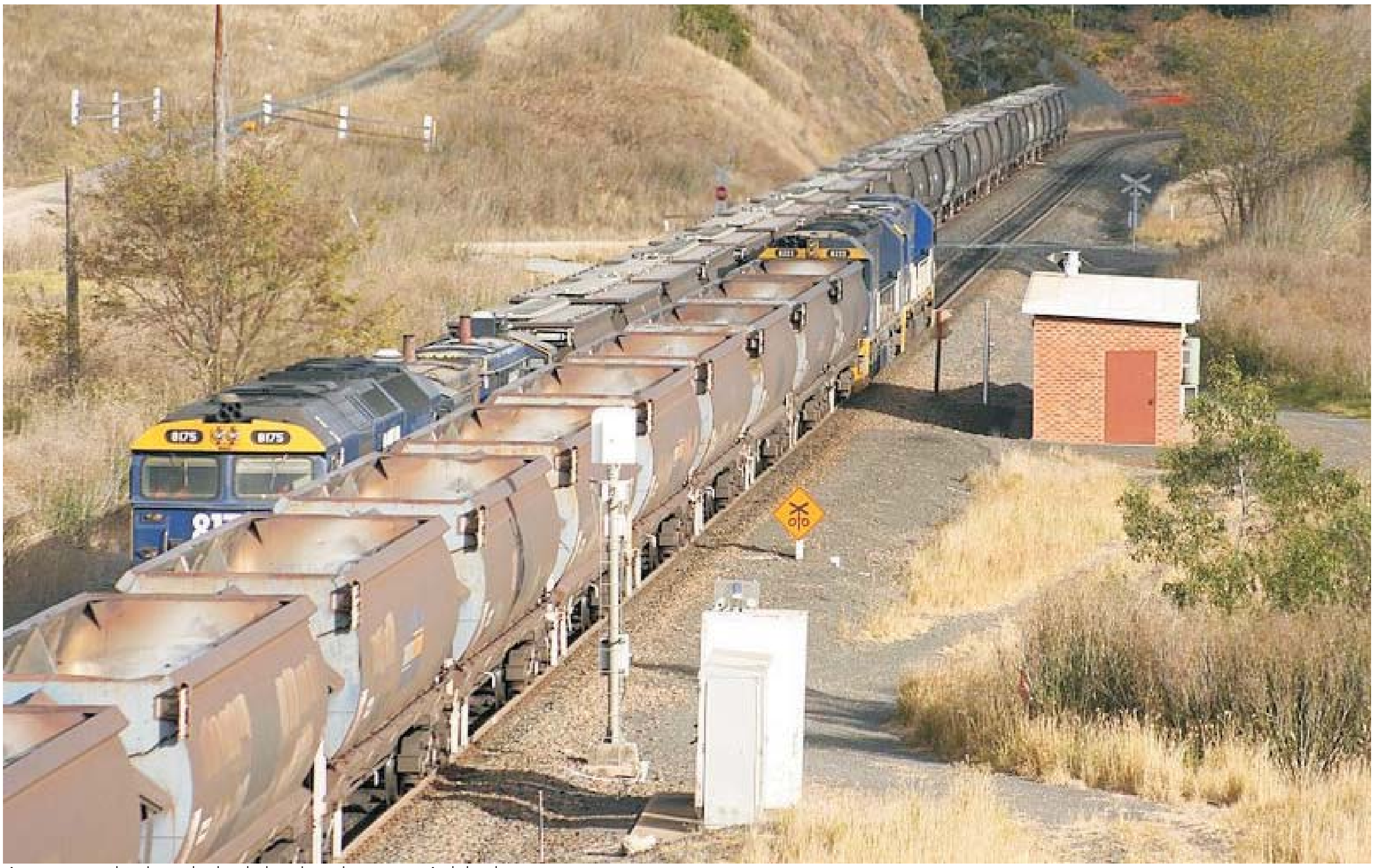


An empty coal train and a loaded grain train cross at Ardglen loop.

Liverpool Range New Route Selection Study Project Conclusions

In January of last year, ARTC commissioned a study to determine a potential new route across the Liverpool Range in the vicinity of Ardglen. Background on the study was made available on ARTC's website on 6 April 2006. This paper sets out the main findings of the study.

This document has been prepared for consultation purposes. Written comments should be directed to Derek Harris (Manager, Planning & Development, GPO Box 14, Sydney, NSW, 2001). Written comments should be provided by 30 March 2007.

Why was the study commissioned?

The grades of the current railway over the Liverpool Range at Ardglen represent a barrier to efficient increased rail operations. Schemes to relieve these grades have been proposed for at least 80 years. Current forecasts of growth in coal volumes transported by rail over the Liverpool Range suggest that the time may now be approaching when, subject to increased volumes of coal or other bulk commodities to underwrite the costs, a new alignment may be justified.

The principal purpose of the study was to provide the information required for stakeholders to evaluate the viability of a new alignment. A range of new alignment options have been identified to ensure that stakeholders have a full suite of options to choose between.

What geographical area was investigated?

The grade that the new alignment will avoid extends from Chilcotts Creek, 4 km south of Willow Tree, to just north of Murrurundi.

The study has considered two broad options:

- A new alignment that would reuse the existing Ardglen tunnel and would be built predominantly on the surface, and
- A new alignment with a new long tunnel at a significantly lower elevation than the existing tunnel.

