (4400HP AC) locos with 96 wagons, following a successful trial in late 2019. The new consist brings Aurizon into line with Pacific National and One Rail. There are potential performance benefits of running this consist and there is a pathway to incorporate its performance into future capacity calculations if its use is adopted on a wider scale.

In addition to the update to train performance, the new approach to live run loss rates has been applied as per Chapter 1.

Actual transaction times have been updated and are reflective of the completed Microlok Upgrade program. A comparison of previous and new transaction times is shown in Figure 4-1, including the simultaneous arrivals



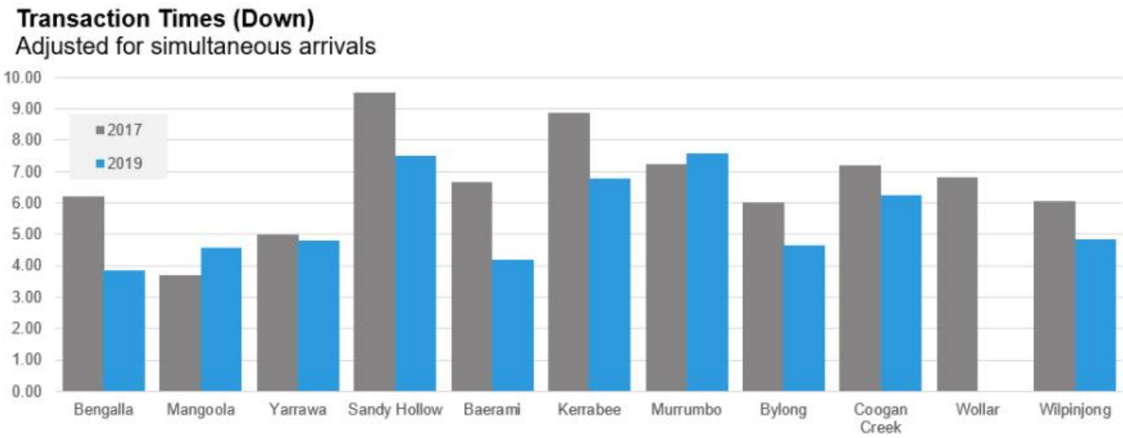


Figure 4-1 - Transaction times

adjustment. There are no updated transaction times for the Wollar loop due to a speed restriction having been in place at the location throughout the period for which data was available.

Table 4-1 shows the incremental change in capacity on the two most capacity limited sections on the Ulan line, Baerami to Kerrabee and Bylong to Murrumbo from the changes above compared with the methodology and inputs used in the 2019 Strategy. The capacities are for the year 2025 and assume no capacity enhancement projects are delivered so that the result reflects the raw change in capacity, though it is structured to make the starting and ending point with and without ATMS also clear.

The combination of the effects results in minor increases in capacity on both sections. The use of updated transaction times results in a marginal decrease in capacity on Baerami to Kerrabee and a slightly larger decrease in capacity on Bylong to Murrumbo, noting this is relative to the predicted outcome following the upgrade program, not the previous actual performance..

The live run loss rate specific to the Ulan line is 9.4% and is slightly higher than the 8.7% that was applied across the Hunter Valley network in the 2019 Strategy. Capacity is slightly reduced as a result of applying this higher rate.

Application of 2019 average train performance for the Ulan line results in a small increase in capacity for both sections. Application of train type-specific performance sees little change on Baerami to Kerrabee while there is a small increase on Bylong to Murrumbo.

Performance Improvement Initiatives

Similarly to the Gunnedah line, ARTC has explored low cost capacity initiatives on the Ulan line. ARTC has undertaken analysis of the following:

- Intermediate signals between Baerami and Kerrabee:

Assuming a local utilisation rate of 74% as discussed in Chapter 3, the increase in capacity on this capacity-limiting section is estimated to be 2.6 mtpa. The section would remain the capacity-limiting section

Section capacity Q1 2025 (mtpa) - without projects		
	Baerami to Kerrabee	Bylong to Murrumbo
Capacity as per 2019 Strategy (with ATMS)	52.10	58.38
Capacity as per 2019 Strategy (w/o ATMS)	41.80	45.50
Add 2020 contract paths	41.92	45.63
Add updated transaction times	41.82	44.90
Live run losses (8.7% to 9.4%)	41.55	44.61
Add updated train performance	42.03	45.18
Add forecast train proportions	42.01	45.61
Add ATMS	52.57	59.70

Table 4-1 - Changes to capacity from using the different methodology—Contracted and Most Likely scenarios despite this additional capacity. Hence Widden Creek loop, which would make the investment in intermediate signals redundant, may be the preferred option to deliver additional capacity.

- Installation of speed boards at all turnouts rated higher than 25km/h:

The turnouts for Coggan Creek and Sandy Hollow loops are designed for 50km/h operation but were limited to 25km/h because speed boards were not in place. Savings of between one and a half and two minutes had been estimated for Sandy Hollow and in the down direction at Coggan Creek. The reduction in transaction times from the higher speed at the loops is not expected to increase line capacity as the relevant sections are not capacity-limiting but is expected to improve cycle times at the margin.

A program of works to reinstate these speed boards was completed in early 2020. The impacts of this program have not been captured in the train performance data used in this Strategy but will be reflected in future editions.

- 100km/h running of down trains:

Unlike for Muswellbrook to Narrabri, increasing the permitted speed of down coal trains on the Ulan line to 100km/h is estimated to provide minimal benefit. The curvature and grades along the line effectively limit down trains to below the current limit of 80km/h for much of the journey. Hence increasing the permitted speed to 100km/h would not provide much benefit in cycle time or capacity.

In contrast to the analysis in Chapter 3, these projects are not of benefit under any of the scenarios.

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 have long shown interest in introducing longer trains on the Ulan line. The issue of longer trains is discussed in general in Section 2.

Past analysis by the HVCCC and ARTC found that any introduction of trains that were longer than the current length without complimentary investment would lead to a net reduction in capacity due to the inability of such trains to fit in some loops.

Analysis by ARTC in late 2019 found that the most cost effective way to introduce longer trains without negatively impacting on capacity involved delivering a series of infrastructure enhancements on the Ulan line and between Muswellbrook and the port, optimised for a 102 wagon train, or 1640 metres.

The required scope includes extending Sandy Hollow loop to at least 1,670 metres (providing for 15 metres clearance at both ends of the train), and extending both Kerrabee and Baerami loops. Due to geography

constraints, these loops would need to be extended by 850 and 700 metres respectively. As the best solution likely involve extending the loops towards each other, it also has a consequential effect of reducing the length of the section, and given that this is the capacity limiting section, it would also provide a general uplift in track capacity beyond the direct benefit of the longer train.

The estimated cost of these three extensions in Zone 2 is $23 million.

In addition to these works, altering the signalling at a number of locations including the Hexham Relief Roads, at North Fork (Sandgate) and at the arrival and departure roads at Kooragang, and reconfiguration of track and signalling works inside NCIG, would also be required. The cost of these works is estimated to be around $24 million in addition to the Ulan line works. In addition to these costs, there may be other costs associated with infrastructure that is not owned or operated by ARTC (including balloon loops) that are yet to be fully analysed.

The total cost of accommodating 1,640m trains in zones 1 and 2 is therefore estimated to cost approximately $47 million.

The proposed works, if approved, would take up to three years to deliver. The cost and capacity benefit of the works to accommodate 1640 m trains would need to be weighed against other works that could provide capacity uplift in a similar timeframe including delivery of the Widden Creek loop and rollout of ATMS.

More detailed analysis and cost estimates for the 1640 m train option are proposed to be undertaken this year.

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 (i.e. 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 though it was appropriate to further consider this issue, and a review has now been undertaken.

Project Name	Most Likely with ANCO (no ATMS)[1]	Most Likely with ANCO / ATMS[1]	Prospective with ANCO (no ATMS)[1]	Prospective with ANCO / ATMS[1]
Coggan Creek west extension			Q4 2023	
Murrumbo west extension			Q4 2023	
Widden Creek loop	Q1 2022		Q1 2022	
324 Km Loop			Q1 2025	
Mt Pleasant loop			Q1 2024	

Table 4-2 - Project timings under various demand scenarios

Note 1—Project timing is based on the later of when the project is required, when the project can be delivered and when it adds to capacity given other capacity constraints.

In regard to the heat issue, past locomotive 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 an in-cab air quality 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 minimum time is 16 minutes as of this year. The air quality review determined that a 16 minute purge time would be acceptable and this is now being implemented. Capacity modelling for this Strategy has assumed this 16 minute purge time.

Investment Pathway

Table 4-2 shows the projects required to address the capacity constraint on each local section as demand requires, for the most likely and prospective scenarios, with and without ATMS. No projects are required or proposed for contracted volumes beyond the technology initiatives.

The location of each of the loop projects is shown in Figure 4-2. The projects identified assume that there is no change to current actual train performance in the future.

It is also assumed that the rail connection to the Mount Pleasant mine moves from its current location west of Bengalla junction to the east of that junction in Q1 2022 as per Modification 4 to the Mount Pleasant development approval.

Figure 4-3 shows the preferred investment pathway to meet the most likely volume forecast scenario. Figure 4-4 shows the pathway to meet the prospective forecast scenario. Both show pathways with and without ATMS.

Note that these graphs show volume at Muswellbrook plus the surplus capacity on the most capacity limiting section of the corridor. Hence, capacity can change independent of capacity enhancement projects if the volume increment is on the port side of the capacity limiting section.

ATMS has been assessed as having the theoretical potential to lift utilisation by a five percentage points, which would take utilisation from 70% to 75%. A 2.5% improvement in average train speed has also been assumed.

The strategy and achievable timeframe for rollout of ATMS is the subject of ongoing review informed by progress in the finalisation of the system safety case and the prioritisation of rollout of the system in the context of Inland Rail delivery. The current judgement is that Q2 2024 is a realistic target for implementation of ATMS on the Ulan line. However, as discussed in Chapter 2, there remains scope for varying that timeframe.

It is important to emphasise that the scale of benefit from ATMS, and the timeframes for implementation, are somewhat uncertain given the nature of the technology.

Accordingly, if access holders wish to ensure certainty around the delivery of additional capacity, it is

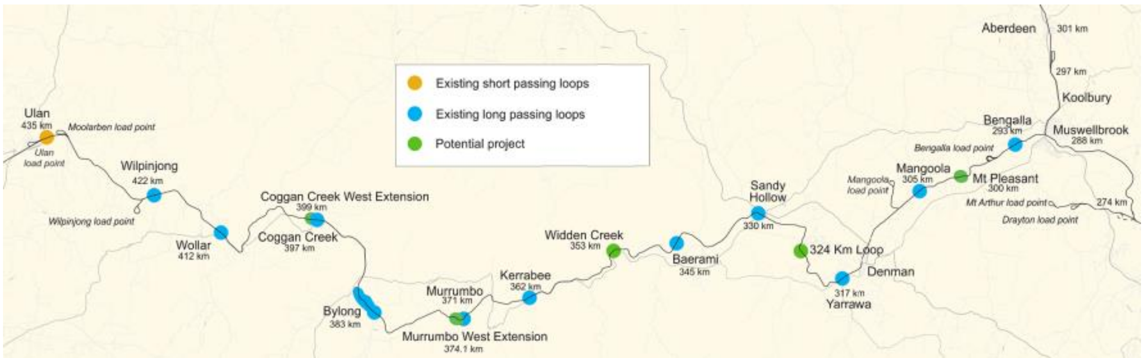


Figure 4-2 - Ulan Loops

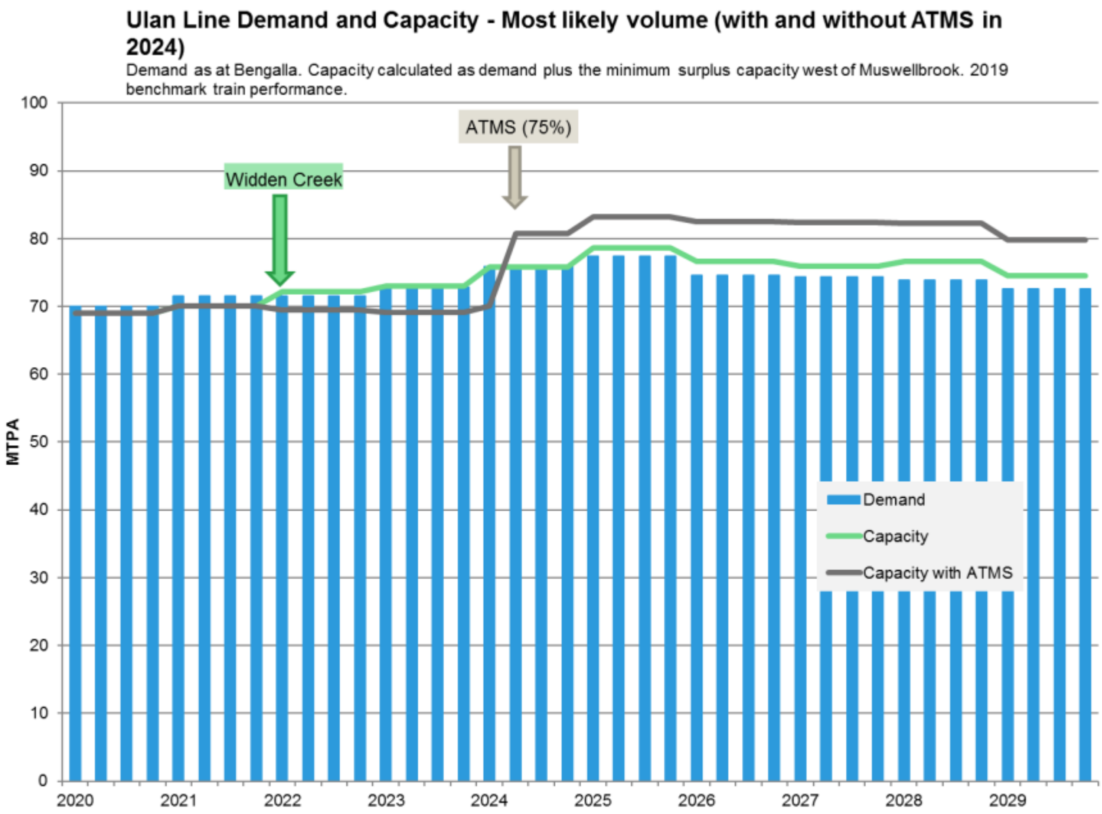


Figure 4-3 - Conceptual pathway for investment to meet Most Likely volume scenario.

Note 1—Unlabelled changes in capacity reflect changes in volume on the port side of the capacity limiting section.

preferable to continue with 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

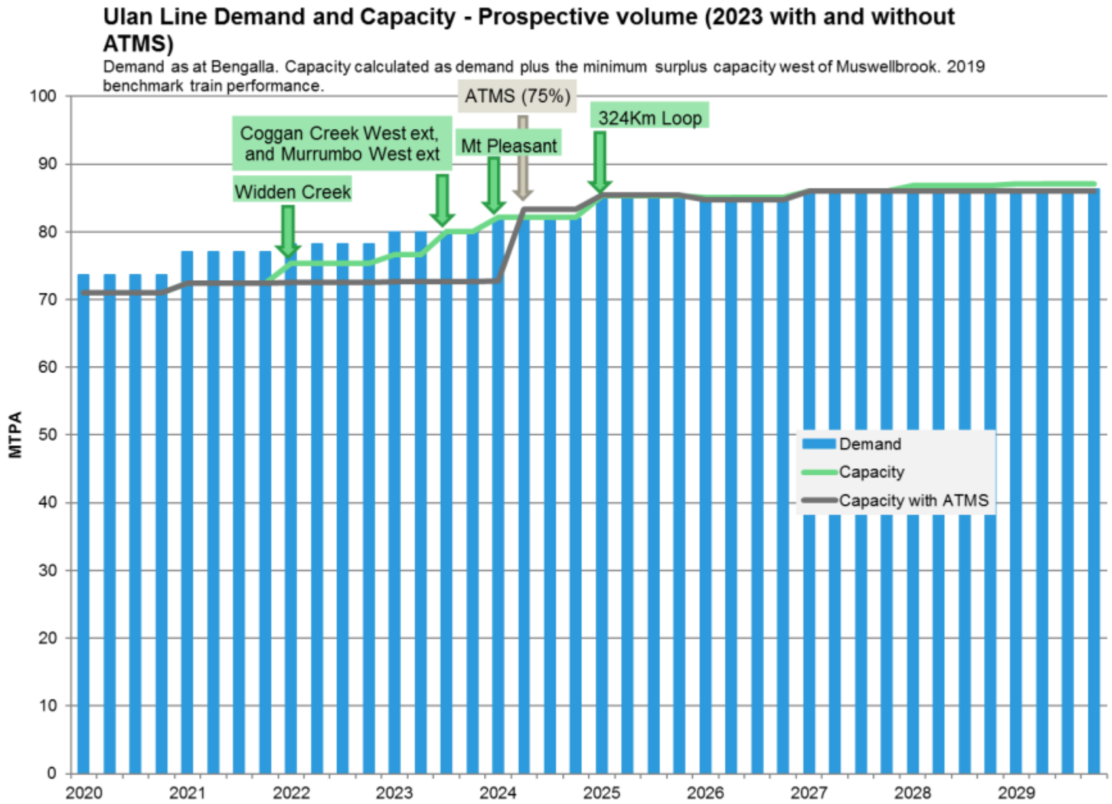


Figure 4-4 - Conceptual pathway for investment to meet the Prospective volume scenario.

Note 1—Unlabelled changes in capacity reflect changes in volume on the port side of the capacity limiting section.

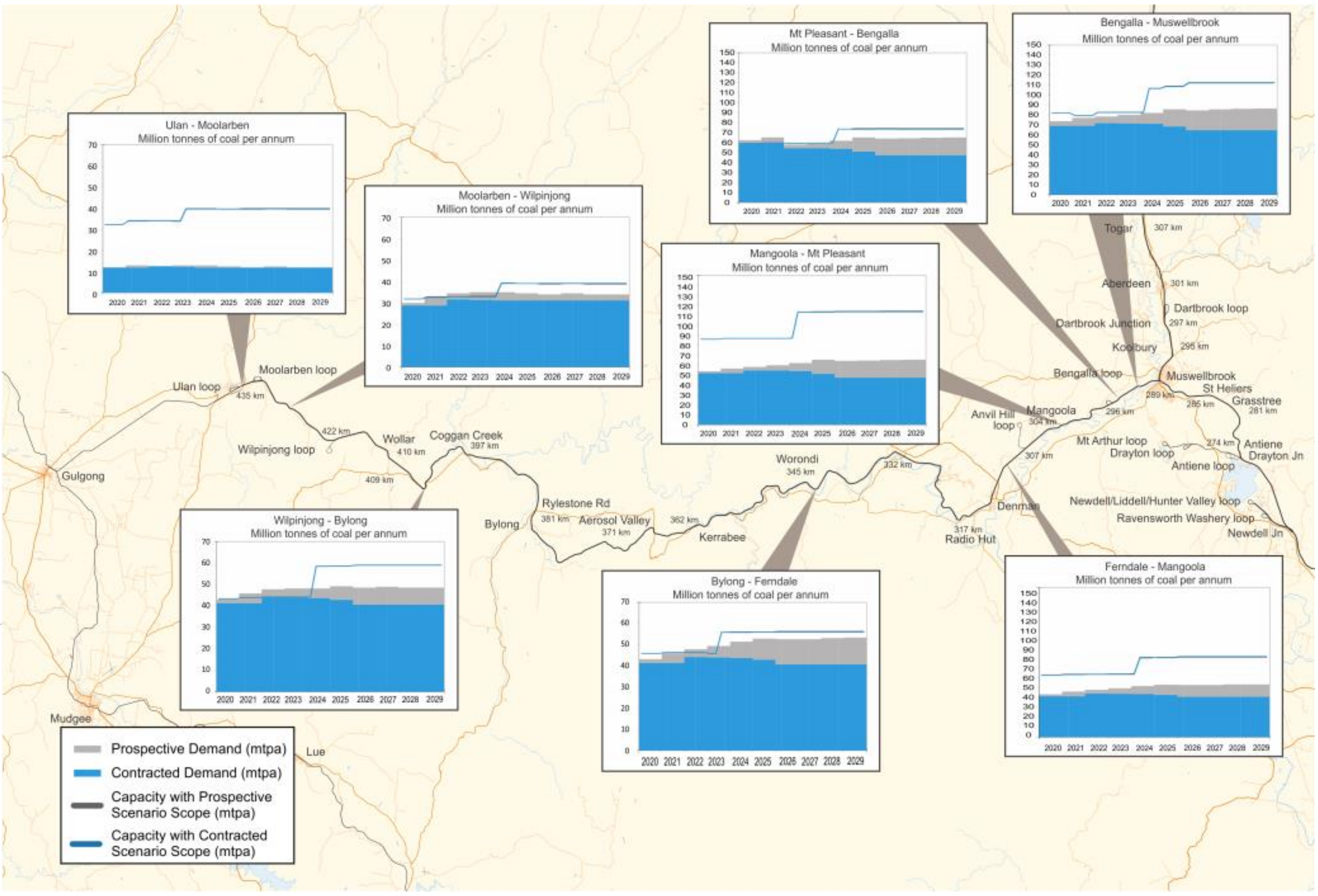


Figure 4-5 - Volume and capacity on the Ulan line

expenditure on loops would ultimately be of value in expediting construction later in the planning period.

Volume & Capacity

Demand and capacity by sector, based on the project timings recommended in this Chapter, and using the calculation methodology set out in Chapter 1, is shown in Figure 4-5. This chart shows both contracted and prospective volumes for the proposed infrastructure scope including ATMS.

As discussed in Chapter 1, a new chart showing forecast surplus capacity, in both paths and tonnes, under the most likely volume and infrastructure scenario with ATMS, is shown in Figure 4-6. Figure 4-7 shows the same analysis without ATMS. The graphs are calculated as the surplus capacity on the most capacity constrained section, assuming a 10% TMTC and are equivalent to the difference between demand and capacity as shown in Figure 4-3.

Under both scenarios the volumes are expected to increase faster than capacity can be provided, which results in the small negative surplus capacity in the years leading up to the delivery of Widden Creek Loop in Q1 2022 under the 'without ATMS' scenario or ATMS in 2023.

Transit Times

As discussed in Chapter 1, the capacity modelling tools were enhanced for the 2019 Strategy to include a transit time calculator. This uses actual train performance and

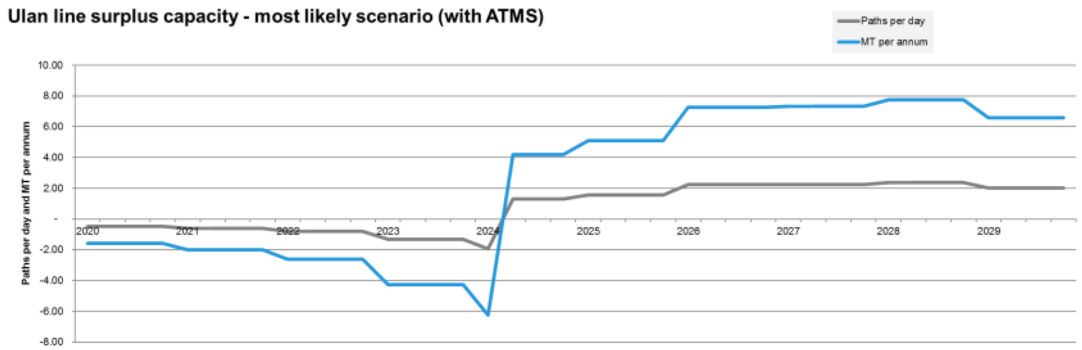


Figure 4-6 - Saleable surplus capacity in paths and tonnes for Zone 2 under the most likely volume and recommended projects scenario with ATMS

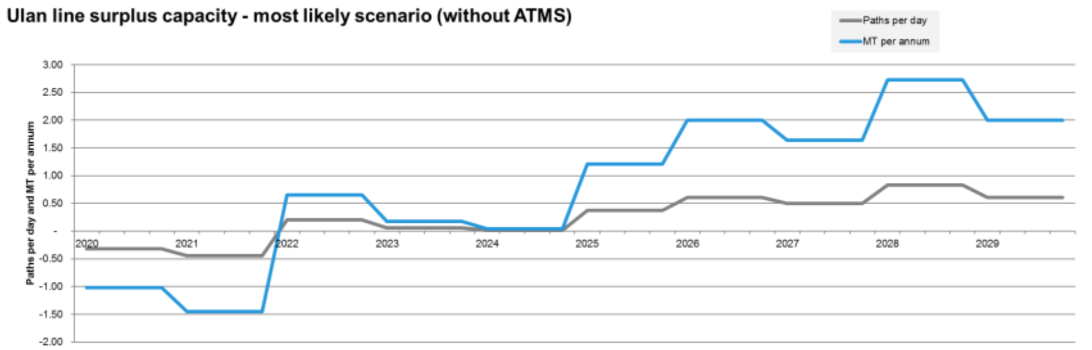


Figure 4-7- Saleable surplus capacity in paths and tonnes for Zone 2 under the most likely volume and recommended projects without ATMS

transaction times, together with a probabilistic tool for calculating loop dwell time, to forecast the likely average transit time.

This is shown in Figure 4-8 for the three volume / infrastructure scenarios with ATMS. The predicted Muswellbrook - Ulan mine transit time has been adopted as being illustrative of the likely performance for all load points. A scenario without ATMS is provided in Figure 4-9.

Transit time improves over time as demand declines.

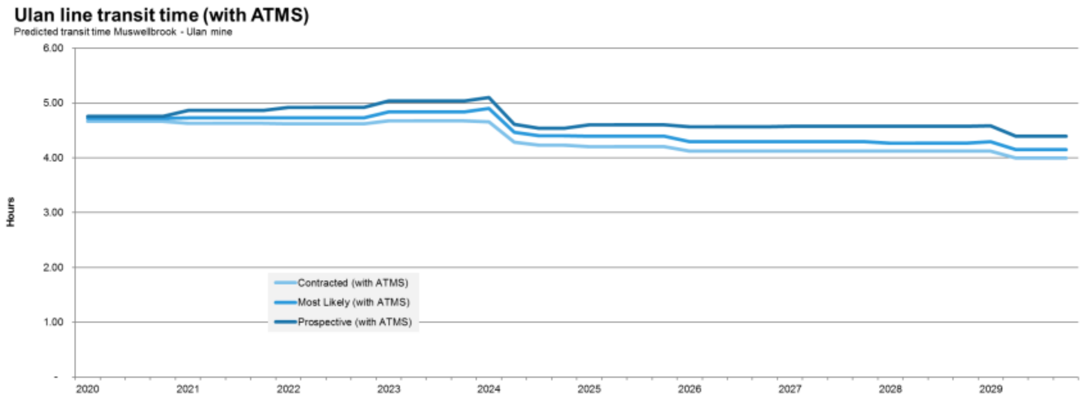


Figure 4-8 - Forecast transit time Muswellbrook - Ulan mine under contracted, most likely and prospective volume scenarios and works as per Table 4-1 with ATMS

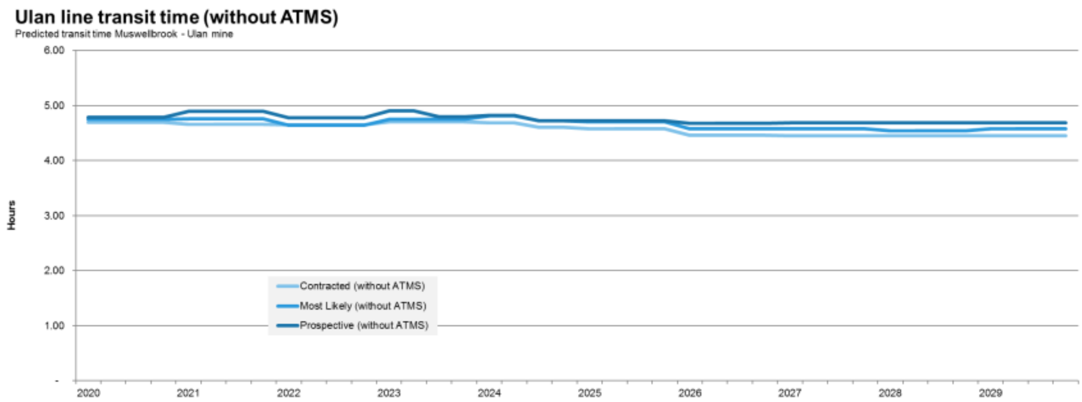


Figure 4-9 - Forecast transit time Muswellbrook - Ulan mine under contracted, most likely and prospective volume scenarios and works as per Table 4-1 without ATMS.

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 two daily return Singleton passenger services and a daily return 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, create a disproportionate loss of capacity, particularly in the loaded direction. However, there is sufficient capacity on

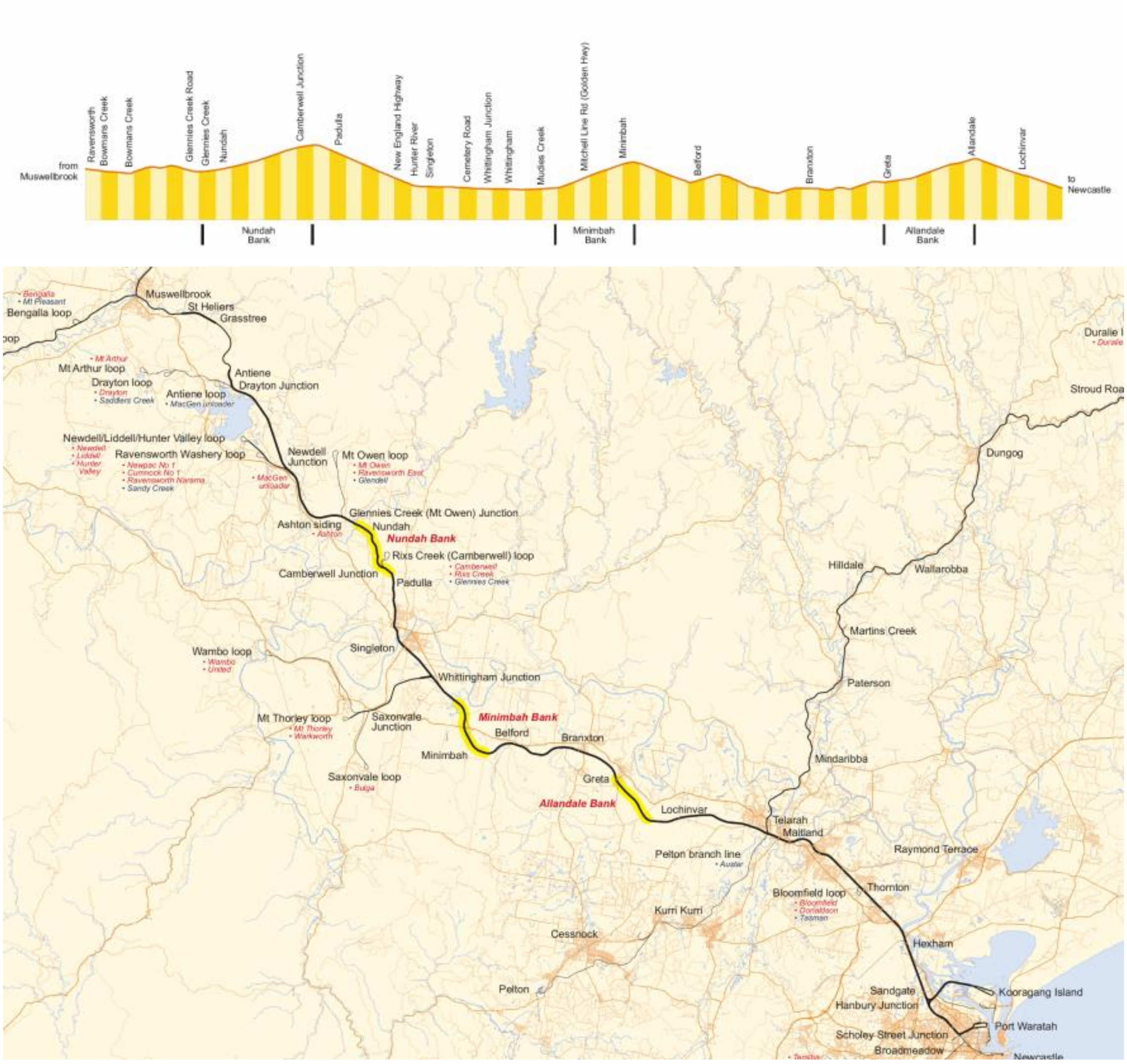


Figure 5-1 - The Nundah, Minimbah and Allandale Banks.

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.

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. A third track, or second Up track, exists on all three of the major banks.

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 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.

The 2019 Strategy calculated actual train performance between Muswellbrook and the ports for the first time. This actual train data largely validated previous theoretical calculations.

There were also no capacity constraints identified. Given the ample capacity on this section and that train performance for the Gunnedah and Ulan lines in this Strategy was an improvement on the performance used in the 2019 Strategy, there would be no adverse impact on this section and hence it was determined that there was no requirement to update train performance for Muswellbrook to the port for this Strategy.

Effective headway is at around 8 to 10 minutes in both directions south of Minimbah, though the data has identified a short peak of around 12 minutes approaching Hexham. Headway increases further up the valley with spacing as high as 14 minutes in the vicinity of Drayton Junction in the Up direction.

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.

Current contracted volumes do not trigger a requirement for any headway projects. In the event that ATMS proceeds on this section it will fundamentally alter the operating environment with trains able to operate at the minimum safe distance in all circumstances, which can be as low as four minutes. On Minimbah and Nundah banks though it will still be desirable to avoid two trains being on the bank on the same track, which means that on these sections ATMS would deliver a minimal reduction in headway compared to the current fixed signalling.

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. As discussed in Chapter 2, there is likely to be a case for early delivery of ATMS between Muswellbrook and Singleton and the current ATMS implementation strategy has this targeted for Q2 2026. Singleton—Maitland—Ports is likely to have a relatively higher cost due to the number of interlocking and the scope of benefits will be relatively less. Hence it is targeted for toward the end of the roll-out program, in 2029. As discussed in Chapter 2, there may be opportunities to accelerate this timeframe if there is an appetite to do so.

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).

Replacement of the low speed, high maintenance turnouts around Maitland was completed in early 2018. This upgrade was undertaken to reduce the future maintenance task and increase reliability and 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 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 limited 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 highly efficient. As discussed in Chapter 2, there is an emerging need for renewal of some of the signalling equipment at these junctions, but this is not driven by capacity.

Muswellbrook junction stands apart from the other junctions due to the need to sequence trains onto the single track lines to Gunnedah and Ulan and the significant number of trains from both lines, which means a large number of conflicting movements at the at-grade junction.

While a level of congestion at Muswellbrook is present under contracted volumes, it is tolerable based on theoretical analysis assuming a level of intelligent design in the live run train plan.

Analysis of actual train arrivals at Muswellbrook in 2019 suggested that in reality the operating practices are generating considerable pressure at the junction. The pattern of departure of trains from the port terminals shows that there are frequent instances of multiple trains for one line being released onto the network at separations that are inconsistent with the loop spacing on that line. This necessarily means that trains have to queue at Muswellbrook waiting for a path. This effect does not occur in the Up direction since trains traversing the single track lines are naturally well spaced as they approach the junction.

This issue is purely an operational one and further assessment of congestion and pathing issues is not expected to be progressed until after the rollout of ANCO between Hexham and the port is completed. It is likely that when ANCO is fully rolled-out, it will mitigate pathing and congestion issues at this junction, though

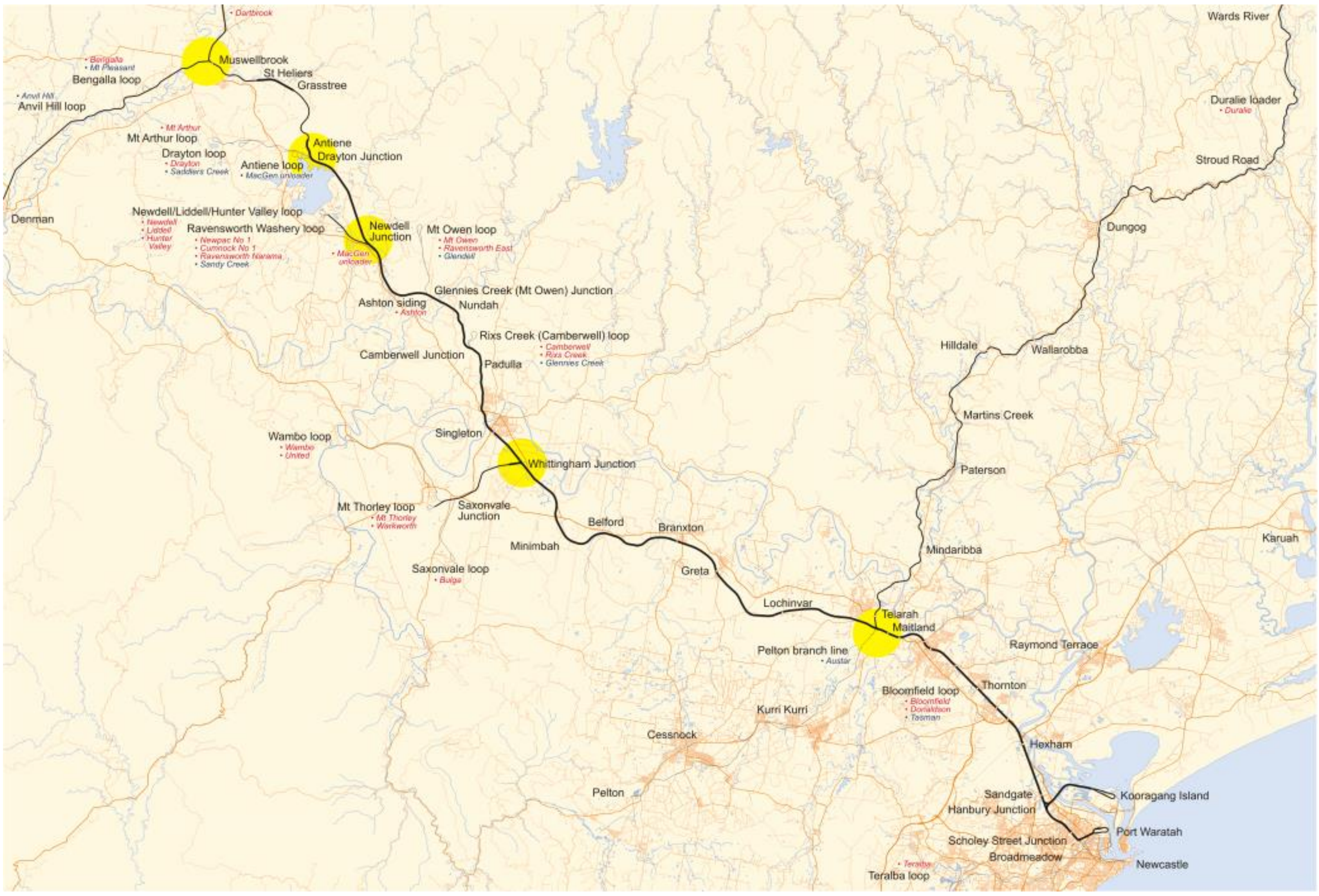


Figure 5-2 - Maitland, Whittingham, Newdell, Drayton and Muswellbrook Junctions

this would be further enhanced by ATMS, as discussed in Chapter 2.