As the objective of the new alignment is to reduce the grade from 1 in 40 to 1 in 80, the length of the grade on a new surface alignment must necessarily be almost twice as long as the length of the existing grade. To achieve this while retaining a relatively direct route requires alignments that extend some way past Murrurundi and Willow Tree. This has defined the bounds of the study area.

How has the study been undertaken?

ARTC engaged Worley Parsons TMG as the lead consultant for the project.

ARTC specified that the lead consultants were to employ the software tool Quantm to assist in identifying preferred alignments. This tool can be used to analyse and compare an almost infinite number of route options. All relevant engineering construction cost data (eg the cost of cutting, filling, bridging, building viaducts, tunnelling etc) is entered into the software along with a topographical model and important environmental and geological zones.

Design constraints are also entered into the system (eg maximum grades, curve radius etc) and the software then 'randomly' generates millions of alignments to determine the viable solutions.

Quantm results tend to group around a few differentiable corridors. The next step is therefore to work up just one alignment representing each of the main alternatives. The representative alignments were selected on the basis of upfront capital cost, along with consideration of train operations, maintenance and relative construction risk. The desired result was to end up with a suite of alignments representing a range of cost - benefit options available to industry.

The selected Quantm generated alignments were then validated in a CAD package and finally, the raw construction costs as generated by Quantm were reviewed by a cost engineer and adjusted to including items like contingency and project management.

Operational analysis on the final alignments was completed with train and timetable simulators to determine the likely impact on operations of the new alignments, and also the level of capacity they would facilitate.

What is the basis of design for the new alignments?

The study has identified a total of six new alignment options. The different alignment options provide a range of capital costs, risk levels and operational benefits. The relative merits of each option depend on an assessment of future coal volumes, and the quantification of the operational benefits.

The key driver for a new alignment across the Liverpool Ranges is to provide more efficient rail operations. The primary means to achieve this is by reducing the gradient.

Coal trains currently require "banking" to cross the Liverpool Ranges due to the 1 in 40 grades. "Banking" simply means that extra locomotives need to be added to the train to provide sufficient power. They are generally attached at Werris Creek or Willow Tree and detached at Ardglen[1].

Additionally, the steepness of the alignment and the use of bank engines limits the length of train that can be run.

While it is planned to increase train length with the current form of operation, the maximum length considered practical using front and rear power is around 1,200 metres[2]. To go to a longer train length requires the bank engines to be spliced into the train, which is logistically difficult, time consuming and difficult to justify for the short distance of the 1 in 40 grade.

Trains could operate at considerably longer lengths (say 2 km) using distributed power. However, because the grade only represents about one hour of a 24 hour journey it is not likely to be economical to provide the necessary horsepower for the entire round trip.

By building a new alignment with a reduced grade, an operational cost saving is possible from the elimination of bank engines and to the extent that the elimination of bank engines allows train lengths to increase. The value of this depends on the views of operators as to an optimised train size.

All new alignments have been designed to a maximum grade of 1 in 80 in keeping with the ruling grade for the remainder of the corridor[3]. This means the power requirement is the same for the duration of the journey.

Two additional aspects of operational efficiency are fuel consumption and transit time. In general terms both will be a function of the energy required to move a given weight to a given elevation. Hence, the primary means for achieving savings in transit time and fuel consumption will be to reduce the maximum elevation that an alignment reaches in crossing the range.

The preference for a lower total elevation is typically offset by a rising upfront capital cost. The alignments being put forward from the study provide a range of cost-benefit trade-off possibilities for industry to consider.

What is the alternative to a new alignment?

In the absence of a proposal to build a new alignment, capacity would simply be provided by upgrading infrastructure on the existing alignment. Full duplication is expected to be required to accommodate 25 million tonnes per year of coal.

The progressive double tracking of the line between Murrurundi and Willow Tree is therefore the base case against which the new alignment options have been assessed.

Technical Issues

Geology

The Liverpool Range in the vicinity of Ardglen has complex and difficult geology. This has made identification of suitable tunnel alignments difficult. It will also present a significant construction risk due to the inherent inability to know what the exact

1. *ARTC's capacity enhancement strategy provides for an increase in train length from 750 metres to approximately 1,200 metres in 2008. It is possible that this will change the bank engine operation, with the bank engines needing to be used the full distance from Werris Creek to Murrurundi. Due to wagon underframe and coupler strength issues the bank engines are added to the rear of the train and require a separate crew.*
2. *In the Hunter Valley trains currently operate at up to approximately 1,550 metres.*
3. *The ruling grade for the corridor is generally referred to as 1 in 80. Within the Hunter Valley the ruling grade is set by Minimbah Bank south of Singleton. This has sections as steep as 1 in 78 and is subject to some operating restrictions. There are four short sections of grade slightly steeper than 1 in 80 on the corridor between Narrabri and Muswellbrook. Two of these are between Werris Creek and Willow Tree, one is approaching the Gap and one is between Baan Baa and Boggabbri. 1 in 80 has been adopted for the design of the new alignment. This would need to be reaffirmed during detailed design having regard to the cost implications of alternative gradients. Consideration would also need to be given to the strategy for the grades steeper than 1 in 80 elsewhere on the corridor.*

tunnelling conditions will be until actual construction. The Quantm modelling has applied different cost rates for different ground conditions. The consultants have also tried to keep the tunnel within a single geological zone to avoid the risks associated with transitioning between zones.