Work done to date on potential infrastructure solutions has identified significant construction and environmental challenges that would suggest that any infrastructure solution is only worth pursuing once volume growth, and hence congestion, approaches a level where an infrastructure solution is unavoidable.

In the medium term, prospective volume growth from both the Ulan and Gunnedah basin lines could mean that such a solution may be necessary.

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.

The replacement of the Hunter River / Muscle Creek bridges on the Ulan line immediately west of Muswellbrook is currently being delivered and creates an opportunity to cost effectively create double track between Muswellbrook and Bengalla if required in the future. The new bridges, to be delivered by mid 2022, are being constructed on a new alignment leaving open the option of using the existing alignment for a second track.

If and when there is an emerging need to further consider an infrastructure solution, the options will be further assessed to determine best value for money.

ARTC has previously assessed the threshold where a solution is required at approximately 45 coal paths/day. This threshold continues to be reached in 2025 under the prospective volume scenario, but doesn't climb above 48 paths per day. Demand does not reach 45 paths per day in the most likely scenario.

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 horizon 1 nearing completion, there is reasonable confidence that 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 flows from the two single lines are integrated efficiently onto the double track spine south of Muswellbrook.

Whittingham branch

ARTC owns the short network of branches from Whittingham to Mt Thorley, Bulga and Wambo commonly known as the Whittingham branch.

This network was the subject of intensive analysis in 2014 in response to concerns that the branch network could contribute to upstream congestion. ARTC and HVCCC agreed at that time that the capacity of the branch network was in the order of 30 mtpa +/- 2 mtpa once signalling modifications proposed by ARTC, and subsequently implemented, were taken into account. Actual annual volume of around 29 mtpa was achieved prior to the signalling modifications, suggesting that the modelled capacity was conservative.

Track capacity on its own is an order of magnitude greater than this. Key issues in assessing the capacity were:

- Management of train flow, in particular terminal departure filtering and the feasible extent of staging at Whittingham Junction to access the single track sections, and
- Peaking, which historically has exceeded the 10% TMTC allowance.

ANCO will further assist in improving train flow to help mitigate these issues.

Contracted and most likely volumes are comfortably within the agreed capacity limits, but prospective volume peaks at 35.4 mtpa in 2026. While the track capacity to achieve this is available, capacity limits will be a function of system issues. As discussed in Chapter 1, this is a matter for the HVCCC.

Continuous Train Flow

A key issue for efficiency at the terminals 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

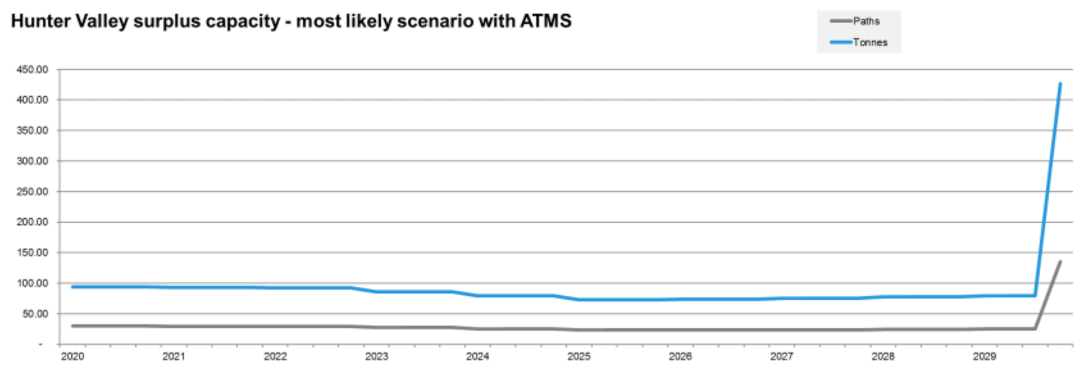


Figure 5-3 - Saleable surplus capacity for Zone 1 under the most likely volume and recommended projects scenario with ATMS

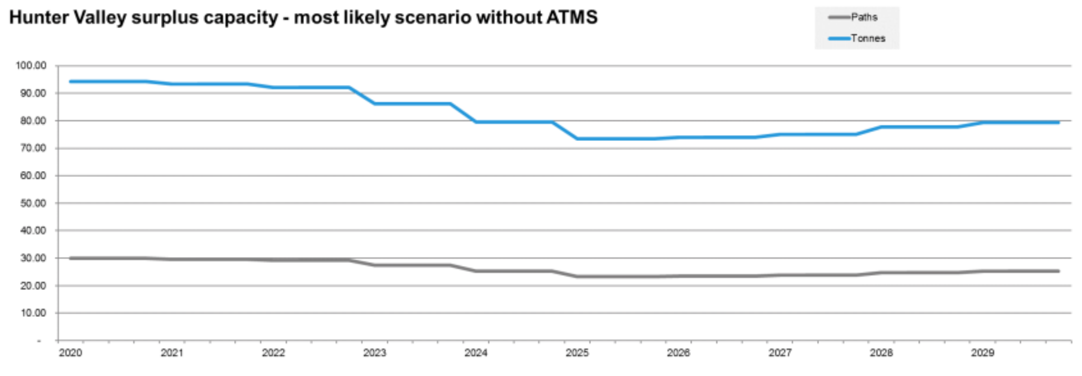


Figure 5-4 - Saleable surplus capacity for Zone 1 under the most likely volume and recommended projects scenario without ATMS terminals is leased by ARTC and all train operations are controlled by ARTC.

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 145 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.

Volume & Capacity

Forecast surplus capacity, in both paths and tonnes, under the most likely volume and infrastructure scenario with ATMS, is shown in Figure 5-3. A scenario without ATMS is shown in Figure 5-4. This is calculated as the surplus capacity on the most capacity constrained section, assuming a 10 per cent TMTC.

Volume and capacity by line sector using the calculation methodology set out in Chapter 1 is shown in figure 5-6. This chart shows both contracted and prospective volumes for the proposed infrastructure scope including ATMS.

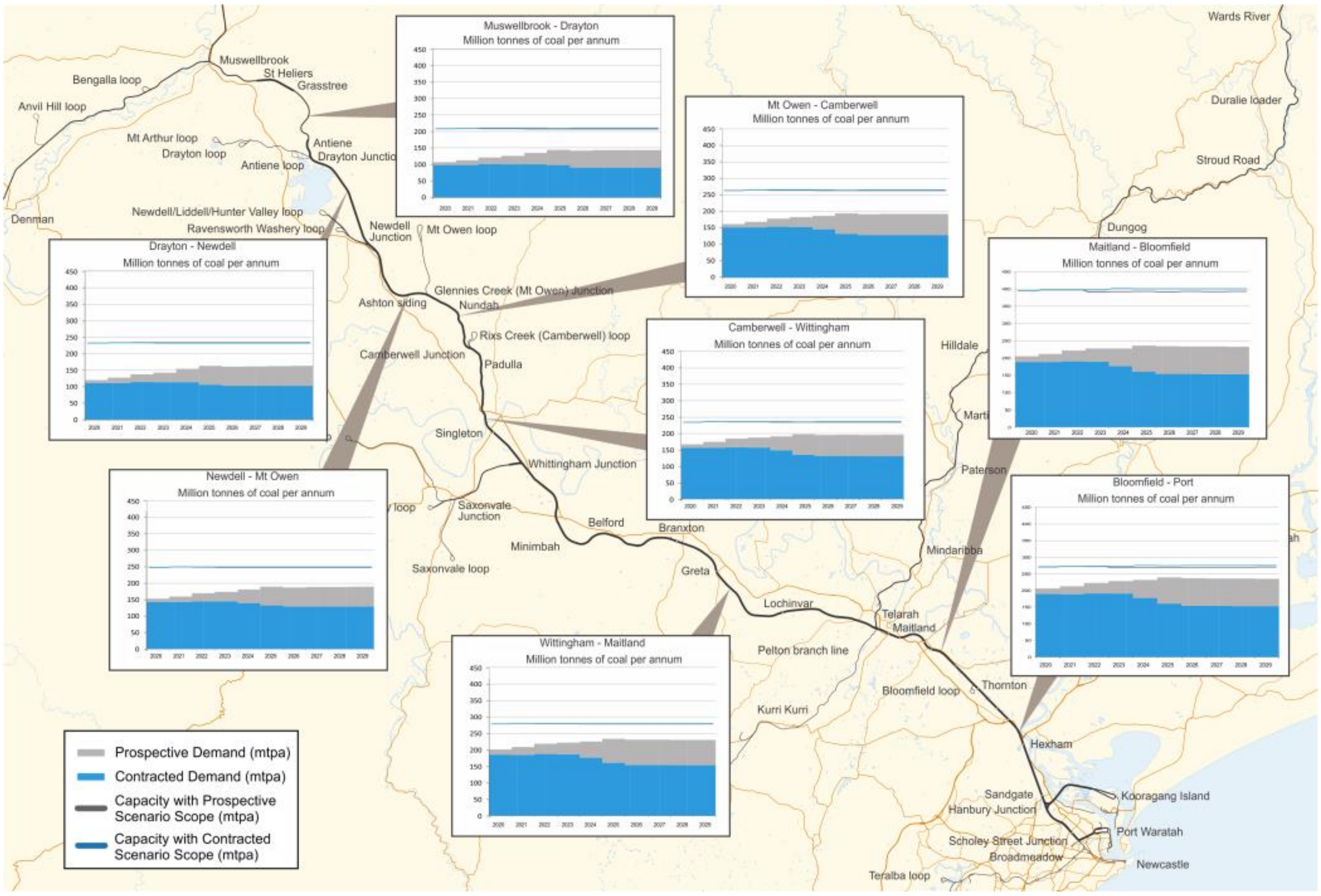


Figure 5-6 - Volume and capacity Muswellbrook—Newcastle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PROJECT INFORMATION

Context

Feedback on the 2017 Strategy suggested that it would be helpful for the Strategy to provide additional detail on the projects that are proposed to achieve the capacity outcomes. This section aims to provide that additional detail, though some of the projects required in later years of the prospective scenario are not covered.

ATMS and ANCO are discussed in detail in Chapter 2.

Mount Pleasant Loop

Phase 1 of the proposed Mt Pleasant project was endorsed by the ARTC's internal project steering group, the Operational Steering Committee (OSC), in July 2013. Due to the length required for the originally proposed western extension to the Bengalla Loop (approx. 4km) and the associated costs to construct this option a mid-section loop is proposed to increase the capacity of the Bengalla to Mangoola section of the Ulan Line.

The Phase 1 Concept Assessment considered five different options for the Bengalla to Mangoola section including combinations of extensions of both existing loops and the recommended mid-section stand-alone loop. The recommended option involves the construction of a stand-alone loop between 299.100km to 301.270km (2.170km long).

The proposed loop will include simultaneous entry signalling functionality, involve eight culvert extensions and future phases will confirm if the two existing level crossings need to be upgraded or relocated to allow for the loop construction/operation. The recommendation to commence Phase 2 works on the project was not submitted to the RCG due to the project being placed on hold.

Further assessment in the early stages of Phase 2 is required to determine the impact of currently identified risks related to ground conditions, environmental approvals, site access for construction, potential noise impacts to adjacent residents, level crossing upgrades and services relocations.

Current status	Phase 1 completed August 2013
Time to complete	30 months
Cost estimate (unescalated)	$33 m
Cost estimate basis	As at end of Phase 1

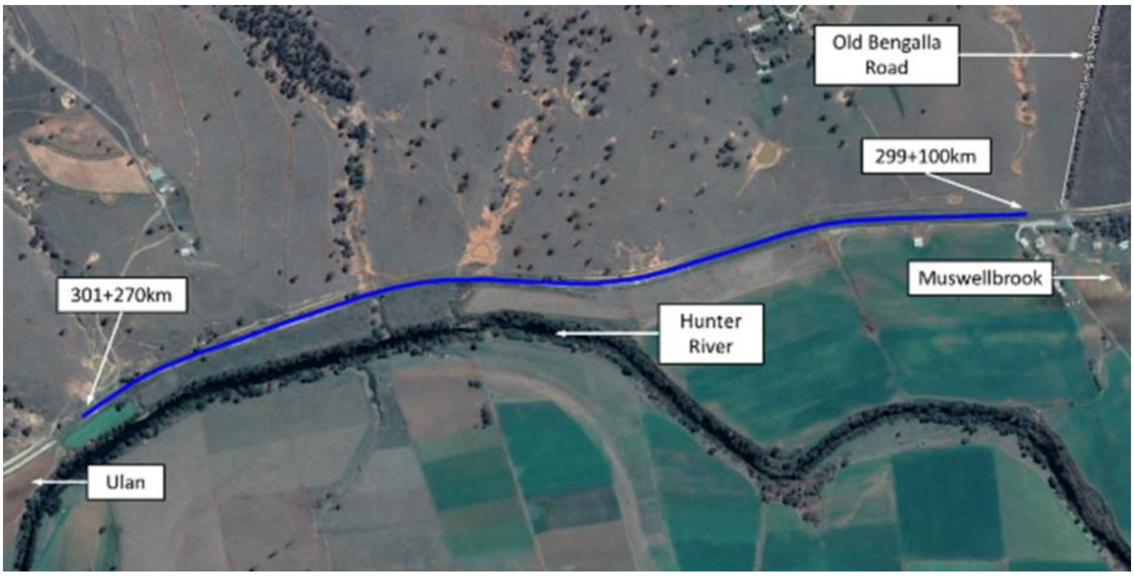

Figure 6-1 - Proposed Mt Pleasant loop

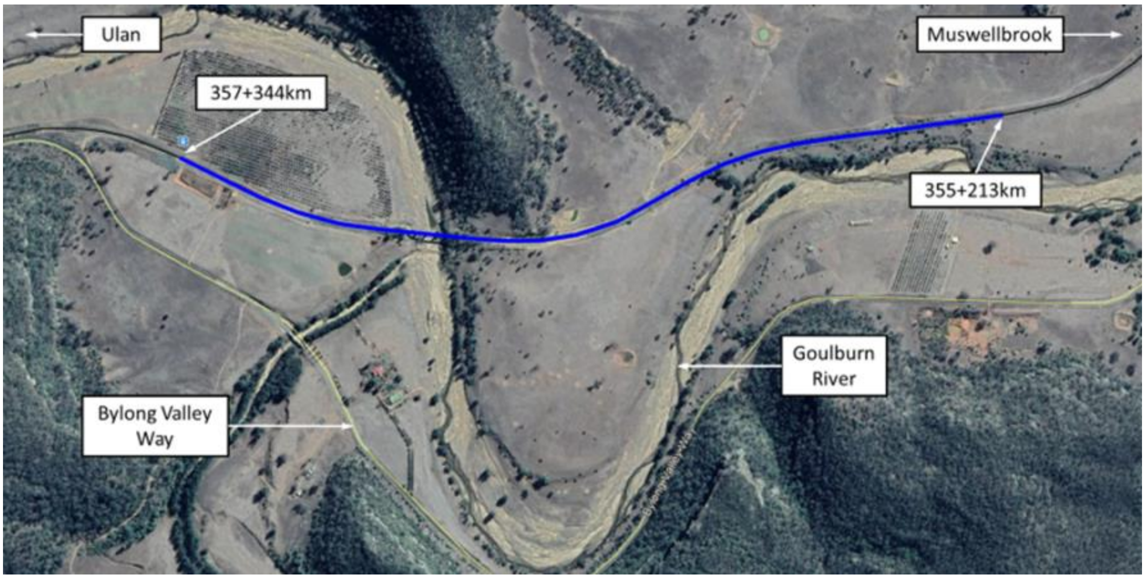

Figure 6-2 - Proposed Widden Creek loop

Widden Creek Loop

Phase 1 of the proposed Widden Creek Crossing Loop was endorsed by OSC on 17 February 2012. The detailed analysis of the options investigated are discussed in the Baerami to Kerrabee (353km Loop) Preliminary Options Report (June 2011) and subsequent Baerami to Kerrabee (353km Loop) Supplementary Options Report (Jan 2012).

The Concept Assessment Report, endorsed by RCG in April 2014, recommended a simultaneous entry crossing loop between 355.190km – 357.335km (2.145 km long). Options to extend either Baerami or Kerrabee loops were considered due to the difficult geography of the section. However, a mid-point loop at Widden Creek was determined to be the least cost option to achieve the capacity objective.

Following endorsement by the RCG for Phase 3 to commence in March 2019 the detailed design and environmental approval work was split into two discrete tenders and contracts for delivery. The detailed designs are currently progressing well whilst issues around the new bridge and two large culverts present challenges for the civil design. Work has also been undertaken to allow the new track to become the mainline which involves additional track slews to incorporate the turnouts on a slightly altered design alignment. The field studies are now underway with a significant portion of this work attributed to Aboriginal Heritage. Site access constraints continue to be a risk for the construction phase with the Track & Civil designer developing a concept for a temporary river crossing that is proposed to be used during construction. Environmental field work to inform the Environmental Approval for the project has experienced some delays due to private property access negotiations.

The proposed loop includes a major bridge across the Goulburn River at 356.619km. The option of building a new bridge wide enough for one track with a maintenance access road has been adopted which will alleviate the lack of access to the city end of the loop following construction.

Current status	Phase 2 completed September 2013
Time to complete	26 months
Cost estimate (unescalated)	$46 m
Cost estimate basis	As at end of Phase 2

Murrumbo West Loop Extension

Phase 1 of the proposed Murrumbo West Loop Extension project was completed in June 2011. The location of the Bylong tunnel precludes the construction of a mid-section loop to increase the capacity of the Murrumbo to Bylong section of the Ulan line. This meant that the considered options for increasing capacity of this section included differing extensions of the end of section loops.

The Phase 1 Concept Assessment considered the loop extensions of both Murrumbo and Bylong and due to the ruling grade of 1:80 on the country side of Bylong Tunnel, and the related additional earthworks costs required to alleviate this grade, the extension of Murrumbo was recommended. The recommended option includes an extension of the existing Murrumbo loop from 371.090km to 374.397km (3.307km long) providing a total loop length of 5.277km.

The proposed loop extension retains simultaneous entry signalling functionality, includes the upgrade of three level crossings, requires the extension of 32 culverts and involves extensive earthworks with retaining structures required to stabilise the existing cutting slopes. Whilst the commencement of Phase 2 works on the project was approved the project was

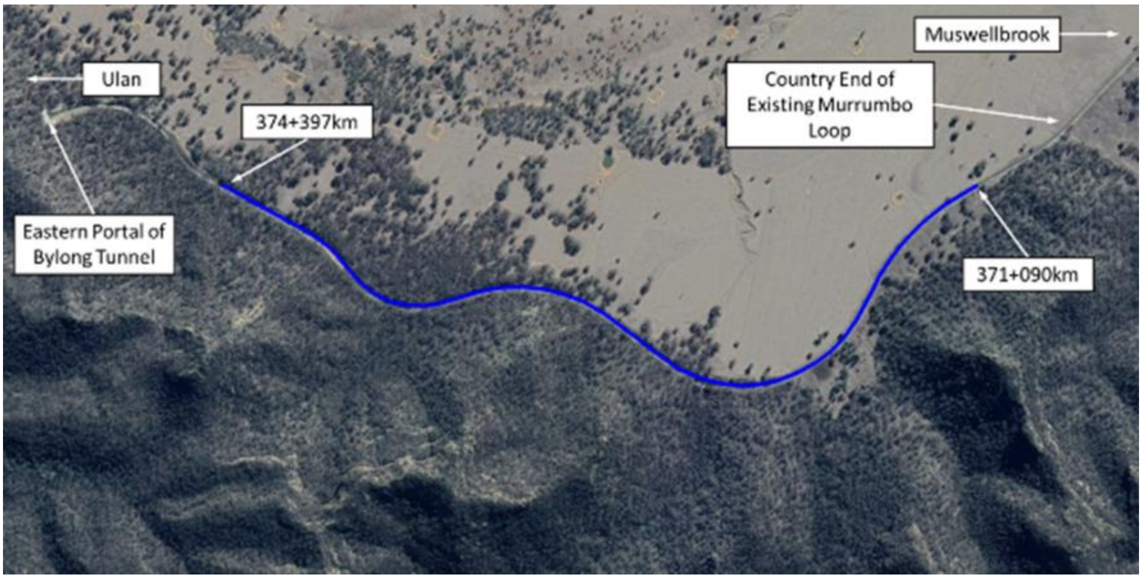

Figure 6-3 - Proposed Murrumbo West loop extension

subsequently placed on hold prior to the completion of any substantial works on this phase.

The main benefits of the proposed option are that it provides greater operational flexibility (with the ability to park two trains in the loop), no requirement to grade ease between Bylong Loop and the Tunnel and allows crossing of three trains within the section. The main risks to the planned project schedule are the environmental approval duration, the environmental constraints of the site (indigenous heritage, endangered species, flora & fauna etc) and the required land acquisition. Further work would be completed in the early stages of Phase 2 to develop mitigation measures for these risks.

Current status	Phase 1 completed June 2011
Time to complete	28 months
Cost estimate (unescalated)	$48 m
Cost estimate basis	As at end of Phase 1

Aberdeen Loop Extension

Phase 1 of the proposed Aberdeen Loop Extension was endorsed by the OSC in November 2012. Three different options were identified and investigated between Koolbury and Togar during Phase 1 of the Aberdeen Loop Extension project.

The completed Concept Assessment recommends an extension of the existing Aberdeen loop towards Koolbury (or Muswellbrook). The concept assessment included a number of investigations including operational modelling, desktop property acquisition investigation, utility searches, geotechnical desktop assessment and environmental desk top searches.

The proposed loop extension alignment requires land acquisition on the Eastern side of the existing corridor and is located between 299.335km and 300.100km (0.765km long). The project was submitted to the RCG in February 2013 with a recommendation to place the

Figure 6-4 - Proposed Aberdeen loop

project on hold as Phase 2 didn't need to start (based on the then capacity demand forecasts) until August 2015.

The minimisation of property acquisition through the introduction of retaining walls and by modifying the proposed access road has been identified as an opportunity for further investigation in future phases.

Current status	Phase 1 completed January 2013
Time to complete	26 months
Cost estimate (unescalated)	$13 m
Cost estimate basis	As at end of Phase 1

Togar North Loop

Phase 1 of the proposed Togar North Loop was endorsed by the OSC on 10 December 2012. Seven options comprising both stand alone loops and loop extensions between Togar and Parkville were investigated during Phase 1 of the Togar North Loop project (311km Loop).

The Concept Assessment Report, endorsed by the RCG in January 2014, recommended a stand alone loop between Togar and Scone that is located as close to Scone as practical. The other considered options were discounted due to site constraints such as level crossings and the increased length of new track required for the alternate options. The stand alone loop at Togar North was determined to be the least cost option to achieve the capacity objective.

Phase 2 of the project was endorsed by the RCG in October 2014 proposing a standalone loop location on the Up side with modified simultaneous entry signalling between 310.345km and 311.957km (1.612km long). Phase 3 works on the project were placed on hold in early 2015.

The proposed loop can be constructed within the current rail corridor land (though leasing will be required for construction). The earthworks includes lime stabilisation to reduce the amount of material that needs to be removed from site while several culverts and minor underbridges require replacement and extensions during the loop construction.

Current status	Phase 2 completed October 2014
Time to complete	29 months
Cost estimate (unescalated)	$23 m
Cost estimate basis	As at end of Phase 2

Wingen Loop

The Parkville to Murulla section of the main north line was initially nominated for duplication. However following further analysis a mid-section loop was determined to be the preferred solution to increasing network capacity in this area.

A Phase 1 Concept Assessment was subsequently undertaken in 2013 which assessed a total of four options. The recommended option from this phase consisted of a stand-alone loop between 325.680km and 327.240km.

The feasibility study for the proposed loop was subsequently completed in 2014. A minor change was proposed to the Phase 1 arrangement with the recommended configuration comprising a standalone loop located on the Down side without simultaneous entry between 325.666km and 327.240km (1.574km long). This option was approved by relevant stakeholders including the RCG for progression into Phase 3 in 2014.

The loop will be constructed on the down side of the existing single line and while the completed concept

Figure 6-5 - Proposed Togar North loop

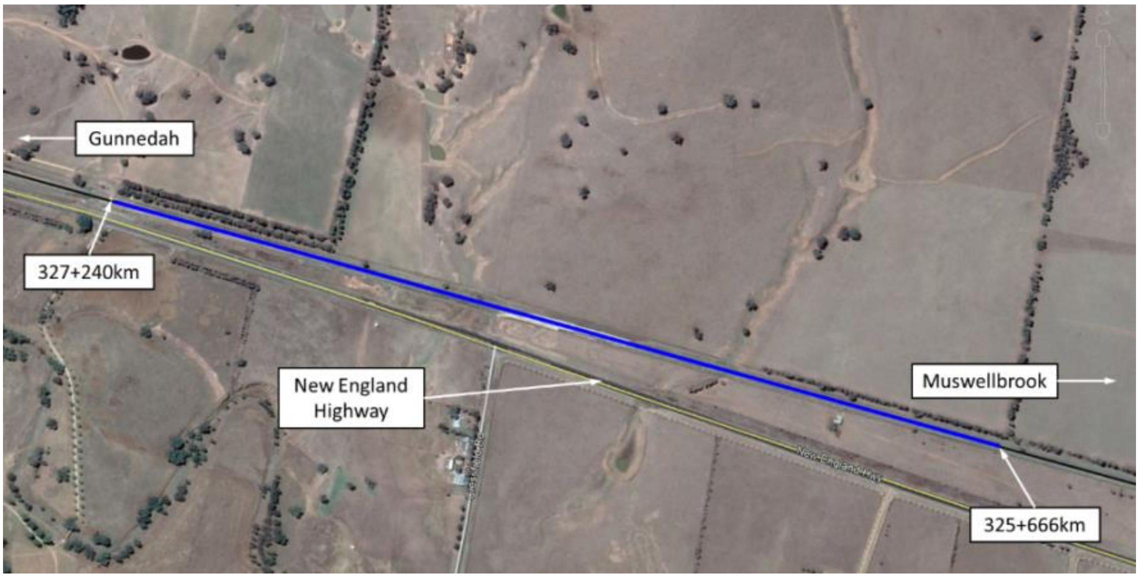

Figure 6-6- Proposed Wingen loop

design does include minor encroachments on adjacent land it is planned for these to be battered into the adjacent land and the existing corridor boundary retained. As typical for the area the majority of the site is located on highly reactive clays that are not considered suitable for re-use. However, further testing will be carried out in the next phase to determine if lime stabilisation can be used to reduce the required earthworks. An existing passive level crossing located to the north of the loop needs to be upgraded to active protection with F-Type lights and bells as the position of the loop will impact on the existing level crossing sighting distance.

It is noted that a more central option was previously discounted based on the recommended option providing the then required forecast section capacity at a reduced cost. The alternative option is still available for development if the additional capacity offered in this section is required (43.9mtpa vs 34.9mtpa) at an additional cost of approximately $10 m.

Current status	Phase 2 completed September 2014
Time to complete	30 months
Cost estimate (unescalated)	$20 m
Cost estimate basis	As at end of Phase 2

Blandford Loop

Phase 1 of the proposed Blandford Loop was endorsed by the OSC on 17 December 2012. Seventeen initial options were narrowed to eight comprising stand alone loops, passing lanes and loop extensions between Murulla and Pages River during Phase 1 of the Blandford Loop project.

The completed Concept Assessment recommends a stand alone loop constructed on the Up side of the existing track between Murulla and Murrurundi. The assessment included a number of investigations including utility searches, geotechnical desktop assessment and environmental desk top searches. The limits of work for the proposed loop were identified and a signalling arrangement plan was prepared, however no track and civil designs have yet been developed for the project.

The proposed standalone loop includes allowance for simultaneous entry signalling and is located between 346.350km and 348.300km (1.950km long). The recommendation to commence Phase 2 works on the project was not submitted to the RCG due to the project being placed on hold.

The proposed loop position has been recommended based on it minimising the constraints imposed by the adjacent Blandford level crossing, the large cuttings in this area, and to minimise the impacts on the nearby residents of Blandford.

Current status	Phase 1 completed September 2012
Time to complete	39 months
Cost estimate (unescalated)	$38 m
Cost estimate basis	As at end of Phase 1

Pages River North Loop Extension

Phase 2 of the proposed Pages River North Loop Extension was completed as a part of the Liverpool Range Duplication project development in March 2013. The Pages River North Loop Extension was detailed within the completed UHVA Project Feasibility design dated April 2012.

The Project Feasibility Report for the Liverpool Range Duplication project, presented to the RCG in March 2013, recommended a staged approach to the implementation of the duplication to enable capacity increases to be introduced as demand required. The

Figure 6-7- Proposed Blandford loop

Pages River North loop extension was designated Stage A of the then planned duplication.

Phase 2 of the project proposes a Northern extension of the existing Pages River loop on the Up side between 355.835km and 356.895km (1.060km long).

The proposed loop extension can be constructed within the existing rail corridor (though leasing will be required for construction access). The works include the requirement to extend/modify 3 existing undertrack culverts and a new turnout at the country end of the loop extension. These works are sufficient for the most likely volume scenario with ATMS.

Phase 3 works on the project were not endorsed to commence due to changing capacity demand. However, if the prospective volume scenario or the most likely volume scenario without ATMS is realised then the Phase 3 works, which includes extension to the Ardglen tunnel at approximately 360km, will be required and that scope has been assumed in this Strategy.

Current status	Phase 2 completed March 2013
Time to complete	32 months
Cost estimate (unescalated)	$91 m
Cost estimate basis	Includes Phase 3 works

Ardglen to Kankool Duplication

The Ardglen to Kankool section of the Main North line was nominated for duplication (designated Stage D) as part of the work completed in investigating the increase to the capacity of the Liverpool Range section of the network.

A Phase 1 Concept Assessment for the Liverpool Range Duplication project was completed in December 2010 identifying an outline for a staged design and construction of the option to duplicate the existing alignment based on the then modelled capacity requirements.

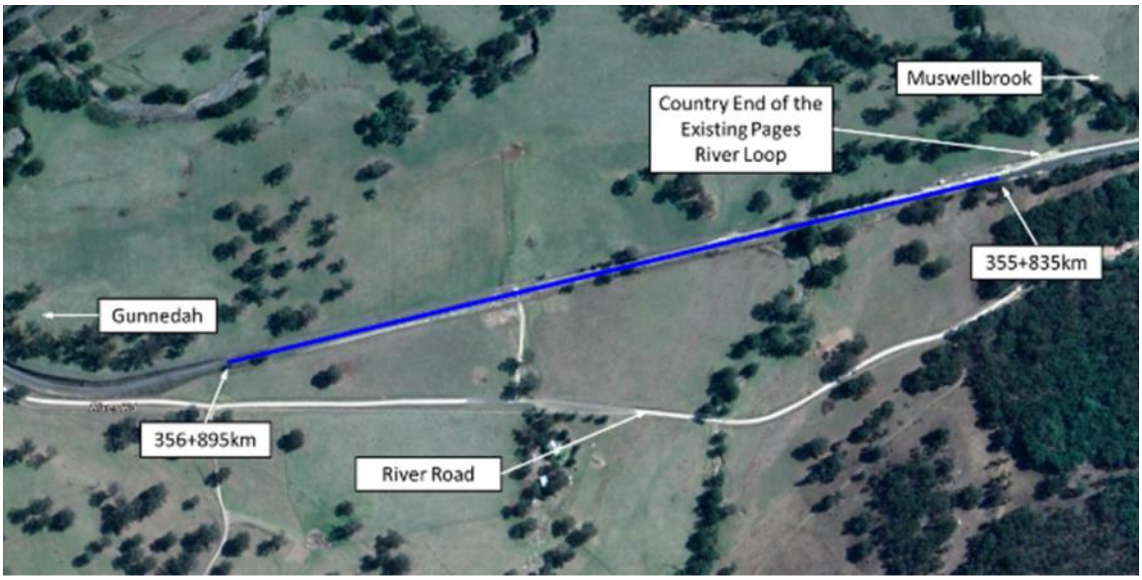

Figure 6-8- Proposed Pages River North loop extension

Figure 6-9- Proposed Ardglen to Kankool duplication

The existing Pages River and Chilcotts Creek loops were subsequently delivered in this area and the Liverpool Ranges Duplication project then focussed on the constrained section between these two new loops.

The Liverpool Range Duplication project feasibility study was subsequently completed in March 2013. The Ardglen to Kankool Duplication was detailed within the completed UHVA Project Feasibility design dated April 2012.

Phase 2 of the project proposes a duplication of the existing single track Main North between Ardglen and Kankool on the Up side between 364.600km and 368.786km (4.386km long). The Phase 2 Feasibility Report was submitted to the RCG for progression to Phase 3 in March 2013; however, the next phase of the works on the project were not endorsed to progress at that time.

The duplicated track will be constructed on the up side and is planned to include the mild easing of curves on the existing alignment at several locations as well as extensive retaining structures to allow for the required earthworks to be completed between the high rock cuttings and the adjacent highway.

The environmental approval for this project will be via an Environmental Impact Statement that will represent a key component of the critical path for the project delivery programme.

Current status	Phase 2 completed March 2013
Time to complete	47 months
Cost estimate (unescalated)	$86 m
Cost estimate basis	As at end of Phase 2

Figure 6-10- Proposed Bells Gate South loop extension

Figure 6-11- Proposed Werris Creek North loop

Bells Gate South Loop Extension

Phase 1 of the proposed Bells Gate South Loop Extension project was endorsed by the OSC on 26 November 2012. Major constraints with the existing mid-section short Quirindi loop meant that extension of this loop to cater for the design train was deemed unfeasible at that time and options were therefore considered for increasing the capacity of the Braefield to Bells Gate section by extending either of the existing loops at the ends of this section or extending both.

The Phase 1 Concept Assessment considered four differing lengths for the Bells Gate South loop extension. The recommended option includes an extension of the existing Bells Gate loop from 398.290km to 394.800km (3.490km) providing a total loop length of 5.416km.

The proposed loop extension retains simultaneous entry signalling functionality, includes the upgrade of one level crossing to active protection, requires the relocation of 3km of the existing signal cable route and involves extensive earthworks within an area containing very low CBR soils. The recommendation to commence Phase 2 works on the project was not submitted to the RCG due to the project being placed on hold.

Further assessment, based on current forecast volumes, of the option to extend the northern end of the existing Quirindi loop would be included in the early stages of Phase 2 to confirm the most cost effective solution for progression through to the next phase.

Current status	Phase 1 completed January 2013
Time to complete	39 months
Cost estimate (unescalated)	$46 m
Cost estimate basis	As at end of Phase 1

Werris Creek North Loop

Phase 1 of the Werris Creek North Loop was endorsed by the OSC in February 2013 as part of a submission considering the three projects between Bells Gate and Burilda (Werris Creek Bypass, Werris Creek South & Werris Creek North). The detailed analysis of the options investigated are discussed in the Werris Creek Bypass, Bypass Extension South and Bypass Extension North Options Report (March 2013).

The Concept Assessment Report recommended a simultaneous entry crossing loop between 413.190km to 415.060km (1.870km long). Options to by-pass Werris Creek, extend the loops either side and build mid-section loops were considered to increase the capacity of the Bells Gate to Werris Creek to Burilda sections. The Werris Creek North Loop was one of the projects recommended to achieve the previously required capacity objective, along with the Werris Creek South Loop and the Burilda South Loop Extension.

The proposed Werris Creek North loop includes one culvert replacement, another culvert extension and a level crossing upgrade. The scope used as the basis for the delivery estimate included the assumption that approximately 25,000m3 of excess earthworks materials could be permanently stockpiled on site.

Current status	Phase 1 completed March 2013
Time to complete	31 months
Cost estimate (unescalated)	$30 m
Cost estimate basis	As at end of Phase 1

South Gunnedah Loop

An options assessment was undertaken in 2011 with three options investigated around the existing level crossings between 465.885km and 470.520km in the section between Gunnedah and Curlewis. The option

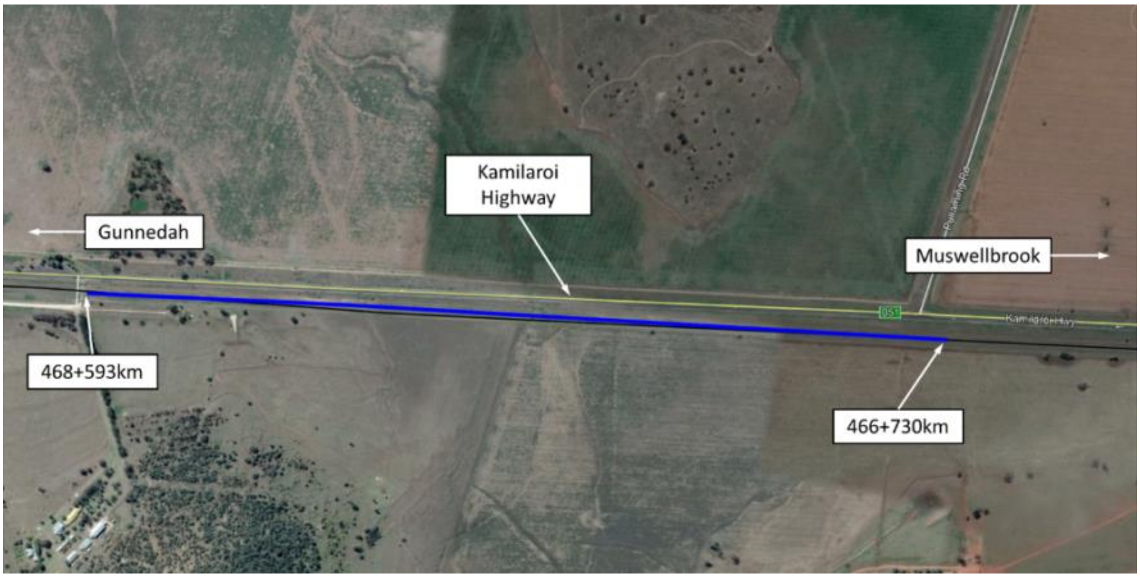

Figure 6-12- Proposed South Gunnedah loop

selected and approved by the relevant stakeholders including the RCG for progression to Phase 2 Feasibility consisted of a standalone loop between 467.066km and 468.615km.

The Phase 2 - Feasibility and subsequent Phase 3 – Project Assessments were completed during 2011 and 2012 with the investigation works including site surveys, identification of utilities, geotechnical investigations, hydraulic modelling of the local drainage, detailed designs, environmental approval and property negotiations.

During the project development the final loop configuration was confirmed as providing a simultaneous entry signalling system with the loop positioned between 466.730km and 468.593km (1.863km long).

The existing passively protected level crossing at 468.650km will be upgraded to active protection based on an assessment of the revised risk profile for this adjacent crossing.

As the Phase 3 scope was completed in 2012 a number of activities will need to be reviewed to ensure designs and assessments are appropriate and satisfy current standards and legislation prior to commencing construction. These activities include the following:

- Review and update track and civil designs
- Review and update designs associated with the RMS Works Authorisation Deed (WAD)
- Negotiate and execute a new WAD with RMS
- Review and update signalling designs
- Prepare an updated project REF and have this updated document approved
- Negotiate and arrange execution of private

Figure 6-13- Proposed Collygra loop

property lease for construction compound.