Gradients

Uphill grades for loaded trains are limited to 1 in 80 for all alignments. As already noted this gradient matches the steepest gradient elsewhere on the corridor.

Downhill it should be possible to operate with 1 in 40 grades[4], and the "surface alignment" options, which retain the existing alignment from the Ardglen tunnel to Murrurundi, will have 1 in 40 downgrades. The tunnel options have 1 in 80 downgrades. This is because their maximum elevation is lower than the surface alignment and 1 in 80 is all that is needed to descend to the elevation of the existing railway at Murrurundi.

All of the tunnel alignments except the eastern tunnel - low crest at the northern portal and have a falling grade through the tunnel. This minimises locomotive heat output and allows the tunnel cross-section to be minimised.

The surface alignments level out in advance of Ardglen tunnel. The tunnel itself is likely to remain single track for the foreseeable future. Consequently it is necessary to provide an area where loaded trains can come to a stop and restart with reasonable ease. There is also a short section of 1 in 40 grade through the tunnel, which it will not be possible to ease. It is therefore necessary to provide a section of less than 1 in 80 so that the 1 in 40 section is averaged out across the length of the train to no greater than 1 in 80.

Tunnel Cross-Section

The minimum allowable diameter for the tunnel has been derived from considerations of heat and ventilation. The tunnel needs to be sufficiently large that the heat generated by the locomotives does not raise the tunnel temperature beyond acceptable operating temperatures, but sufficiently small to achieve a reasonable construction cost.

The tunnel cross-section used in the cost estimates is 50 square metres.

To achieve the best balance between cost and operating performance it would be necessary to have extensive mechanical ventilation in the tunnel. It is also likely that the tunnel would not be able to be used during the day on a very small number of very hot days each year.

It is also important to note that the largest train used to determine the tunnel cross-section is 10,920 tonnes (91 wagons of 120 tonne each)[5]. If a tunnel solution is adopted it may not be possible to increase trains significantly above this size in the future.

An alternative tunnel cross-section of 68 square metres was also considered during the study. This cross-section would ensure that there were no restrictions on operations on very hot days. Alternatively it would allow for an increase in train size in the future, albeit subject to operating restrictions on very hot days.

Tunnel Safety

To minimise cost, the tunnel options were not designed to the fire and life safety standards required for passengers or dangerous goods. These trains would continue to use the existing alignment.

There is no objective international standard to provide a guide as to the appropriate fire and life safety standards for train crew and maintenance staff in newly constructed tunnels. The tunnel designs have therefore adopted design principles considered by the consultants to be consistent with modern safety expectations.

Curves

Generally new railways aim to achieve curves with a radius of 800 metres or greater. However, the trains using the new alignment will be travelling at approximately 20 km/h for the majority of the climb to the summit. At this speed there is no operational advantage in having large radius curves. Larger radius curves do offer a maintenance cost saving but this is not material compared to the capital cost of the project. Accordingly, the new alignments use curves down to 290 metre radius, which allows significant cost savings to be achieved. It also allows for the environmental impact to be minimised.

What are the main options for a new alignment?

As already noted, the study considered two basic alternatives:

The 'surface options' are new alignments with reduced grades that run predominantly on the surface and make use of the existing tunnel at Ardglen.

The 'tunnel options', also new alignments with reduced grades, include a major new tunnel through the Liverpool Ranges at a lower elevation than the existing tunnel.

Four variations on the tunnel option were identified and two surface alignments. These six alignments are depicted in Figure 1.

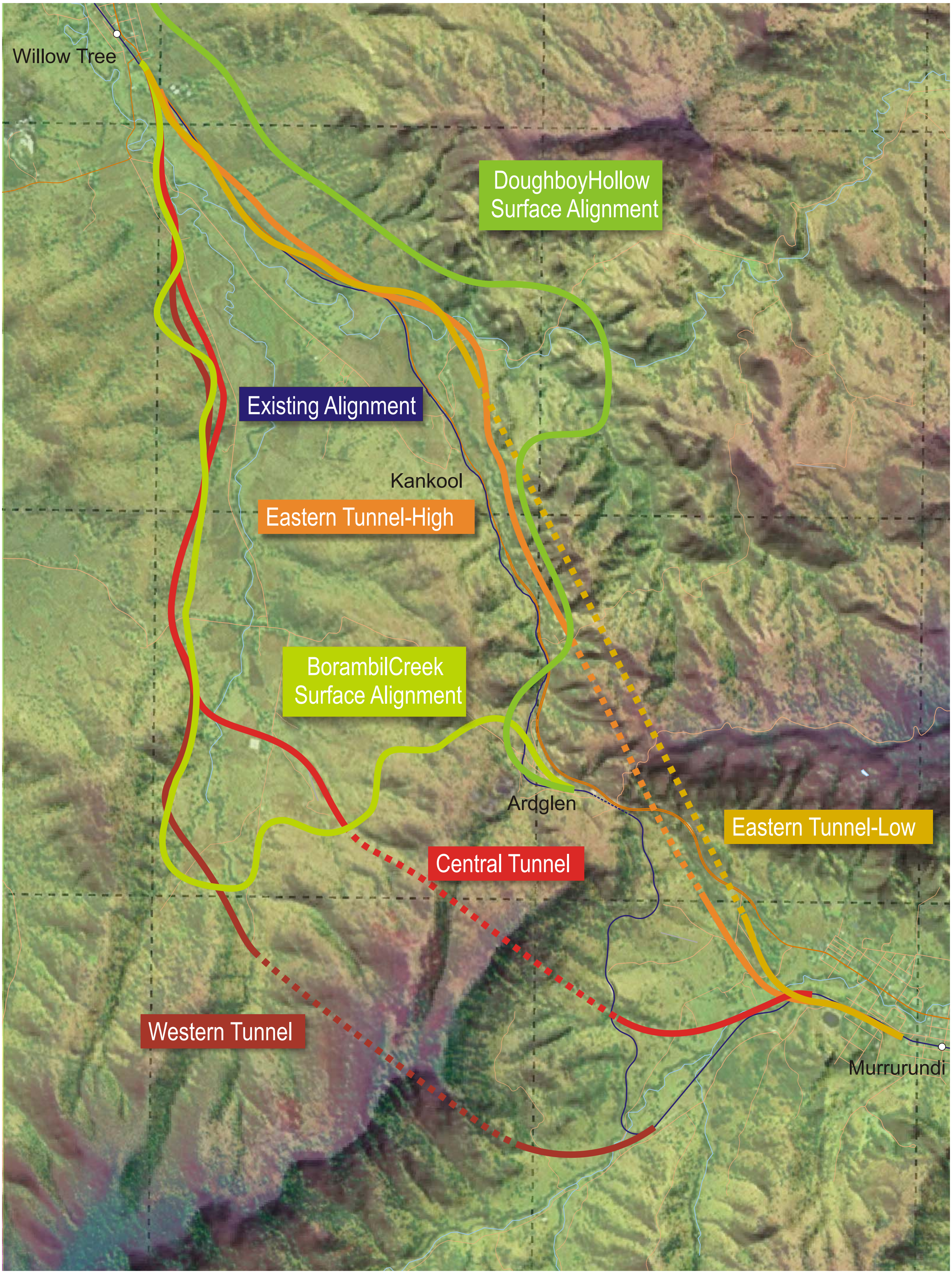
Key features of the alignments are as follows:

- *Borambil Creek surface alignment:*

  The Borambil Creek surface alignment commences from just south of Willow Tree and approximately follows Borambil Creek to the foothills of the Liverpool Range. It them swings around in a large horseshoe and passes through a short tunnel in the vicinity of Swinging Ridges Road. It crosses over the top of the existing railway to the north of Ardglen and then levels out before joining the existing alignment just to the north of Ardglen Tunnel. The option generally follows the alignment proposed in 1917. This alignment was selected through the Quantm process as being the lowest cost solution.

4. *Further consultation will be undertaken with rail operators to confirm operation of larger trains on 1 in 40 grades. In the event that 1 in 40 grades represent an unacceptable level of operational risk, the consequences will need to be taken into account in making a final decision on the way forward for the project.*

5. *The rail line to the Gunnedah basin is not currently suitable for the 30 tonne axle load (120 tonne gross) wagons generally used in the Hunter Valley. At the volumes projected for the corridor it is likely that there will be a strong business justification for the line to be upgraded for 30 tonne operations. The study has assumed that this will occur irrespective of the decision on a new alignment at Ardglen.*



- *Doughboy Hollow surface alignment:*

  The Doughboy Hollow surface alignment commences approximately 6.9 kilometres North of Willow Tree and proceeds largely parallel to the existing alignment to Ardglen. This option was developed to provide a solution that remained within the corridor shared by the existing road and rail lines, and to minimise the total rail distance. To allow it to climb to the required height it necessarily uses the opposite side of the valley to the current rail alignment. The falling grade in the northbound direction on the existing track north of Willow Tree means that the new alignment needs to extend a long way north before it can connect to the existing track (due to the distance involved the full length of this alignment is not shown in Figure 1).

- *Western Tunnel:*

  The Western Tunnel option follows a similar alignment to the Borambil Creek surface alignment as it heads south from Willow Tree. When it reaches the foot of the Liverpool Range it enters into a tunnel which re-emerges to the south-west of the existing alignment, which it joins in the vicinity of the crossing of the Pages River. The tunnel would be constructed through basaltic rock formations. This is considered to present the lowest geological risk of the tunnel options. This alignment is similar to a 1927 proposal.

- *Central Tunnel:*

  The Central Tunnel option is again similar to the Borambil Creek surface alignment for the first section heading south from Willow Tree. It turns south-east somewhat sooner than the Western Tunnel option. The tunnel re-emerges around half-way down the grade between the existing Ardglen Tunnel and Murrurundi. This requires it to pass underneath the existing rail line which it then connects to on the outskirts of Murrurundi. The tunnel would need to be constructed through the interface between the Liverpool Range Volcanic Beds and the underlying sedimentary formations, which is considered to be the highest risk of the materials through which the tunnel could be constructed.