Current status	Phase 3 completed December 2012
Time to complete	24 months
Cost estimate (unescalated)	$25 m
Cost estimate basis	As at end of Phase 3

Collygra Loop

The Phase 1 Concept Assessment for the proposed Collygra Loop project was endorsed by the OSC in December 2012. Four options were considered during Phase 1 to increase the capacity of the section between Emerald Hill and Boggabri. The recommended option comprises a standalone loop between 504.780km and 506.700km (1.920km long) named the Collygra Loop.

The proposed loop will be located on the Up side of the existing mainline and has been located to minimise the impact on existing infrastructure with modifications required to a single existing underbridge. Provision for simultaneous entry signalling has been included within the concept signalling design.

The recommendation to commence Phase 2 works on the project was not submitted to the RCG due to the project being placed on hold.

Further assessment, in the early stages of Phase 2, will be required to determine access requirements via private property, treatments required to the local foundation materials due to the presence of high plasticity/highly reactive soils and the likely timeframes for the acquisition of land required to deliver this project. These investigations may lead to the adjustment of the loop position as a part of these early Phase 2 works.

Current status	Phase 1 completed December 2012
Time to complete	36 months
Cost estimate (unescalated)	$23 m
Cost estimate basis	As at end of Phase 1

7

MAINTENANCE STRATEGY

Context

In this section ARTC aims to provide high level insight into the asset management initiatives aimed at improving the customer value proposition of the existing asset along with a summary of the asset management framework and work programs. It reflects ARTC's major focus on long-term asset reliability improvement.

Changes from Previous Year

This year's maintenance plan takes a more holistic Asset Management approach but still covers the key maintenance matters in previous strategies including an outline of the scope of maintenance works and forecasts of the cost of the maintenance program.

Customer Focus

ARTC's primary focus is to place the customer at the heart of everything we do. Asset Management strategies, processes and practices are central to carrying this focus into our approach and priorities for achieving the best customer outcomes.

Through the execution of divisional plans we aim to increase the availability, reliability and integrity of our rail asset. This is done by focusing our asset strategy in critical areas to deliver a quality service that meets both the current and future needs of our customers.

ARTC's asset management strategy focuses on five key pillars, each important to the continual optimising of our service capabilities:

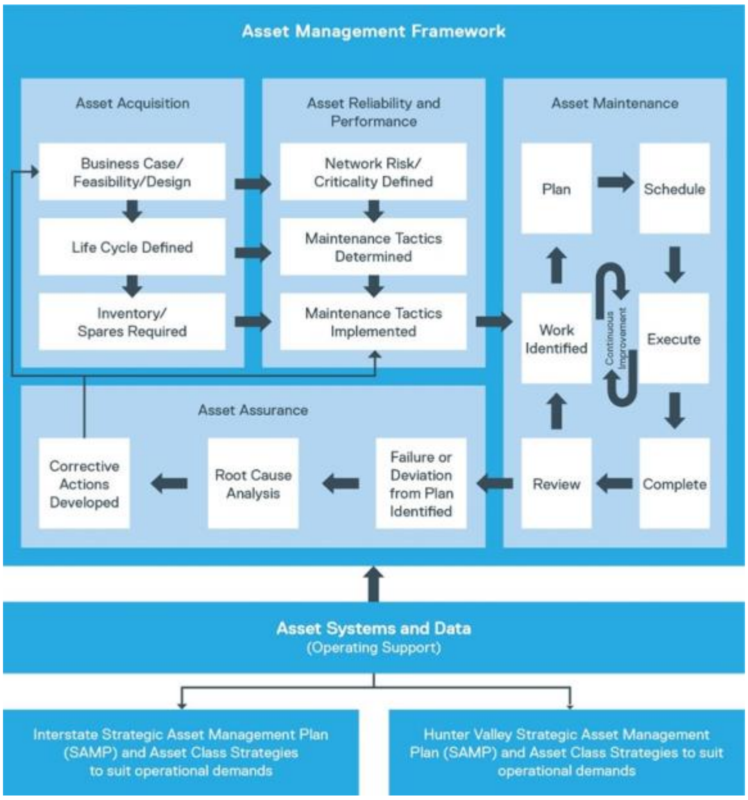

Figure 7-1 - Maintenance Development Process

The five key pillars are:

- Systems and Processes
- People, Capability and Knowledge
- Data Quality and Governance
- Risk and Condition
- Innovation

Each of these Key pillars will pursue the development, implementation and embedment of attitudes and processes that enable us to exceed our customers' needs by delivering operational excellence.

Asset Management Framework

The development of the Hunter Valley Asset Maintenance program involves a detailed process using a number of 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 7-1 outlines the basis of the process.

ARTC continues its work on testing the prudence and efficiency of the maintenance spend. The HV framework principle is to manage ARTC assets based on a 'Risk & Condition' approach moving away from 'Time and Tonnes' approach where appropriate.

Asset Management Focused Initiatives

ARTC have already committed to the delivery of various projects aimed at increasing the understanding of condition and risk to the network, including:

Provision of a sophisticated asset management framework, via the Asset Management Improvement Project (AMIP), to increase operational efficiency and deliver value through improved asset assurance functions, resource optimisation and condition management of rail assets.

Use of new and improved asset condition monitoring platforms and analysis methods to further sharpen response to developing network conditions, delivering ARTC's customer requirements in increasingly efficient ways (For example: new AK Car Vista Geometry System (VGS), updated Speno processes and Instrumented Coal Wagon (ICW) monitoring).

Optimisation of customer outcomes by working within industry safety regulations to challenge time based maintenance and adopt a Risk and Condition approach.

Introduction of Digital Mapping (LiDAR) and Ground Penetrating Radar Surveys (GPR) to replace hazardous or difficult inspection activities.

Adoption of GIS systems to better visualise underlying condition of our asset.

Introduction of a Decision Support Platform (DSP) to rationalise the many models and data sources on the asset into a single analysis system, thereby enabling efficient, reliable and robust decision making.

These initiatives are at various stages of progress from the established use or ICW and GPR to the staged implementation of AMIP, LiDAR, GIS and DSP. Figure 7-2 provides an overview of the development ARTC's monitoring and data systems.

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 Sustaining Capital (CAP). The RCRM and MPM programs are considered an operating expense (OPEX) 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).

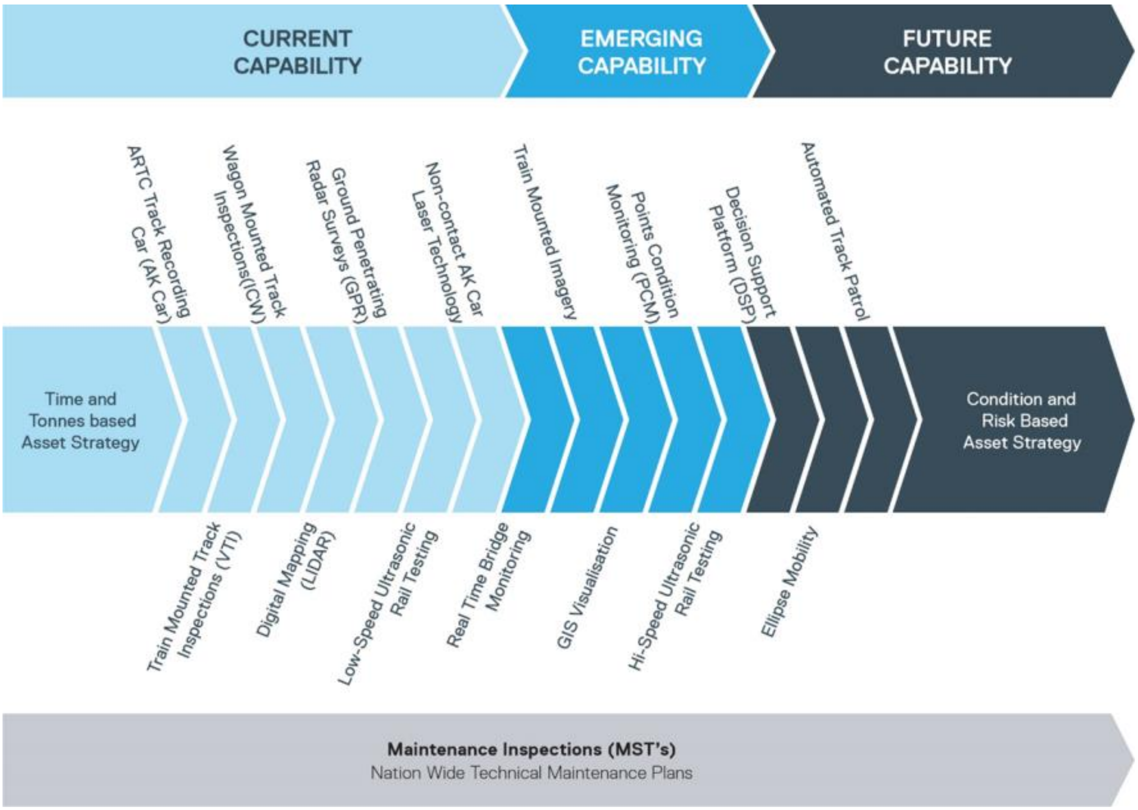

Figure 7-2 - Asset Monitoring Capability

The tonnage profile adopted for the purpose of the FY21 maintenance plans is an increase on the 2019 Strategy. Looking forward, the spend profile may need to change to reflect changes in demand, timing of capacity enabling projects and also asset condition considerations.

The current forecast program of works for both MPM and Capital is presented in the following sections. The charts 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 charts 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.

Sustaining Capital Program

The current forecast of the five-year sustaining capital program for all Pricing Zones is shown in Figure 7-3.

This historical spend profile includes the 30 tonne axle load program of works being delivered in Zone 3 which concluded at the end of 2017. The peak in future year spend is related to a critical bridge replacement programme based on risk and condition and also a significantly increase re-railing programme.

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 represent over 70% of the FY21 and FY22 capital works plan.

BRIDGE RENEWALS

Most structures on the coal network are of concrete construction. However, there are also steel structures and masonry structures 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.

Current projects of note include the replacement of three steel underbridges (Bridge Street, Muscle Creek and Hunter River) located near Muswellbrook on the Ulan Line. The multi-year program is due for completion in FY22.

RERAILING

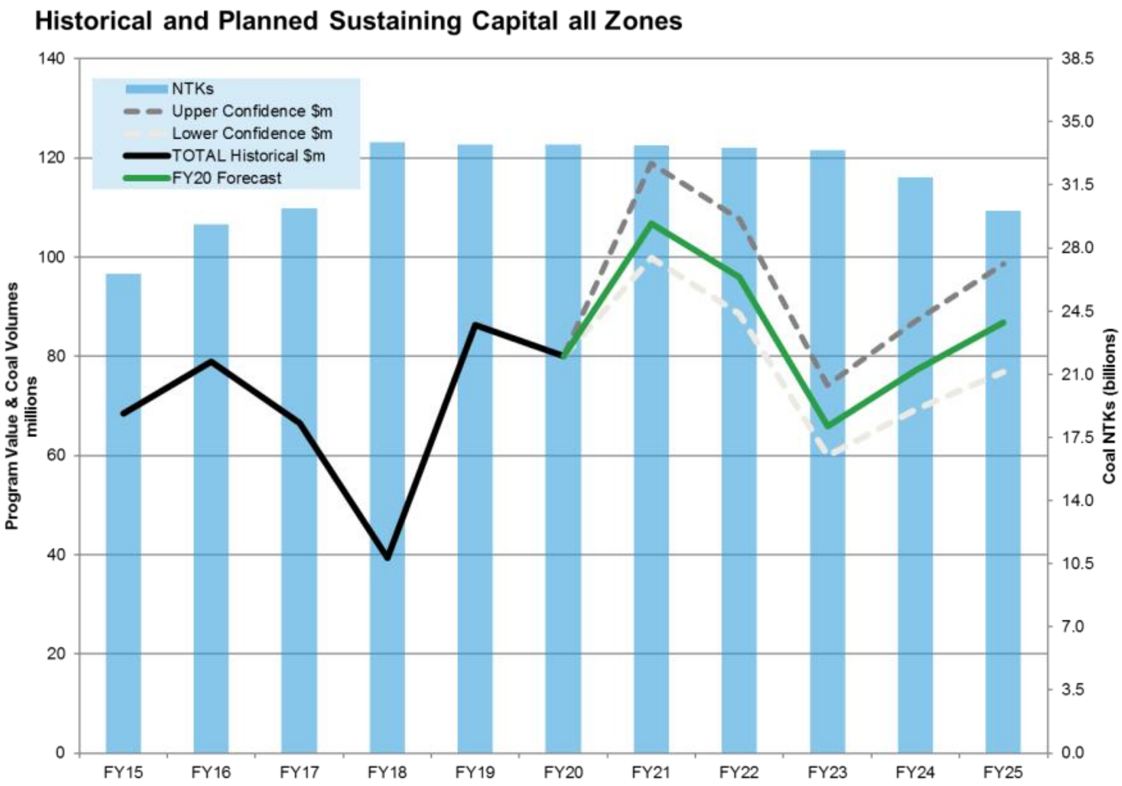

Figure 7-3 - Historical and Planned Corridor Capital

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. The scope of this activity is not steady from year to year and depends on the timing of asset wear. While there is an annual rerailing requirement there is a significant amount of rail requiring replacement during FY21 and FY22 in Pricing Zone 1 and 2.

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

Track strengthening is the reconstruction of the track formation (track bed) arising from formation failure and persistent track geometry issues. Track strengthening includes subgrade treatment, the installation of structural earthworks, a capping layer and new ballast, followed by track and drainage restoration. The purpose being to effectively manage the risk to rail operations from track geometry deterioration. Key drivers of this activity include track failure rates and type of failure; track performance; maintenance effectiveness intervals; and formation and subgrade configuration.

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.

Track strengthening works are predominant in the Lower Hunter around the Hexham Wetlands and in the Upper Hunter in the Black Soil country.

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 heavy haul operations 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.

OPEX Maintenance Program

The forecast spend profile of the OPEX program (RCRM and MPM combined) for all zones is shown in Figure 7-4.

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 70% of the annual OPEX spend in any given year.

RCRM

Routine Corrective Reactive Maintenance (RCRM) are scheduled activities used to inspect or service asset condition on a routine basis. RCRM extends to include reactive and corrective activities that are required as a result of inspections or defect identification that, because of their nature, are dealt with on the spot or as soon as is reasonably practical thereafter.

BALLAST CLEANING

Ballast cleaning is the mechanical excavation of deteriorated track ballast up to 500mm below the bottom of the sleeper across the entire track cross-section. The activity's purpose is to reinstate the function of the ballast as a free-draining medium that holds the track to its correct geometry under the passage of trains. Ballast cleaning is a cyclical maintenance activity across the network, with timing driven by condition and the cumulative tonnages over specific segments of track. It is a large component of the recurrent operating costs at an aggregate level, recognising that the activity will move through the zones across a number of years. The ballast cleaning activity is outsourced achieving approximately 30km per year.

BALLAST UNDERCUTTING

Ballast undercutting addresses localised defects on track sections (typically less than 100m in length), and involves a small crew using an excavator and cutter bar to remove a mud-hole and/or area of highly fouled ballast which impedes drainage. Ballast undercutting provides a lower cost and short-term solution to mud hole removal where the track condition does not require a full track reconditioning.

RAIL GRINDING

Rail grinding is the periodic grinding of rail to manage its profile and stress-related fatigue. Grinding improves wheel and rail interaction to reduce rail and wheel wear and rail defects. The frequency of rail grinding is dependent upon rail and traffic type, tonnages (in Million Gross Tonnes (MGT)) and track geometry. In determining the optimal rail grinding frequency a detailed analysis of rail

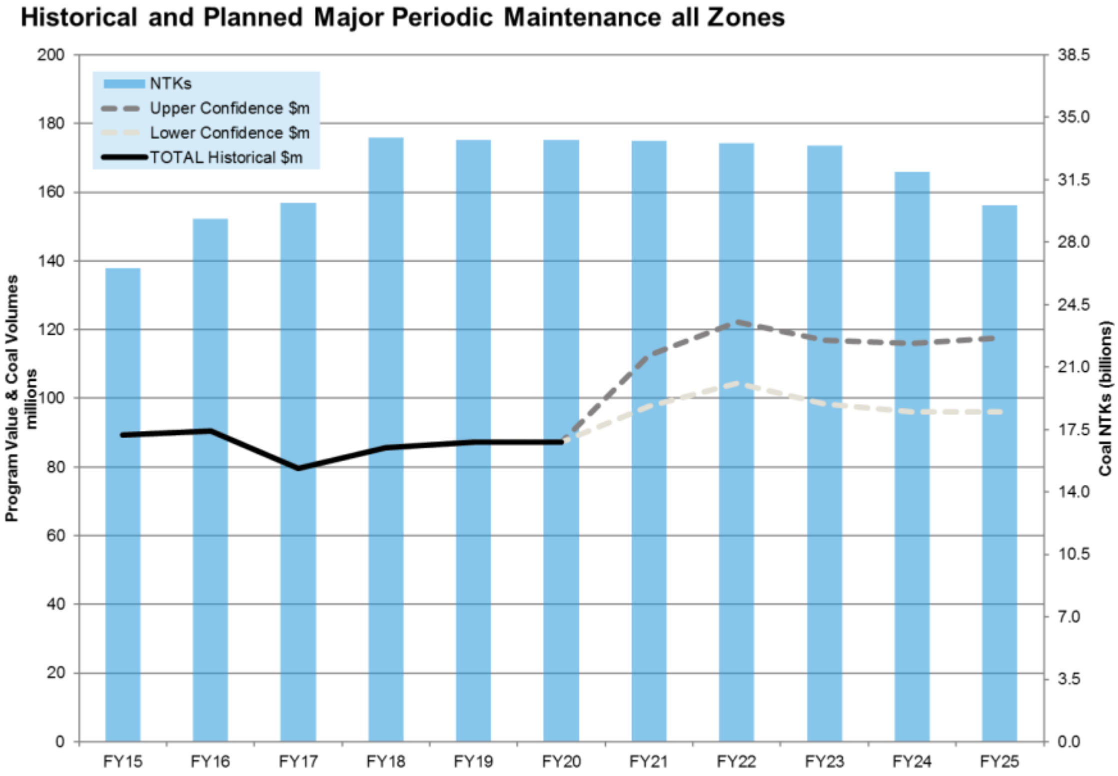

Figure 7-4 - Historical and Planned Major Periodic Maintenance

performance is undertaken to maximise rail life and minimise the development of rail defects.

TURNOUT GRINDING

Turnout grinding is the periodic grinding of turnouts to manage the wheel/rail interface and minimise whole of life costs. Turnout components interface closely with signalling assets and can cause low network reliability and high costs if in poor condition. In determining the optimal grinding frequency, a detailed assessment and review of turnout performance is undertaken annually for all turnouts. Frequency is determined by consideration of factors including tonnage, location and condition.

RESURFACING (TAMPING)

Track resurfacing (tamping) restores the track geometric parameters of top, line, superelevation and alignment by mechanised on-track machinery. Similar to ballast cleaning, the accumulated gross tonnage over the line segment determines the initial resurfacing scope. Frequency is also influenced by the environment, track structure and condition, train axle loads and speeds.

TURNOUT RESURFACING (TAMPING)

Turnout resurfacing (tamping) restores the geometric parameters of top, line, superelevation and alignment by mechanised on-track machinery. Turnouts are generally tamped on a cycle which are derived from tonnage and turnout performance, with factors such as poor drainage and turnout design also having an impact. Some turnouts have a high tamping requirement, for example three times a year for high traffic areas around Hexham, while other turnouts may only require a tamp every two years.