- *Eastern Tunnel - High:*

  The Eastern Tunnel - High option follows the existing rail alignment quiet closely, though on the other side of the New England highway, closer to the base of the valley. It re-emerges to the east of the existing rail line and reconnects to it on the outskirts of Murrurundi. The tunnel would be constructed through steeply dipping Carboniferous geology to the North and East of the Murrurundi Fault and Mooki Fault systems. The risk of tunnelling through this material is considered to fall somewhere between the levels of risk for the Western and Central tunnel options.

- *Eastern Tunnel - Low:*

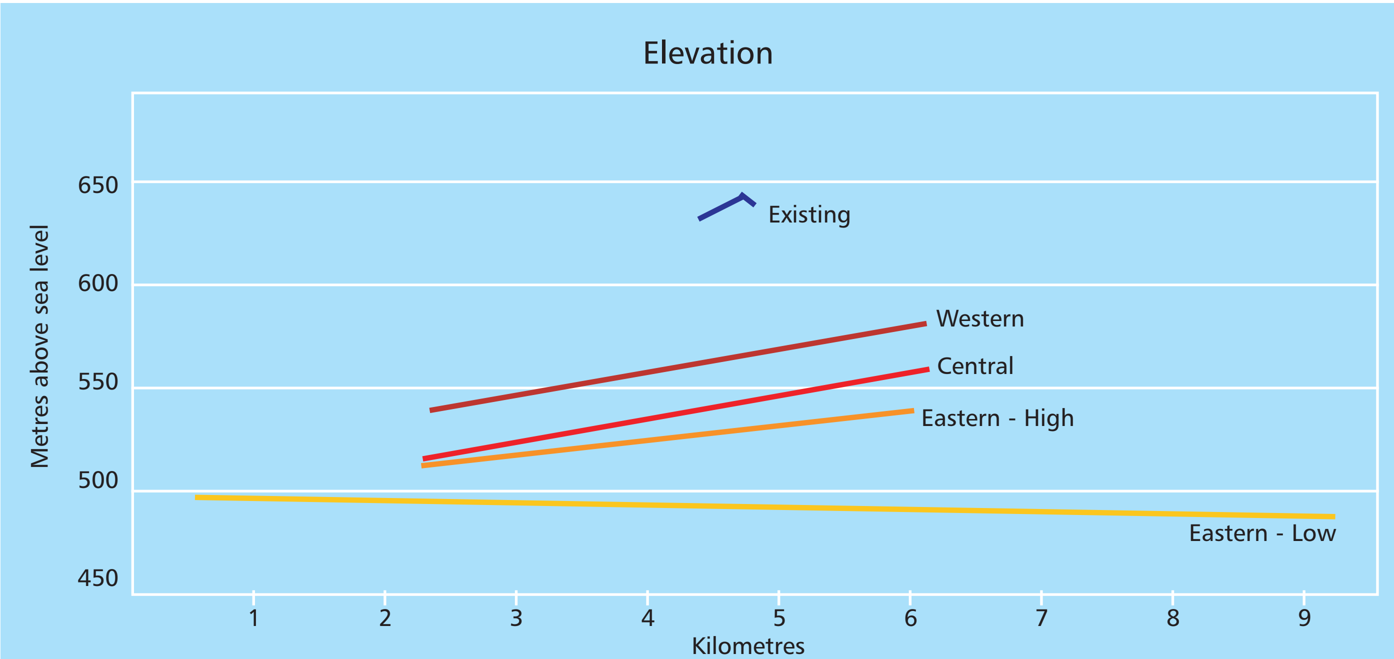
  The Eastern Tunnel - Low option was designed to offer the lowest feasible elevation. It generally follows the Eastern Tunnel - High, but enters into tunnel not far south of Chilcots Creek. Tunnelling risk for this option is similar to the Eastern Tunnel – High. An eastern solution is the only viable option for a tunnel at a very low elevation as the western and central alignments would need to tunnel through the sedimentary formations underlying the Liverpool Range volcanic beds, which is considered an unacceptably high tunnelling risk.

Alignments - Key Data

The following table summarises key characteristics of the alignment options:

	Surface Alignments			Tunnel Alignments			
	Duplication of Existing	Borambil Creek	Doughboy Hollow	Western	Central	Eastern - High	Eastern - Low
Length (km)	30.3	35.24	33.5	30.26	26.54	24.17	23.92
Rising Grade	1:40	1:80	1:80	1:80	1:80	1:80	1:80
Tunnel Grade	-	-	-	1:100 Falling	1:100 Falling	1:170 Falling	1:1000 Rising
Falling Grade	1:40	1:40	1:40	1:80	1:80	1:80	1:80
Tunnel Length (km)	0.49	0.82	0.49	4.16	4.12	4.16	8.76

As discussed above, maximum elevation is a key differentiating feature between the options. The following chart compares tunnel elevation, length and gradient of the tunnel options against the existing Ardglen tunnel. Murrurundi is to the left and Willow Tree to the right.



How would the new alignments be operated?

In ARTC's Hunter Valley Capacity Enhancement Strategy it was identified that double track would be required between Ardglen and Kankool from around 2009. Full double track is expected to be required from Willow Tree to Murrurundi to accommodate volumes over 25 million tonnes per year.

To remain in keeping with this finding, the study considered the options of:

- Building the new alignment as double track.
- Building the new alignment as single track and retaining the existing track to effectively provide double track.

The conclusion was that in all cases the new alignment should be single track only and that the old alignment should be used for all traffic other than loaded coal and grain trains (ie passenger trains, empty coal trains etc).

The reasons for this conclusion include that:

- The existing alignment provides acceptable levels of performance for empty coal/grain trains and non-coal/grain traffic.
- Constructing a tunnel option to the fire and life safety standards required for passenger trains and dangerous goods would add considerably to the cost.
- The surface alignment would be considerably longer than the current alignment, which would add time and cost for non-coal/grain trains but not offer any operating benefit.
- Loaded coal and grain trains would be travelling very slowly on the new alignment and other trains would be able to overtake them using the existing alignment.

It should be noted that the tunnel options effectively provide double track for the entire distance from Willow Tree to Murrurundi, where the surface alignments only provide double track from Willow Tree to Ardglen. Provision of capacity is an important function of any new alignment. Hence to allow assessment of options on a like-for-like basis the cost of duplication of the existing track between the south portal of the existing Ardglen Tunnel and Murrurundi has also been estimated. The cost of this duplication is included in the financial assessment of the surface alignments. However, as double track will be required between Willow Tree and Ardglen at a lower volume than between Ardglen and Murrurundi, cost estimates have been adjusted to reflect this duplication occurring in later years.

Cost - benefit summary

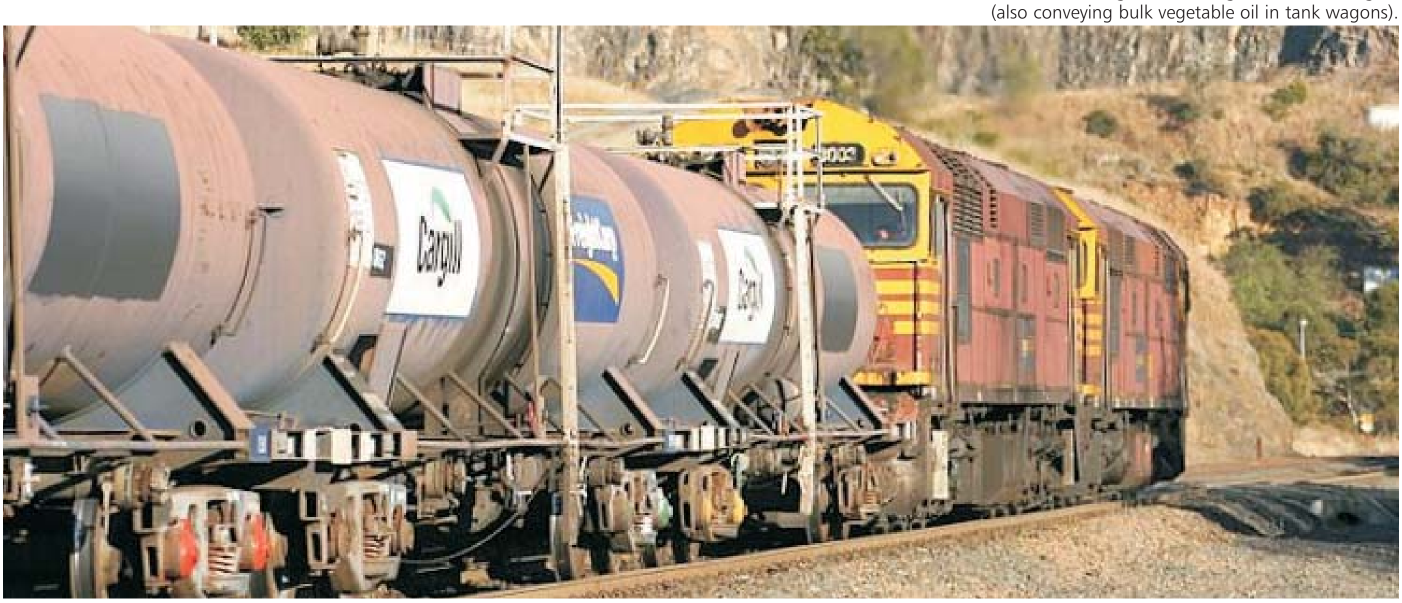
The following table summarises the key results of the study, with the duplication of the existing alignment as the base case.

	Surface			Tunnels			
	Duplicate Existing	Borambil Creek	Doughboy Hollow	Western	Central	Eastern - High	Eastern - Low
Capital Cost ($mill)	$209	$167	$235	$305	$290	$290	$465
Construction risk	Low - Medium	Low	Low	Medium	High	Medium - High	Medium - High
Track maintenance impact ($m per km per year)	Base Case	+$0.1	+$0.2	-$0.2	-$0.3	-$0.4	-$0.5
Benefit of Eliminating Bank Engines ($ per tonne)	Base Case	-$0.43 to -$0.80	-$0.43 to -$0.80	-$0.43 to -$0.80	-$0.43 to -$0.80	-$0.43 to -$0.80	-$0.43 to -$0.80
Benefit of Longer Trains ($ per tonne)	Base Case	-$0.20	-$0.20	-$0.20	-$0.20	-$0.20	-$0.20
Elevation Reduction (metres)	Base Case	0	0	64	88	104	151
Transit time impact (minutes)	Base Case	+20	+21	-10	-18	-23	-33
Transit time impact ($ per tonne)	Base Case	+$0.04	+$0.04	-$0.02	-$0.03	-$0.05	-$0.06
Fuel consumption impact (litres per loaded coal train)	Base Case	+131	+156	-578	-769	-934	-1,150
Fuel cost impact ($ per tonne)	Base Case	+$0.02	+$0.02	-$0.09	-$0.10	-$0.12	-$0.15
Resultant operational savings ($ per tonne)	Base Case	$0.37 to $0.94	$0.37 to $0.94	$0.54 to $1.11	$0.56 to $1.13	$0.60 to $1.15	$0.61 to $1.18

The assumptions behind these numbers are detailed in Appendix 1.