TURNOUT STEEL COMPONENT REPLACEMENT

Replacement of worn and defective turnout rail components reduces the risk of turnout rail component failure and derailment. Sites are identified by field staff based on a condition assessment. Data for the upcoming year is submitted showing individual turnout requirements. Turnout performance varies due to track formation, design issues, drainage and tonnage. The scope of this activity is not steady from year to year and depends on the timing of asset wear and the complexity of the location.

TURNOUT RESURFACING (TAMPING)

Steel bridge maintenance relates to a range of repair and maintenance activities designed to maintain the operation and safety of steel bridge structures. Steel bridge maintenance does not have a steady year on year spend rate as it is dependent on condition and scope specific to the site requiring work. These works can range from minor to significant projects.

8

RECOMMENDED PROJECTS AND NETWORK CAPACITY

Recommended Projects

This Chapter summarises the projects required under each of the volume scenarios and the outcomes in terms of saleable paths and saleable coal tonnage.

In general, 'required by' dates reflect the timing required to deliver capacity in advance of the demand as per a given volume scenario. As discussed elsewhere in this Strategy, and detailed in Chapter 6 for each project, there can be a considerable period between approval by the RCG for a project to proceed to the next delivery phase, and the earliest realistic time that it can be delivered. 'Proposed by' dates in this Chapter are the latter of the required by date and the earliest the project could be expected to be delivered as at the time of this Strategy.

Where a project could be delivered in a certain timeframe, but another project with a later feasible delivery date dictates the capacity limit, the 'Proposed by' date of the first project is assumed to be the same as the project required to enhance the capacity limiting section.

A summary of the recommended projects for contracted volumes comparing previous and new proposed delivery timeframes, together with estimated costs, is shown in Table 8-1.

Saleable coal path capacity and coal tonnage capacity by sector for the contracted volume scenario is shown in tables 8-2 and 8-3 respectively, for a no-ATMS pathway and in tables 8-4 and 8-5 respectively where ATMS is implemented.

Table 8-6 shows the same detail as Table 8-1, for the scope of work required for the most likely volume scenario. Note that while ATMS is recommended for contracted volumes for the safety and productivity benefits it provides, table 8-6 nonetheless shows both with and without ATMS pathways.

Saleable coal path capacity and coal tonnage capacity by sector for the most likely volume scenario is shown in tables 8-7 and 8-8 respectively for a no-ATMS pathway and tables 8-9 and 8-10 for a with-ATMS pathway.

Table 8-11 is equivalent to table 8-6 for the prospective volume scenario. Saleable coal train capacity and coal tonnage capacity by sector for this scenario is shown in tables 8-12 and 8-13 respectively for a no-ATMS pathway and tables 8-14 and 8-15 for a with-ATMS pathway.

Costs shown in the tables are unescalated, \$2019-20 orders of magnitude only. 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.

Note also that the projects in tables 8-6 and 8-11 assume ANCO and the coded track circuit upgrades.

Recommended projects - Contracted Volume	2019 Strategy – Proposed by	2020 Strategy – Required by	2020 Strategy – Proposed by	Estimated Cost ($m) un-escalated
Gunnedah Line				
Nil				
Ulan Line				
Widden Creek (or other sufficient project)	-	Q1 2022	Q1 2022	$46
Muswellbrook - Port				
Nil				
Productivity Projects				
ARTC Network Control Optimisation (ANCO) - Horizon 1				
Gunnedah basin line	Complete			$36
Ulan line	Complete			
Muswellbrook - Port	Q4 2019	-	Q3 2020	
Advanced Train Management System (ATMS) [1]				
Turrawan—Werris Creek	Q1 2023	-	Q4 2024	$21
Werris Creek—Koolbury	Q1 2023	-	Q1 2025	$22
Ulan—Mangoola	Q3 2023	-	Q2 2024	$26
Mangoola / Koolbury—Singleton	Q1 2024	-	Q2 2026	$30
Singleton—Maitland	Q1 2024	-	Q1 2029	$15
Maitland—Port	Q3 2024	-	Q4 2029	$35
Trainborne units (270) [2]	-	-	Progressive	$53
System, development and project management	-	-	Progressive	$80

Table 8-1 - 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 unless the project has proceeded, to Phase 5, delivery.

Note 1 - 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 2 - The assumed 270 trainbourne units comprises 220 for dedicated coal locomotives and 50 for passenger and non-coal locomotives.

	2019				2020				2021	2022	2023	2024	2025	2026	2027	2028	2029
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
Narrabri - Boggabri	4.0	4.0	4.2	5.0	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
Boggabri - Vickery	13.0	13.0	14.0	15.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
Vickery - Gunnedah	13.7	13.7	14.8	16.3	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.7	15.7	15.7	15.7
Gunnedah - Watermark Jct	8.8	8.8	9.4	10.5	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.3	10.3	10.3	10.3
Watermark Jct - Werris Creek	11.2	11.2	12.0	13.3	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1
Werris Creek - Scone	11.0	11.0	11.0	12.3	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Scone - Dartbrook	11.2	11.2	11.2	12.5	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.7	11.7	11.7	11.7
Dartbrook - Muswellbrook	27.3	27.3	27.3	29.9	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0
Ulan - Moolarben	8.8	8.8	9.2	10.1	10.0	10.0	10.0	10.0	10.0	10.1	10.1	10.0	10.0	10.1	10.1	10.1	10.1
Moolarben - Wilpinjong	8.8	8.8	9.2	10.1	10.0	10.0	10.0	10.0	10.0	10.1	10.1	10.0	10.0	10.1	10.1	10.1	10.1
Wilpinjong - Bylong	12.5	12.5	13.3	14.4	13.7	13.7	13.7	13.7	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8
Bylong - Ferndale	11.4	11.4	12.1	13.1	12.9	12.9	12.9	12.9	12.9	14.0	14.0	14.0	14.1	14.1	14.1	14.1	14.1
Ferndale - Mangoola	17.8	17.8	17.8	19.3	19.7	19.7	19.7	19.7	19.8	19.8	19.8	19.8	20.0	20.1	20.1	20.1	20.1
Mangoola - Mt Pleasant	21.8	21.8	24.2	26.1	26.9	26.9	26.9	26.9	27.0	27.0	27.0	27.0	26.9	27.0	27.0	27.0	27.0
Mt Pleasant - Bengalla	15.9	15.9	17.1	18.5	18.6	18.6	18.6	18.6	18.6	18.5	18.5	18.5	18.4	18.3	18.3	18.3	18.3
Bengalla - Muswellbrook	20.9	20.9	23.1	25.0	25.8	25.8	25.8	25.8	24.8	25.8	25.8	25.8	26.2	26.9	26.9	26.9	26.9
Muswellbrook -Drayton	70.0	70.0	70.0	70.0	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1
Drayton - Newdell	78.1	78.1	78.1	78.1	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4
Newdell - Mt Owen	82.8	82.8	82.8	82.8	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1
Mt Owen - Camberwell	87.9	87.9	87.9	87.9	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3
Camberwell - Whittingham	78.1	78.1	78.1	78.1	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4
Whittingham - Maitland	92.3	92.3	92.3	92.3	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8
Maitland - Bloomfield	132.4	132.4	132.4	132.4	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5
Bloomfield - Hexham	90.9	90.9	90.9	90.9	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3

Table 8-2 - Saleable capacity in coal train numbers (round-trips per day) assuming volumes and the recommended scope of work as per the contracted volume scenario without ATMS.

	2019				2020				2021	2022	2023	2024	2025	2026	2027	2028	2029
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
Narrabri - Boggabri	11.7	11.7	12.3	14.6	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
Boggabri - Vickery	37.8	37.8	40.7	44.9	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3
Vickery - Gunnedah	39.8	39.8	42.9	47.2	45.3	45.3	45.3	45.3	45.3	45.3	45.3	45.3	45.3	45.7	45.7	45.7	45.7
Gunnedah - Watermark Jct	25.6	25.6	27.3	30.4	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8
Watermark Jct - Werris Creek	32.6	32.6	34.9	38.7	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1
Werris Creek - Scone	32.0	32.0	32.0	35.6	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8
Scone - Dartbrook	32.5	32.5	32.5	36.3	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	33.9	33.9	33.9	33.9
Dartbrook - Muswellbrook	79.3	79.3	79.3	86.9	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.2	110.2	110.2	110.2
Ulan - Moolarben	28.3	28.3	29.5	32.5	32.0	32.0	32.0	32.0	33.3	33.4	33.4	33.3	33.4	33.5	33.5	33.5	33.5
Moolarben - Wilpinjong	28.5	28.5	29.8	32.7	32.3	32.3	32.3	32.3	33.0	33.1	33.0	33.0	33.0	33.1	33.1	33.1	33.1
Wilpinjong - Bylong	40.1	40.1	42.7	46.1	43.9	43.9	43.9	43.9	44.5	44.7	44.7	44.7	44.8	45.0	45.0	45.0	45.0
Bylong - Ferndale	36.5	36.5	38.7	41.8	41.5	41.5	41.5	41.5	41.9	45.5	45.5	45.5	45.6	45.8	45.8	45.8	45.8
Ferndale - Mangoola	56.9	56.9	56.9	61.7	63.3	63.3	63.3	63.3	64.0	64.2	64.2	64.2	64.8	65.4	65.4	65.4	65.4
Mangoola - Mt Pleasant	70.1	70.1	77.9	84.1	86.8	86.8	86.8	86.8	87.5	87.6	87.6	87.6	87.6	87.9	87.9	87.9	87.9
Mt Pleasant - Bengalla	51.2	51.2	55.0	59.6	59.8	59.8	59.8	59.8	60.2	60.1	60.1	60.1	59.8	59.7	59.7	59.7	59.7
Bengalla - Muswellbrook	67.2	67.2	74.4	80.3	83.1	83.1	83.1	83.1	80.1	83.5	83.5	83.6	84.9	87.2	87.2	87.2	87.2
Muswellbrook -Drayton	218.1	218.1	218.1	218.1	221.8	221.8	221.8	221.8	222.7	223.0	223.0	223.0	222.8	223.4	223.4	223.4	223.4
Drayton - Newdell	243.5	243.5	243.5	243.5	247.6	247.6	247.6	247.6	248.5	248.8	248.8	248.8	248.7	249.4	249.4	249.4	249.4
Newdell - Mt Owen	259.6	259.6	259.6	259.6	263.9	263.9	263.9	263.9	265.6	265.8	265.8	265.4	265.4	266.1	266.1	266.1	266.1
Mt Owen - Camberwell	276.3	276.3	276.3	276.3	281.1	281.1	281.1	281.1	282.8	283.0	283.0	282.4	281.8	282.5	282.5	282.5	282.5
Camberwell - Whittingham	246.0	246.0	246.0	246.0	250.3	250.3	250.3	250.3	251.7	251.9	251.9	251.3	250.8	251.4	251.4	251.3	251.3
Whittingham - Maitland	291.0	291.0	291.0	291.0	296.3	296.3	296.3	296.3	298.4	298.6	298.6	298.0	297.4	297.9	297.9	297.8	297.8
Maitland - Bloomfield	412.4	412.4	412.4	412.4	420.0	420.0	420.0	420.0	422.9	423.2	423.2	427.1	426.2	426.9	426.9	426.8	426.8
Bloomfield - Hexham	283.1	283.1	283.1	283.1	288.3	288.3	288.3	288.3	290.3	290.5	290.5	293.1	292.5	293.0	293.0	293.0	293.0

Table 8-3 - Saleable capacity in million tonnes assuming volumes and the recommended scope of work as per the contracted volume scenario without ATMS. This tonnage capacity is equal to table 8-2 times average train size times 365.

	2019				2020				2021	2022	2023	2024	2025	2026	2027	2028	2029
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
Narrabri - Boggabri	4.0	4.0	4.2	5.0	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	6.4	6.4	6.4	6.4	6.4
Boggabri - Vickery	13.0	13.0	14.0	15.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	19.6	19.6	19.6	19.6	19.6
Vickery - Gunnedah	13.7	13.7	14.8	16.3	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	20.7	20.9	20.9	20.9	20.9
Gunnedah - Watermark Jct	8.8	8.8	9.4	10.5	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	13.2	13.2	13.2	13.2	13.2
Watermark Jct - Werris Creek	11.2	11.2	12.0	13.3	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	17.1	17.1	17.1	17.1	17.1
Werris Creek - Scone	11.0	11.0	11.0	12.3	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	16.1	16.1	16.1	16.1	16.1
Scone - Dartbrook	11.2	11.2	11.2	12.5	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	15.5	15.4	15.4	15.4	15.4
Dartbrook - Muswellbrook	27.3	27.3	27.3	29.9	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	49.7	49.7	49.7	49.7	49.7
Ulan - Moolarben	8.8	8.8	9.2	10.1	10.0	10.0	10.0	10.0	10.0	10.1	10.1	12.0	12.0	12.1	12.1	12.1	12.1
Moolarben - Wilpinjong	8.8	8.8	9.2	10.1	10.0	10.0	10.0	10.0	10.0	10.1	10.1	12.0	12.0	12.1	12.1	12.1	12.1
Wilpinjong - Bylong	12.5	12.5	13.3	14.4	13.7	13.7	13.7	13.7	13.8	13.8	13.8	18.3	18.3	18.4	18.4	18.4	18.4
Bylong - Ferndale	11.4	11.4	12.1	13.1	12.9	12.9	12.9	12.9	12.9	14.0	14.0	18.4	18.4	18.5	18.5	18.5	18.5
Ferndale - Mangoola	17.8	17.8	17.8	19.3	19.7	19.7	19.7	19.7	19.8	19.8	19.8	25.0	25.2	25.4	25.4	25.4	25.4
Mangoola - Mt Pleasant	21.8	21.8	24.2	26.1	26.9	26.9	26.9	26.9	27.0	27.0	27.0	35.2	35.1	35.2	35.2	35.2	35.2
Mt Pleasant - Bengalla	15.9	15.9	17.1	18.5	18.6	18.6	18.6	18.6	18.6	18.5	18.5	22.9	22.8	22.7	22.7	22.7	22.7
Bengalla - Muswellbrook	20.9	20.9	23.1	25.0	25.8	25.8	25.8	25.8	24.8	25.8	25.8	33.3	33.9	34.9	34.9	34.9	34.9
Muswellbrook -Drayton	70.0	70.0	70.0	70.0	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	198.2
Drayton - Newdell	78.1	78.1	78.1	78.1	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	198.2
Newdell - Mt Owen	82.8	82.8	82.8	82.8	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	198.2
Mt Owen - Camberwell	87.9	87.9	87.9	87.9	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	198.2	198.2	198.2	198.2
Camberwell - Whittingham	78.1	78.1	78.1	78.1	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	198.2
Whittingham - Maitland	92.3	92.3	92.3	92.3	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	198.2	198.2	198.2	198.2
Maitland - Bloomfield	132.4	132.4	132.4	132.4	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	217.9
Bloomfield - Hexham	90.9	90.9	90.9	90.9	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	217.9

Table 8-4 - Saleable capacity in coal train numbers (round-trips per day) assuming volumes and the recommended scope of work as per the contracted volume scenario with ATMS.

	2019				2020				2021	2022	2023	2024	2025	2026	2027	2028	2029
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
Narrabri - Boggabri	11.7	11.7	12.3	14.6	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	18.7	18.7	18.7	18.7	18.7
Boggabri - Vickery	37.8	37.8	40.7	44.9	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	57.0	57.0	57.0	57.0	57.0
Vickery - Gunnedah	39.8	39.8	42.9	47.2	45.3	45.3	45.3	45.3	45.3	45.3	45.3	45.3	60.2	60.6	60.6	60.6	60.6
Gunnedah - Watermark Jct	25.6	25.6	27.3	30.4	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	38.2	38.2	38.2	38.2	38.2
Watermark Jct - Werris Creek	32.6	32.6	34.9	38.7	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1	49.6	49.6	49.6	49.6	49.6
Werris Creek - Scone	32.0	32.0	32.0	35.6	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	46.9	46.9	46.9	46.9	46.9
Scone - Dartbrook	32.5	32.5	32.5	36.3	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	45.0	44.7	44.7	44.7	44.7
Dartbrook - Muswellbrook	79.3	79.3	79.3	86.9	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.3	144.3	144.2	144.2	144.2	144.2
Ulan - Moolarben	28.3	28.3	29.5	32.5	32.0	32.0	32.0	32.0	33.3	33.4	33.4	39.9	40.0	40.2	40.2	40.2	40.2
Moolarben - Wilpinjong	28.5	28.5	29.8	32.7	32.3	32.3	32.3	32.3	33.0	33.1	33.0	39.5	39.6	39.8	39.8	39.8	39.8
Wilpinjong - Bylong	40.1	40.1	42.7	46.1	43.9	43.9	43.9	43.9	44.5	44.7	44.7	59.2	59.4	59.7	59.7	59.7	59.7
Bylong - Ferndale	36.5	36.5	38.7	41.8	41.5	41.5	41.5	41.5	41.9	45.5	45.5	59.6	59.7	60.0	60.0	60.0	60.0
Ferndale - Mangoola	56.9	56.9	56.9	61.7	63.3	63.3	63.3	63.3	64.0	64.2	64.2	81.1	81.9	82.6	82.6	82.6	82.6
Mangoola - Mt Pleasant	70.1	70.1	77.9	84.1	86.8	86.8	86.8	86.8	87.5	87.6	87.6	114.3	114.2	114.7	114.7	114.7	114.7
Mt Pleasant - Bengalla	51.2	51.2	55.0	59.6	59.8	59.8	59.8	59.8	60.2	60.1	60.1	74.4	74.1	74.0	74.0	74.0	74.0
Bengalla - Muswellbrook	67.2	67.2	74.4	80.3	83.1	83.1	83.1	83.1	80.1	83.5	83.5	107.9	109.9	113.3	113.3	113.3	113.3
Muswellbrook -Drayton	218.1	218.1	218.1	218.1	221.8	221.8	221.8	221.8	222.7	223.0	223.0	223.0	222.8	223.4	223.4	223.4	622.8
Drayton - Newdell	243.5	243.5	243.5	243.5	247.6	247.6	247.6	247.6	248.5	248.8	248.8	248.8	248.7	249.4	249.4	249.4	622.7
Newdell - Mt Owen	259.6	259.6	259.6	259.6	263.9	263.9	263.9	263.9	265.6	265.8	265.8	265.4	265.4	266.1	266.1	266.1	627.2
Mt Owen - Camberwell	276.3	276.3	276.3	276.3	281.1	281.1	281.1	281.1	282.8	283.0	283.0	282.4	281.8	627.2	627.2	627.2	627.2
Camberwell - Whittingham	246.0	246.0	246.0	246.0	250.3	250.3	250.3	250.3	251.7	251.9	251.9	251.3	250.8	251.4	251.4	251.3	627.5
Whittingham - Maitland	291.0	291.0	291.0	291.0	296.3	296.3	296.3	296.3	298.4	298.6	298.6	298.0	297.4	629.4	629.4	629.2	629.2
Maitland - Bloomfield	412.4	412.4	412.4	412.4	420.0	420.0	420.0	420.0	422.9	423.2	423.2	427.1	426.2	426.9	426.9	426.8	691.4
Bloomfield - Hexham	283.1	283.1	283.1	283.1	288.3	288.3	288.3	288.3	290.3	290.5	290.5	293.1	292.5	293.0	293.0	293.0	691.4

Table 8-5 - Saleable capacity in million tonnes assuming volumes and the recommended scope of work as per the contracted volume scenario with ATMS. This tonnage capacity is equal to table 8-4 times average train size times 365.