As previously noted, the capital cost estimates have been based on a tunnel cross-section of 50 square metres. In the event that the tunnel diameter was increased to the alternative size of 68 square metres the cost of delivery would increase by approximately $40 million.

Bank engines assist a grain train at Ardglen (also conveying bulk vegetable oil in tank wagons).



What are the commercial issues in building a new alignment?

There are two possible justifications for building a new alignment across the Liverpool Range:

- As a capacity project.
- As a cost saving project.

In practice it is likely that the project will be justified through a combination of cost saving and capacity benefits.

As previously noted, the new alignment is an effective alternative to double tracking of the corridor. Full double tracking is expected to be required to accommodate volumes over 25 million tonnes per year. The Borambil Creek surface alignment has been estimated to cost less than double tracking on the existing alignment. Hence there is a strong prima facie case that a new alignment should be preferred as the means to achieve duplication.

It is important to note though that there are a number of capacity projects that may be required to provide for volume growth prior to complete double tracking. These could become "stranded" investments in the event that a new alignment is ultimately built. If a new alignment is considered by industry to be desirable then there may be a case for bringing forward the timing of a new alignment to avoid asset stranding. This case will be a function both of the capital cost of the short-term capacity projects, and expectations of coal volume growth.

Alternatively, in a slow growth environment it may not be possible to justify a new alignment. A new alignment would need to be built in full to gain the capacity benefit, whereas capacity can be added incrementally on the existing alignment. A series of partial projects on the existing alignment over an extended period of time may have a lower net present value than a new alignment even though the undiscounted capital cost is higher.

These considerations highlight the importance of future volume forecasts in making a decision on a new alignment.

The justification for the capital expenditure on a new alignment needs to come from the project benefits, namely operational cost savings and enhanced capacity.

The incremental revenue that ARTC will require if a new alignment is built will be the capital cost of the project amortised over a period in the order of 35 years at ARTC's discount rate. This incremental revenue will need to come from a price increase for coal haulage. The impact of this on a per tonne basis will be a direct function of the volumes being transported.

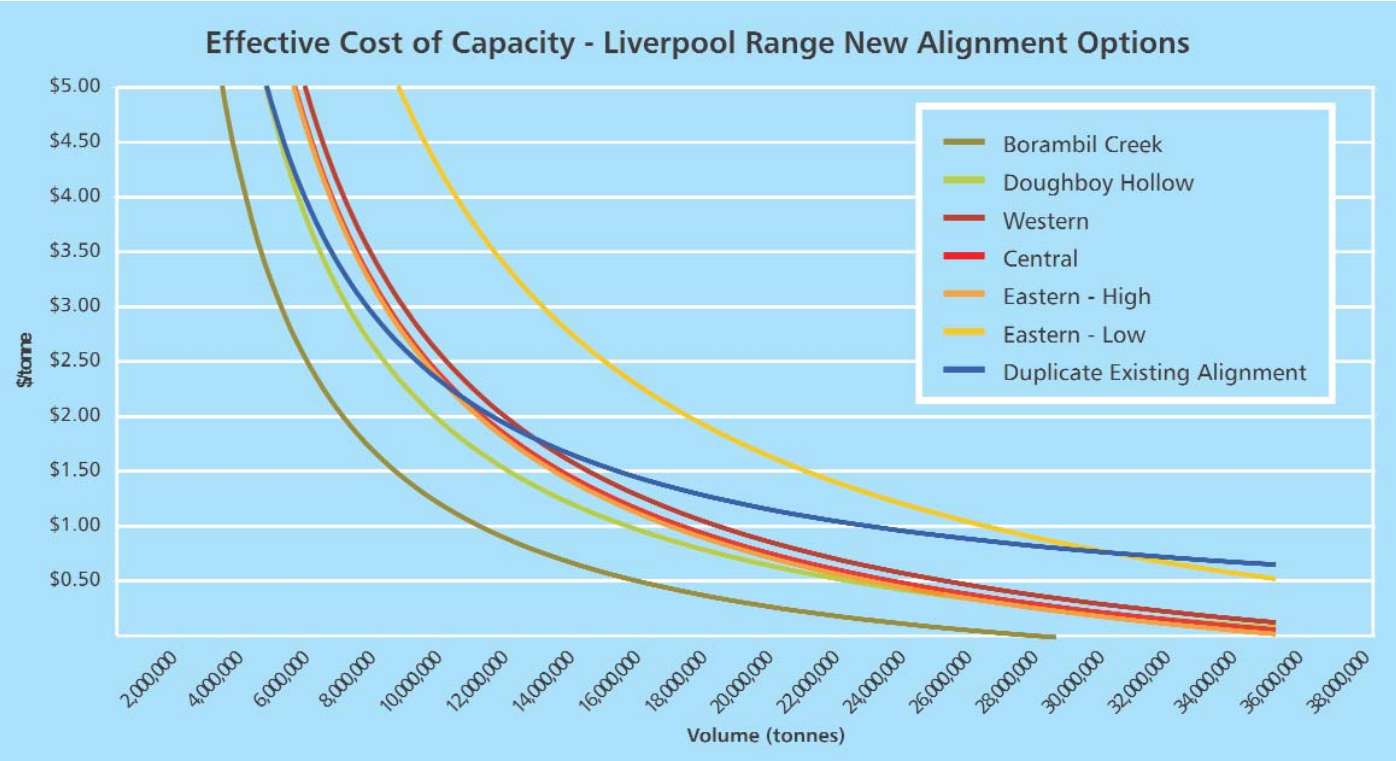
At the same time, coal companies can expect to receive the benefit of the operational cost savings as facilitated by the new alignment.