Recommended projects - Most Likely Volume Scenario	2019 Strategy – Proposed by (Without ATMS)	2020 Strategy – Required by (Note 1)	2020 Strategy – Proposed by without ATMS	2020 Strategy—Proposed by with ATMS	Estimated Cost ($m) un-escalated
Scope as per contracted volume, plus					
Gunnedah Basin Line					
Collygra	Q3 2023	-	-	-	$23
486 km loop	Q3 2023	-	-	-	$26
South Gunnedah loop	Q3 2021	Q1 2020	Q3 2022	Q3 2022	$25
Burilda north extension	Q1 2024	-	-	-	$82
414 km loop (Werris Creek North)	Q3 2023	Q1 2023	Q3 2024	-	$30
407 km loop (Werris Creek South)	Q1 2024	Q1 2025	Q1 2025	-	$30
Bells Gate south extension	Q3 2022	Q1 2023	Q3 2023	Q3 2023	$46
Braefield north extension	Q3 2023	Q1 2025	Q1 2025	-	$51
Kankool—Ardglen	Q1 2024	Q1 2025	Q1 2025	-	$86
Pages River North extension	Q3 2021	Q1 2025	Q1 2025	-	$91
Blandford loop	Q3 2022	Q1 2023	Q3 2024	-	$38
Wingen loop	Q3 2021	Q1 2023	Q3 2023	Q3 2023	$20
316 km loop (Parkville South)	Q1 2024	Q1 2025	Q1 2025	-	$42
Togar North Loop	Q3 2021	Q1 2023	Q3 2023	Q3 2023	$23
Aberdeen	Q3 2023	-	-	-	$13
Ulan Line					
Widden Creek	Q4 2021	Q1 2020	Q1 2022	-	$46
Port—Muswellbrook					
Nil	-	-	-	-	-
Congestion Projects					
Train Parkup	See Note 2	See Note 2	TBD		-

Table 8-6- Recommended Projects, Delivery Schedule and Costs for Most Likely 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: Required dates for capacity-enhancing projects assume no-ATMS

Note 2: ARTC continue to work with HVCCC to identify the requirements for this project

	2019				2020				2021	2022	2023	2024	2025	2026	2027	2028	2029
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
Narrabri - Boggabri	4.0	4.0	4.2	5.0	4.8	4.8	4.8	4.8	5.0	5.0	4.9	5.0	4.9	4.9	4.9	4.9	4.9
Boggabri - Vickery	13.0	13.0	14.0	15.5	13.5	13.5	13.5	13.5	13.5	13.5	13.3	13.2	13.0	12.9	12.9	12.9	12.9
Vickery - Gunnedah	13.7	13.7	14.8	16.3	15.6	15.6	15.6	15.6	15.6	15.6	15.7	15.7	15.7	15.7	15.7	15.9	15.9
Gunnedah - Watermark Jct	8.8	8.8	9.4	10.5	10.2	10.2	10.2	10.2	10.2	16.8	16.5	16.3	16.1	16.0	16.0	16.0	16.0
Watermark Jct - Werris Creek	11.2	11.2	12.0	13.3	12.1	12.1	12.1	12.1	12.1	12.1	12.1	16.0	16.0	16.0	16.0	16.0	16.0
Werris Creek - Scone	11.0	11.0	11.0	12.3	12.0	12.0	12.0	12.0	12.0	12.0	13.7	15.1	17.5	17.5	17.5	17.5	17.5
Scone - Dartbrook	11.2	11.2	11.2	12.5	11.8	11.8	11.8	11.8	11.8	11.9	13.7	13.7	17.0	17.0	17.0	17.0	16.9
Dartbrook - Muswellbrook	27.3	27.3	27.3	29.9	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0
Ulan - Moolarben	8.8	8.8	9.2	10.1	10.0	10.0	10.0	10.0	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.0	10.1
Moolarben - Wilpinjong	8.8	8.8	9.2	10.1	10.0	10.0	10.0	10.0	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.0	10.1
Wilpinjong - Bylong	12.5	12.5	13.3	14.4	13.7	13.7	13.7	13.7	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8
Bylong - Ferndale	11.4	11.4	12.1	13.1	12.9	12.9	12.9	12.9	12.9	14.0	13.9	13.7	13.7	13.6	13.7	13.6	13.6
Ferndale - Mangoola	17.8	17.8	17.8	19.3	19.9	19.9	19.9	19.9	19.9	19.9	20.0	19.9	19.7	19.7	19.8	19.7	20.0
Mangoola - Mt Pleasant	21.8	21.8	24.2	26.1	26.9	26.9	26.9	26.9	27.0	27.0	27.0	27.0	26.9	27.0	27.0	27.0	27.0
Mt Pleasant - Bengalla	15.9	15.9	17.1	18.5	18.5	18.5	18.5	18.5	18.5	18.4	18.4	18.5	18.6	18.5	18.5	18.5	18.4
Bengalla - Muswellbrook	20.9	20.9	23.1	25.0	25.8	25.8	25.8	25.8	24.8	25.8	25.8	25.8	26.2	26.9	26.9	26.9	26.9
Muswellbrook -Drayton	70.0	70.0	70.0	70.0	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1
Drayton - Newdell	78.1	78.1	78.1	78.1	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4
Newdell - Mt Owen	82.8	82.8	82.8	82.8	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1
Mt Owen - Camberwell	87.9	87.9	87.9	87.9	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3
Camberwell - Whittingham	78.1	78.1	78.1	78.1	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4
Whittingham - Maitland	92.3	92.3	92.3	92.3	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8
Maitland - Bloomfield	132.4	132.4	132.4	132.4	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5
Bloomfield - Hexham	90.9	90.9	90.9	90.9	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3

Table 8-7 - Saleable capacity in coal train numbers (round-trips per day) assuming volumes and the recommended scope of work as per the most likely volume scenario without ATMS.

	2019				2020				2021	2022	2023	2024	2025	2026	2027	2028	2029
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
Narrabri - Boggabri	11.7	11.7	12.3	14.6	14.0	14.0	14.0	14.0	14.5	14.5	14.3	14.4	14.2	14.4	14.3	14.2	14.4
Boggabri - Vickery	37.8	37.8	40.7	44.9	39.3	39.3	39.3	39.3	39.3	39.3	38.5	38.3	37.9	37.3	37.3	37.4	37.3
Vickery - Gunnedah	39.8	39.8	42.9	47.2	45.4	45.4	45.4	45.4	45.3	45.3	45.6	45.6	45.6	45.7	45.7	46.2	46.2
Gunnedah - Watermark Jct	25.6	25.6	27.3	30.4	29.8	29.8	29.8	29.8	29.8	48.7	47.9	47.3	46.7	46.5	46.5	46.4	46.4
Watermark Jct - Werris Creek	32.6	32.6	34.9	38.7	35.1	35.1	35.1	35.1	35.1	35.1	35.1	46.5	46.5	46.5	46.5	46.5	46.5
Werris Creek - Scone	32.0	32.0	32.0	35.6	34.8	34.8	34.8	34.8	34.8	34.8	39.8	43.8	50.9	50.8	50.8	50.8	50.8
Scone - Dartbrook	32.5	32.5	32.5	36.3	34.4	34.4	34.4	34.4	34.4	34.5	39.7	39.8	49.3	49.4	49.3	49.3	49.2
Dartbrook - Muswellbrook	79.3	79.3	79.3	86.9	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.2	110.2	110.2	110.2
Ulan - Moolarben	28.3	28.3	29.5	32.5	32.0	32.0	32.0	32.0	33.6	33.4	33.6	33.6	33.5	33.5	33.6	33.2	33.5
Moolarben - Wilpinjong	28.5	28.5	29.8	32.7	32.3	32.3	32.3	32.3	33.3	33.1	33.3	33.3	33.2	33.1	33.3	32.9	33.1
Wilpinjong - Bylong	40.1	40.1	42.7	46.1	44.0	44.0	44.0	44.0	44.6	44.7	44.7	44.7	44.8	45.0	45.0	45.0	45.0
Bylong - Ferndale	36.5	36.5	38.7	41.8	41.6	41.6	41.6	41.6	41.9	45.5	45.2	44.7	44.5	44.4	44.7	44.2	44.2
Ferndale - Mangoola	56.9	56.9	56.9	61.7	63.7	63.7	63.7	63.7	64.4	64.5	64.8	64.7	64.0	64.3	64.3	64.3	65.1
Mangoola - Mt Pleasant	70.1	70.1	77.9	84.1	86.9	86.9	86.9	86.9	87.6	87.6	87.6	87.8	87.8	88.2	88.2	88.2	88.1
Mt Pleasant - Bengalla	51.2	51.2	55.0	59.6	59.7	59.7	59.7	59.7	60.1	59.8	59.9	60.3	60.5	60.5	60.4	60.4	60.2
Bengalla - Muswellbrook	67.2	67.2	74.4	80.3	83.2	83.2	83.2	83.2	80.2	83.5	83.6	83.7	85.1	87.4	87.4	87.4	87.4
Muswellbrook -Drayton	218.1	218.1	218.1	218.1	221.4	221.4	221.4	221.4	222.3	221.9	221.2	221.1	220.8	220.7	220.8	220.9	220.8
Drayton - Newdell	243.5	243.5	243.5	243.5	246.6	246.6	246.6	246.6	247.7	247.3	246.7	247.2	247.3	247.1	247.1	247.2	247.2
Newdell - Mt Owen	259.6	259.6	259.6	259.6	263.0	263.0	263.0	263.0	264.9	264.4	263.7	263.8	263.8	263.5	263.6	263.7	263.7
Mt Owen - Camberwell	276.3	276.3	276.3	276.3	280.2	280.2	280.2	280.2	282.0	281.4	280.6	280.5	280.5	280.2	280.3	280.4	280.4
Camberwell - Whittingham	246.0	246.0	246.0	246.0	249.4	249.4	249.4	249.4	251.0	250.5	249.7	249.5	249.5	249.3	249.3	249.4	249.4
Whittingham - Maitland	291.0	291.0	291.0	291.0	295.6	295.6	295.6	295.6	297.7	297.2	296.4	296.2	296.2	296.1	296.1	296.2	296.2
Maitland - Bloomfield	412.4	412.4	412.4	412.4	422.3	422.3	422.3	422.3	425.4	424.7	416.8	416.5	416.9	415.4	416.6	415.7	417.5
Bloomfield - Hexham	283.1	283.1	283.1	283.1	289.9	289.9	289.9	289.9	292.0	291.5	286.1	286.2	286.4	285.4	286.2	285.6	286.8

Table 8-8 - Saleable capacity in tonnes assuming volumes and the recommended scope of work as per the most likely volume scenario without ATMS. This tonnage capacity is equal to table 8-7 times average train size times 365.

	2019				2020				2021	2022	2023	2024	2025	2026	2027	2028	2029
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
Narrabri - Boggabri	4.0	4.0	4.2	5.0	4.8	4.8	4.8	4.8	5.0	5.0	4.9	5.0	6.5	6.6	6.6	6.5	6.6
Boggabri - Vickery	13.0	13.0	14.0	15.5	13.5	13.5	13.5	13.5	13.5	13.5	13.3	13.2	18.8	18.6	18.6	18.6	18.6
Vickery - Gunnedah	13.7	13.7	14.8	16.3	15.6	15.6	15.6	15.6	15.6	15.6	15.7	15.7	20.9	20.9	20.9	21.1	21.1
Gunnedah - Watermark Jct	8.8	8.8	9.4	10.5	10.2	10.2	10.2	10.2	10.2	16.8	16.5	16.3	21.8	21.6	21.6	21.6	21.6
Watermark Jct - Werris Creek	11.2	11.2	12.0	13.3	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	17.1	17.1	17.1	17.1	17.1
Werris Creek - Scone	11.0	11.0	11.0	12.3	12.0	12.0	12.0	12.0	12.0	12.0	13.7	13.7	17.5	17.5	17.5	17.5	17.5
Scone - Dartbrook	11.2	11.2	11.2	12.5	11.8	11.8	11.8	11.8	11.8	11.9	13.7	13.7	18.4	18.4	18.4	18.4	18.4
Dartbrook - Muswellbrook	27.3	27.3	27.3	29.9	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	49.7	49.7	49.7	49.7	49.7
Ulan - Moolarben	8.8	8.8	9.2	10.1	10.0	10.0	10.0	10.0	10.1	10.1	10.1	12.1	12.1	12.1	12.1	12.0	12.1
Moolarben - Wilpinjong	8.8	8.8	9.2	10.1	10.0	10.0	10.0	10.0	10.1	10.1	10.1	12.1	12.1	12.1	12.1	12.0	12.1
Wilpinjong - Bylong	12.5	12.5	13.3	14.4	13.7	13.7	13.7	13.7	13.8	13.8	13.8	18.3	18.3	18.4	18.4	18.4	18.4
Bylong - Ferndale	11.4	11.4	12.1	13.1	12.9	12.9	12.9	12.9	12.9	12.9	12.9	16.2	16.2	16.2	16.2	16.2	16.2
Ferndale - Mangoola	17.8	17.8	17.8	19.3	19.9	19.9	19.9	19.9	19.9	19.9	20.0	25.1	24.8	24.9	24.9	24.9	25.2
Mangoola - Mt Pleasant	21.8	21.8	24.2	26.1	26.9	26.9	26.9	26.9	27.0	27.0	27.0	35.2	35.1	35.2	35.2	35.2	35.2
Mt Pleasant - Bengalla	15.9	15.9	17.1	18.5	18.5	18.5	18.5	18.5	18.5	18.4	18.4	22.9	22.9	22.9	22.9	22.8	22.8
Bengalla - Muswellbrook	20.9	20.9	23.1	25.0	25.8	25.8	25.8	25.8	24.8	25.8	25.8	33.3	33.9	34.9	34.9	34.9	34.9
Muswellbrook -Drayton	70.0	70.0	70.0	70.0	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	198.2
Drayton - Newdell	78.1	78.1	78.1	78.1	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	198.2
Newdell - Mt Owen	82.8	82.8	82.8	82.8	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	198.2
Mt Owen - Camberwell	87.9	87.9	87.9	87.9	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	198.2	198.2	198.2	198.2
Camberwell - Whittingham	78.1	78.1	78.1	78.1	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	198.2
Whittingham - Maitland	92.3	92.3	92.3	92.3	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	198.2	198.2	198.2	198.2
Maitland - Bloomfield	132.4	132.4	132.4	132.4	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	217.9
Bloomfield - Hexham	90.9	90.9	90.9	90.9	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	217.9

Table 8-9 - Saleable capacity in coal train numbers (round-trips per day) assuming volumes and the recommended scope of work as per the most likely volume scenario with ATMS.

	2019				2020				2021	2022	2023	2024	2025	2026	2027	2028	2029
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
Narrabri - Boggabri	11.7	11.7	12.3	14.6	14.0	14.0	14.0	14.0	14.5	14.5	14.3	14.4	19.0	19.1	19.3	18.9	19.1
Boggabri - Vickery	37.8	37.8	40.7	44.9	39.3	39.3	39.3	39.3	39.3	39.3	38.5	38.3	54.7	53.9	53.9	53.9	53.9
Vickery - Gunnedah	39.8	39.8	42.9	47.2	45.4	45.4	45.4	45.4	45.3	45.3	45.6	45.6	60.5	60.6	60.6	61.3	61.3
Gunnedah - Watermark Jct	25.6	25.6	27.3	30.4	29.8	29.8	29.8	29.8	29.8	48.7	47.9	47.3	63.2	62.8	62.8	62.7	62.7
Watermark Jct - Werris Creek	32.6	32.6	34.9	38.7	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1	49.6	49.6	49.6	49.6	49.6
Werris Creek - Scone	32.0	32.0	32.0	35.6	34.8	34.8	34.8	34.8	34.8	34.8	39.8	39.8	50.9	50.8	50.8	50.8	50.8
Scone - Dartbrook	32.5	32.5	32.5	36.3	34.4	34.4	34.4	34.4	34.4	34.5	39.7	39.8	53.4	53.3	53.3	53.3	53.3
Dartbrook - Muswellbrook	79.3	79.3	79.3	86.9	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.3	144.3	144.2	144.2	144.2	144.2
Ulan - Moolarben	28.3	28.3	29.5	32.5	32.0	32.0	32.0	32.0	33.6	33.4	33.6	40.2	40.2	40.2	40.3	39.9	40.2
Moolarben - Wilpinjong	28.5	28.5	29.8	32.7	32.3	32.3	32.3	32.3	33.3	33.1	33.3	39.8	39.7	39.8	39.9	39.5	39.8
Wilpinjong - Bylong	40.1	40.1	42.7	46.1	44.0	44.0	44.0	44.0	44.6	44.7	44.7	59.3	59.4	59.7	59.7	59.6	59.7
Bylong - Ferndale	36.5	36.5	38.7	41.8	41.6	41.6	41.6	41.6	41.9	42.0	42.0	52.6	52.7	52.8	52.8	52.8	52.8
Ferndale - Mangoola	56.9	56.9	56.9	61.7	63.7	63.7	63.7	63.7	64.4	64.5	64.8	81.7	80.8	81.1	81.2	81.2	82.2
Mangoola - Mt Pleasant	70.1	70.1	77.9	84.1	86.9	86.9	86.9	86.9	87.6	87.6	87.6	114.5	114.5	115.0	115.0	115.0	115.0
Mt Pleasant - Bengalla	51.2	51.2	55.0	59.6	59.7	59.7	59.7	59.7	60.1	59.8	59.9	74.5	74.8	74.8	74.7	74.7	74.5
Bengalla - Muswellbrook	67.2	67.2	74.4	80.3	83.2	83.2	83.2	83.2	80.2	83.5	83.6	108.1	110.2	113.7	113.6	113.6	113.6
Muswellbrook -Drayton	218.1	218.1	218.1	218.1	221.4	221.4	221.4	221.4	222.3	221.9	221.2	221.1	220.8	220.7	220.8	220.9	615.5
Drayton - Newdell	243.5	243.5	243.5	243.5	246.6	246.6	246.6	246.6	247.7	247.3	246.7	247.2	247.3	247.1	247.1	247.2	617.4
Newdell - Mt Owen	259.6	259.6	259.6	259.6	263.0	263.0	263.0	263.0	264.9	264.4	263.7	263.8	263.8	263.5	263.6	263.7	621.7
Mt Owen - Camberwell	276.3	276.3	276.3	276.3	280.2	280.2	280.2	280.2	282.0	281.4	280.6	280.5	280.5	622.2	622.3	622.5	622.5
Camberwell - Whittingham	246.0	246.0	246.0	246.0	249.4	249.4	249.4	249.4	251.0	250.5	249.7	249.5	249.5	249.3	249.3	249.4	622.9
Whittingham - Maitland	291.0	291.0	291.0	291.0	295.6	295.6	295.6	295.6	297.7	297.2	296.4	296.2	296.2	625.6	625.7	625.9	625.9
Maitland - Bloomfield	412.4	412.4	412.4	412.4	422.3	422.3	422.3	422.3	425.4	424.7	416.8	416.5	416.9	415.4	416.6	415.7	676.4
Bloomfield - Hexham	283.1	283.1	283.1	283.1	289.9	289.9	289.9	289.9	292.0	291.5	286.1	286.2	286.4	285.4	286.2	285.6	676.9

Table 8-10 - Saleable capacity in tonnes assuming volumes and the recommended scope of work as per the most likely volume scenario with ATMS. This

Recommended projects - Prospective Volume Scenario	2019 Strategy – Proposed by (Without ATMS)	2020 Strategy – Required by (Note 1)	2020 Strategy – Proposed by without ATMS	2020 Strategy—Proposed by with ATMS	Estimated Cost ($m) un-escalated
Scope as per contracted volume, plus					
Gunnedah Basin Line					
Collygra	Q3 2023	-	-	-	-
486 km loop	Q3 2023	-	-	-	-
South Gunnedah loop	Q3 2021	Q1 2020	Q3 2022	Q3 2022	$25
Breeza north extension	Q1 2024	-	-	-	-
Burilda north extension	Q1 2024	Q1 2024	Q1 2025		$82
414 km loop (Werris Creek North)	Q3 2023	Q1 2023	Q3 2024	Q3 2024	$30
407 km loop (Werris Creek South)	Q1 2024	Q1 2024	Q1 2025	-	$30
Bells Gate south extension	Q3 2022	Q1 2022	Q3 2023	Q3 2023	$46
Braefield north extension	Q3 2023	Q1 2022	Q1 2025	-	$51
Kankool—Ardglen	Q1 2024	Q1 2024	Q1 2025	-	$86
Pages River North extension	Q3 2021	Q1 2023	Q1 2025	-	$91
Blandford loop	Q3 2022	Q1 2022	Q3 2023	Q3 2023	$38
Wingen loop	Q3 2021	Q1 2022	Q3 2023	Q3 2023	$20
316 km loop (Parkville South)	Q1 2024	Q1 2022	Q1 2025	-	$42
Togar North Loop	Q3 2023	Q1 2022	Q3 2023	Q3 2023	$23
Aberdeen	Q3 2023	Q1 2023	Q1 2025	Q1 2025	$13
Ulan Line					
Coggan Creek West extension	Q4 2022	Q1 2021	Q4 2023	-	$57
Murrumbo west extension	Q4 2022	Q1 2021	Q4 2023	-	$48
Widden Creek	Q4 2021	Q1 2020	Q1 2022	Q1 2022	$46
324 Km Loop	-	Q1 2025	Q1 2025	-	$52
Mt Pleasant	Q4 2022	Q1 2024	Q1 2024	-	$33
Port—Muswellbrook					
Nil	-	-	-	-	-
Congestion Projects					
Train Parkup	See Note 2	See Note 2	TBD	-	-

Table 8-11 - 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 required dates for the capacity-enhancing projects assume no-ATMS.

Note 2: ARTC continue to work with HVCCC to identify the requirements for this project

	2019				2020				2021	2022	2023	2024	2025	2026	2027	2028	2029
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
Narrabri - Boggabri	4.0	4.0	4.2	5.0	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.5	4.4	4.4	4.4	4.4
Boggabri - Vickery	13.0	13.0	14.0	15.5	13.5	13.5	13.5	13.5	13.5	13.3	13.2	13.1	13.0	13.0	13.0	13.0	13.0
Vickery - Gunnedah	13.7	13.7	14.8	16.3	15.6	15.6	15.6	15.6	15.6	15.6	15.7	15.7	15.7	15.7	15.7	15.7	15.7
Gunnedah - Watermark Jct	8.8	8.8	9.4	10.5	10.2	10.2	10.2	10.2	10.2	16.6	16.4	16.2	16.2	16.2	16.2	16.2	16.2
Watermark Jct - Werris Creek	11.2	11.2	12.0	13.3	12.1	12.1	12.1	12.1	12.1	12.1	12.1	16.0	21.7	21.7	21.7	21.7	21.7
Werris Creek - Scone	11.0	11.0	11.0	12.3	12.0	12.0	12.0	12.0	12.0	12.0	15.1	15.1	20.7	20.7	20.7	20.7	20.7
Scone - Dartbrook	11.2	11.2	11.2	12.5	11.9	11.9	11.9	11.9	11.9	12.1	13.7	13.7	26.9	26.9	26.9	26.9	26.9
Dartbrook - Muswellbrook	27.3	27.3	27.3	29.9	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0
Ulan - Moolarben	8.8	8.8	9.2	10.1	9.9	9.9	9.9	9.9	10.1	10.6	10.7	10.7	10.6	10.5	10.6	10.5	10.5
Moolarben - Wilpinjong	8.8	8.8	9.2	10.1	9.9	9.9	9.9	9.9	10.1	10.6	10.7	10.7	10.6	10.5	10.6	10.5	10.5
Wilpinjong - Bylong	12.5	12.5	13.3	14.4	13.7	13.7	13.7	13.7	13.8	13.8	15.3	15.3	15.3	15.3	15.3	15.3	15.3
Bylong - Ferndale	11.4	11.4	12.1	13.1	12.9	12.9	12.9	12.9	12.9	14.0	15.6	15.4	15.4	15.4	15.5	15.3	15.3
Ferndale - Mangoola	17.8	17.8	17.8	19.3	19.8	19.8	19.8	19.8	19.8	19.9	19.9	19.9	19.8	19.9	19.9	19.9	19.9
Mangoola - Mt Pleasant	21.8	21.8	24.2	26.1	26.9	26.9	26.9	26.9	27.0	27.0	27.0	35.7	35.7	35.8	35.8	35.8	35.8
Mt Pleasant - Bengalla	15.9	15.9	17.1	18.5	18.5	18.5	18.5	18.5	18.6	18.4	18.5	27.2	27.3	27.2	27.1	27.1	27.1
Bengalla - Muswellbrook	20.9	20.9	23.1	25.0	25.8	25.8	25.8	25.8	24.8	25.8	25.8	25.8	26.2	26.9	26.9	26.9	26.9
Muswellbrook -Drayton	70.0	70.0	70.0	70.0	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1
Drayton - Newdell	78.1	78.1	78.1	78.1	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4
Newdell - Mt Owen	82.8	82.8	82.8	82.8	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1
Mt Owen - Camberwell	87.9	87.9	87.9	87.9	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3
Camberwell - Whittingham	78.1	78.1	78.1	78.1	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4
Whittingham - Maitland	92.3	92.3	92.3	92.3	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8
Maitland - Bloomfield	132.4	132.4	132.4	132.4	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5
Bloomfield - Hexham	90.9	90.9	90.9	90.9	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3

Table 8-12 - Saleable capacity in coal train numbers (round-trips per day) assuming volumes and the recommended scope of work as per the prospective volume scenario without ATMS.

	2019				2020				2021	2022	2023	2024	2025	2026	2027	2028	2029
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
Narrabri - Boggabri	11.7	11.7	12.3	14.6	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	13.2	12.7	12.7	12.7	12.7
Boggabri - Vickery	37.8	37.8	40.7	44.9	39.3	39.3	39.3	39.3	39.3	38.5	38.3	37.9	37.6	37.7	37.7	37.7	37.7
Vickery - Gunnedah	39.8	39.8	42.9	47.2	45.4	45.4	45.4	45.4	45.3	45.4	45.5	45.6	45.6	45.7	45.7	45.7	45.7
Gunnedah - Watermark Jct	25.6	25.6	27.3	30.4	29.8	29.8	29.8	29.8	29.8	48.2	47.7	47.2	47.0	46.9	46.9	46.9	47.0
Watermark Jct - Werris Creek	32.6	32.6	34.9	38.7	35.1	35.1	35.1	35.1	35.1	35.1	35.1	46.5	63.0	63.0	63.0	63.0	63.0
Werris Creek - Scone	32.0	32.0	32.0	35.6	34.8	34.8	34.8	34.8	34.8	34.8	43.8	43.8	60.0	60.0	60.0	60.0	60.0
Scone - Dartbrook	32.5	32.5	32.5	36.3	34.5	34.5	34.5	34.5	34.6	35.1	39.7	39.8	78.1	78.0	78.0	78.0	78.0
Dartbrook - Muswellbrook	79.3	79.3	79.3	86.9	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.2	110.2	110.2	110.2
Ulan - Moolarben	28.3	28.3	29.5	32.5	31.9	31.9	31.9	31.9	33.6	35.2	35.4	35.5	35.2	35.0	35.2	35.0	35.0
Moolarben - Wilpinjong	28.5	28.5	29.8	32.7	32.2	32.2	32.2	32.2	33.3	34.9	35.1	35.1	34.9	34.7	34.9	34.7	34.7
Wilpinjong - Bylong	40.1	40.1	42.7	46.1	44.0	44.0	44.0	44.0	44.6	44.8	49.6	49.7	49.8	50.1	50.1	50.1	50.1
Bylong - Ferndale	36.5	36.5	38.7	41.8	41.6	41.6	41.6	41.6	42.0	45.6	50.8	50.2	50.2	50.3	50.5	50.1	50.1
Ferndale - Mangoola	56.9	56.9	56.9	61.7	63.5	63.5	63.5	63.5	64.4	64.5	64.7	64.9	64.6	64.9	64.9	64.9	64.9
Mangoola - Mt Pleasant	70.1	70.1	77.9	84.1	86.9	86.9	86.9	86.9	87.7	87.7	87.8	116.5	116.6	117.2	117.2	117.2	117.2
Mt Pleasant - Bengalla	51.2	51.2	55.0	59.6	59.8	59.8	59.8	59.8	60.4	60.0	60.2	88.5	89.0	89.2	88.8	88.9	88.9
Bengalla - Muswellbrook	67.2	67.2	74.4	80.3	83.3	83.3	83.3	83.3	80.3	83.7	83.7	83.8	85.3	87.6	87.7	87.7	87.7
Muswellbrook -Drayton	218.1	218.1	218.1	218.1	221.7	221.7	221.7	221.7	222.6	221.7	221.5	220.9	220.7	221.0	221.1	221.2	221.2
Drayton - Newdell	243.5	243.5	243.5	243.5	247.5	247.5	247.5	247.5	248.5	247.9	247.6	247.3	247.5	247.5	247.6	247.6	247.7
Newdell - Mt Owen	259.6	259.6	259.6	259.6	263.8	263.8	263.8	263.8	265.5	264.8	264.5	263.7	263.7	263.7	263.9	263.9	263.9
Mt Owen - Camberwell	276.3	276.3	276.3	276.3	281.0	281.0	281.0	281.0	282.6	281.9	281.5	280.5	280.4	280.4	280.5	280.5	280.5
Camberwell - Whittingham	246.0	246.0	246.0	246.0	250.2	250.2	250.2	250.2	251.6	251.0	250.6	249.6	249.5	249.5	249.6	249.5	249.6
Whittingham - Maitland	291.0	291.0	291.0	291.0	296.6	296.6	296.6	296.6	298.6	297.8	297.5	296.4	296.4	296.6	296.6	296.5	296.6
Maitland - Bloomfield	412.4	412.4	412.4	412.4	420.5	420.5	420.5	420.5	423.4	422.5	416.5	417.8	418.1	417.1	418.2	417.2	418.9
Bloomfield - Hexham	283.1	283.1	283.1	283.1	288.7	288.7	288.7	288.7	290.6	290.1	285.9	287.1	287.2	286.5	287.2	286.6	287.7

Table 8-13 - Saleable capacity in tonnes assuming volumes and the recommended scope of work as per the prospective volume scenario without ATMS. This tonnage capacity is equal to table 8-12 times average train size times 365.

	2019				2020				2021	2022	2023	2024	2025	2026	2027	2028	2029
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
Narrabri - Boggabri	4.0	4.0	4.2	5.0	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	6.1	5.9	5.9	5.9	5.9
Boggabri - Vickery	13.0	13.0	14.0	15.5	13.5	13.5	13.5	13.5	13.5	13.3	13.2	13.1	18.7	18.7	18.7	18.7	18.7
Vickery - Gunnedah	13.7	13.7	14.8	16.3	15.6	15.6	15.6	15.6	15.6	15.6	15.7	15.7	20.8	20.8	20.8	20.8	20.8
Gunnedah - Watermark Jct	8.8	8.8	9.4	10.5	10.2	10.2	10.2	10.2	10.2	16.6	16.4	16.2	21.8	21.8	21.8	21.8	21.8
Watermark Jct - Werris Creek	11.2	11.2	12.0	13.3	12.1	12.1	12.1	12.1	12.1	12.1	12.1	16.0	21.1	21.1	21.1	21.1	21.1
Werris Creek - Scone	11.0	11.0	11.0	12.3	12.0	12.0	12.0	12.0	12.0	12.0	15.1	15.1	19.5	19.5	19.5	19.5	19.5
Scone - Dartbrook	11.2	11.2	11.2	12.5	11.9	11.9	11.9	11.9	11.9	12.1	13.7	13.7	22.3	22.3	22.3	22.3	22.3
Dartbrook - Muswellbrook	27.3	27.3	27.3	29.9	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	49.7	49.7	49.7	49.7	49.7
Ulan - Moolarben	8.8	8.8	9.2	10.1	9.9	9.9	9.9	9.9	10.1	10.1	10.2	12.1	12.0	12.0	12.0	12.0	12.0
Moolarben - Wilpinjong	8.8	8.8	9.2	10.1	9.9	9.9	9.9	9.9	10.1	10.1	10.2	12.1	12.0	12.0	12.0	12.0	12.0
Wilpinjong - Bylong	12.5	12.5	13.3	14.4	13.7	13.7	13.7	13.7	13.8	13.8	13.8	18.3	18.3	18.4	18.4	18.4	18.4
Bylong - Ferndale	11.4	11.4	12.1	13.1	12.9	12.9	12.9	12.9	12.9	12.9	12.9	16.2	16.2	16.2	16.2	16.2	16.2
Ferndale - Mangoola	17.8	17.8	17.8	19.3	19.8	19.8	19.8	19.8	19.8	19.9	19.9	25.1	25.0	25.0	25.0	25.0	25.0
Mangoola - Mt Pleasant	21.8	21.8	24.2	26.1	26.9	26.9	26.9	26.9	27.0	27.0	27.0	35.2	35.1	35.2	35.2	35.2	35.2
Mt Pleasant - Bengalla	15.9	15.9	17.1	18.5	18.5	18.5	18.5	18.5	18.6	18.4	18.5	22.9	23.0	22.9	22.9	22.9	22.9
Bengalla - Muswellbrook	20.9	20.9	23.1	25.0	25.8	25.8	25.8	25.8	24.8	25.8	25.8	33.3	33.9	34.9	34.9	34.9	34.9
Muswellbrook -Drayton	70.0	70.0	70.0	70.0	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	198.2
Drayton - Newdell	78.1	78.1	78.1	78.1	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	198.2
Newdell - Mt Owen	82.8	82.8	82.8	82.8	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	84.1	198.2
Mt Owen - Camberwell	87.9	87.9	87.9	87.9	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	198.2	198.2	198.2	198.2
Camberwell - Whittingham	78.1	78.1	78.1	78.1	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	79.4	198.2
Whittingham - Maitland	92.3	92.3	92.3	92.3	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8	198.2	198.2	198.2	198.2
Maitland - Bloomfield	132.4	132.4	132.4	132.4	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	134.5	217.9
Bloomfield - Hexham	90.9	90.9	90.9	90.9	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	217.9

Table 8-14 - Saleable capacity in coal train numbers (round-trips per day) assuming volumes and the recommended scope of work as per the prospective volume scenario with ATMS.

	2019				2020				2021	2022	2023	2024	2025	2026	2027	2028	2029
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1	Q1
Narrabri - Boggabri	11.7	11.7	12.3	14.6	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	17.7	17.2	17.2	17.2	17.2
Boggabri - Vickery	37.8	37.8	40.7	44.9	39.3	39.3	39.3	39.3	39.3	38.5	38.3	37.9	54.2	54.2	54.2	54.2	54.2
Vickery - Gunnedah	39.8	39.8	42.9	47.2	45.4	45.4	45.4	45.4	45.3	45.4	45.5	45.6	60.5	60.5	60.5	60.5	60.5
Gunnedah - Watermark Jct	25.6	25.6	27.3	30.4	29.8	29.8	29.8	29.8	29.8	48.2	47.7	47.2	63.3	63.2	63.2	63.2	63.3
Watermark Jct - Werris Creek	32.6	32.6	34.9	38.7	35.1	35.1	35.1	35.1	35.1	35.1	35.1	46.5	61.2	61.3	61.3	61.3	61.3
Werris Creek - Scone	32.0	32.0	32.0	35.6	34.8	34.8	34.8	34.8	34.8	34.8	43.8	43.8	56.7	56.7	56.7	56.7	56.7
Scone - Dartbrook	32.5	32.5	32.5	36.3	34.5	34.5	34.5	34.5	34.6	35.1	39.7	39.8	64.7	64.6	64.6	64.6	64.6
Dartbrook - Muswellbrook	79.3	79.3	79.3	86.9	110.3	110.3	110.3	110.3	110.3	110.3	110.3	110.3	144.3	144.2	144.2	144.2	144.2
Ulan - Moolarben	28.3	28.3	29.5	32.5	31.9	31.9	31.9	31.9	33.6	33.5	33.7	40.2	39.9	39.7	39.9	39.7	39.7
Moolarben - Wilpinjong	28.5	28.5	29.8	32.7	32.2	32.2	32.2	32.2	33.3	33.3	33.5	39.8	39.5	39.3	39.5	39.3	39.3
Wilpinjong - Bylong	40.1	40.1	42.7	46.1	44.0	44.0	44.0	44.0	44.6	44.8	44.8	59.4	59.5	59.9	59.9	59.9	59.9
Bylong - Ferndale	36.5	36.5	38.7	41.8	41.6	41.6	41.6	41.6	42.0	42.0	42.1	52.7	52.8	52.9	52.9	52.9	53.0
Ferndale - Mangoola	56.9	56.9	56.9	61.7	63.5	63.5	63.5	63.5	64.4	64.5	64.7	81.8	81.3	81.8	81.7	81.8	81.8
Mangoola - Mt Pleasant	70.1	70.1	77.9	84.1	86.9	86.9	86.9	86.9	87.7	87.7	87.8	114.6	114.7	115.2	115.2	115.3	115.3
Mt Pleasant - Bengalla	51.2	51.2	55.0	59.6	59.8	59.8	59.8	59.8	60.4	60.0	60.2	74.6	75.0	75.2	75.0	75.1	75.1
Bengalla - Muswellbrook	67.2	67.2	74.4	80.3	83.3	83.3	83.3	83.3	80.3	83.7	83.7	108.2	110.4	113.9	113.9	114.0	114.0
Muswellbrook -Drayton	218.1	218.1	218.1	218.1	221.7	221.7	221.7	221.7	222.6	221.7	221.5	220.9	220.7	221.0	221.1	221.2	616.6
Drayton - Newdell	243.5	243.5	243.5	243.5	247.5	247.5	247.5	247.5	248.5	247.9	247.6	247.3	247.5	247.5	247.6	247.6	618.6
Newdell - Mt Owen	259.6	259.6	259.6	259.6	263.8	263.8	263.8	263.8	265.5	264.8	264.5	263.7	263.7	263.7	263.9	263.9	622.2
Mt Owen - Camberwell	276.3	276.3	276.3	276.3	281.0	281.0	281.0	281.0	282.6	281.9	281.5	280.5	280.4	622.6	622.8	622.8	622.9
Camberwell - Whittingham	246.0	246.0	246.0	246.0	250.2	250.2	250.2	250.2	251.6	251.0	250.6	249.6	249.5	249.5	249.6	249.5	623.4
Whittingham - Maitland	291.0	291.0	291.0	291.0	296.6	296.6	296.6	296.6	298.6	297.8	297.5	296.4	296.4	626.6	626.6	626.5	626.6
Maitland - Bloomfield	412.4	412.4	412.4	412.4	420.5	420.5	420.5	420.5	423.4	422.5	416.5	417.8	418.1	417.1	418.2	417.2	678.7
Bloomfield - Hexham	283.1	283.1	283.1	283.1	288.7	288.7	288.7	288.7	290.6	290.1	285.9	287.1	287.2	286.5	287.2	286.6	679.1

Table 8-15 - Saleable capacity in tonnes assuming volumes and the recommended scope of work as per the prospective volume scenario with ATMS. This tonnage capacity is equal to table 8-14 times average train size times 365.

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

Australian Rail Track Corporation Ltd

11 Sir Donald Bradman Drive, Keswick Terminal SA 5035

PO Box 10343, Gouger Street, Adelaide SA 5000

Tel: (08) 8217 4366   Fax: (08) 8217 4578