ARTC's estimates indicate that at currently forecast coal volumes the operational cost saving is unlikely to fully cover the cost of the increased access charge. The 'residual cost' representing the gap between the access charge and the operational cost saving would therefore need to be justified by its capacity benefits.

Thus, the ARTC rate increase, less the operational saving, represents the 'effective cost of capacity'. This effective cost of capacity declines as volumes increase.

The following graph provides a simplified illustration of this. The curves represent the effective cost of capacity (ARTC rate increase minus operational savings) for each of the alignments at progressively increasing volumes. Surface alignments are shown in shades of green and tunnel alignments are shown in shades of red. Duplication of the existing alignment, the base case, is shown in blue.

It is important to note that this graph is simplified in a number of ways. Most importantly, it ignores the effect of the regulatory price ceiling. Second, the capital cost of the surface alignments



includes the duplication of the southern side of the Liverpool Range. This is not strictly required for volumes below 25 million tonnes per year and so the effective cost is overstated below this volume.

What about the other users of the railway?

The discussion above has focussed primarily on coal haulage. There are two main reasons for this.

- First, the existing alignment does not provide the same barrier to most other traffic as it does to coal operations. Only coal and grain trains require banking and only coal trains face train length constraints. For other traffics there is little wrong with the existing alignment.
- Second, coal is the only traffic that has the potential to be able to support the capital cost of a new alignment. While grain will also receive a significant benefit from the removal of the bank engine requirement, this benefit is not sufficiently large in total value to have much influence on the decision making process.

Nonetheless the value to the grain industry of the elimination of bank engines is an important consideration and ARTC will be consulting with the grain industry as the project moves forward.

Next Steps

As previously noted, the analysis of the viability of a new alignment is sensitive to the various input assumptions - in particular the assumed operational cost savings and the assumed future coal volumes.

For this reason, the next step to progress the decision making process is further consultation with the mining companies and the rail operators.

The infrastructure costs are also preliminary at this stage of the project development process. Final costs will depend on many factors that will be progressively firmed-up as the project develops. In the event that the industry is supportive of the project progressing, firming-up project costs will be a key focus of the next stage of project development.

It is also important to note that the study has only identified a number of potential alignments. A final alignment can only be determined as part of the process of gaining environmental approvals. This was not part of the current study, and ARTC will only seek such approvals when industry support and financial commitment for the project has been confirmed. The feasibility and cost can only be confirmed once the environmental approval process is complete.

An empty coal train emerges from the northern end of Ardglen tunnel.

Appendix 1: Notes to results table

The following notes provide an explanation of the derivation of each line item in the cost/benefit summary:

Capital cost

In the first instance, capital costs were estimated by Quantm. Quantm undertakes cost estimating primarily for the purpose of cost optimisation of alignments. To this end it bases its cost estimates on quantities multiplied by standard unit rates, but does not include project level costs. Estimates are therefore highly reliable between alignments, but not necessarily accurate in absolute terms.

To address this, one surface alignment and one tunnel alignment had their Quantm costs further refined by a cost estimating engineer. Overheads like project management costs and contingency allowances were included at this stage to provide a total expected outlay.

The result of this refinement was a 40% escalation from the initial Quantm cost to the final expected Capital Cost. Rather than have the cost engineer individually cost each of the other alignments, the 40% escalation factor was consistently applied to the Quantm cost.

The surface options have an advantage over the tunnel alignments in that they can be constructed in stages. From a capacity perspective construction of a surface alignment on the Gunnedah side of the range would be required before duplication is necessary on the Murrurundi side. Coal forecasts suggest that the delay between the two stages will be around 5 years. For this reason, the capital costs for surface alignments quoted in the results table have been adjusted so that the cost of duplication on the eastern side is discounted by 5 years.

It should be noted that land acquisition costs have not been included in the estimates at this stage. Land acquisition cost will be highly dependent on the detailed effects of the new alignment on individual properties and the ability of ARTC to repackage severed parcels of land. At this stage the complexity of this makes estimation with reasonable confidence impossible.

Construction Risk

Construction risk is not possible to objectively quantify and is provided as a guide only. The primary basis for the determination of the risk level is geological issues.

Track maintenance costs

The relative track maintenance cost is a factor that could contribute to a differentiation between the options.

Track maintenance costs were estimated based on typical current costs, as follows:

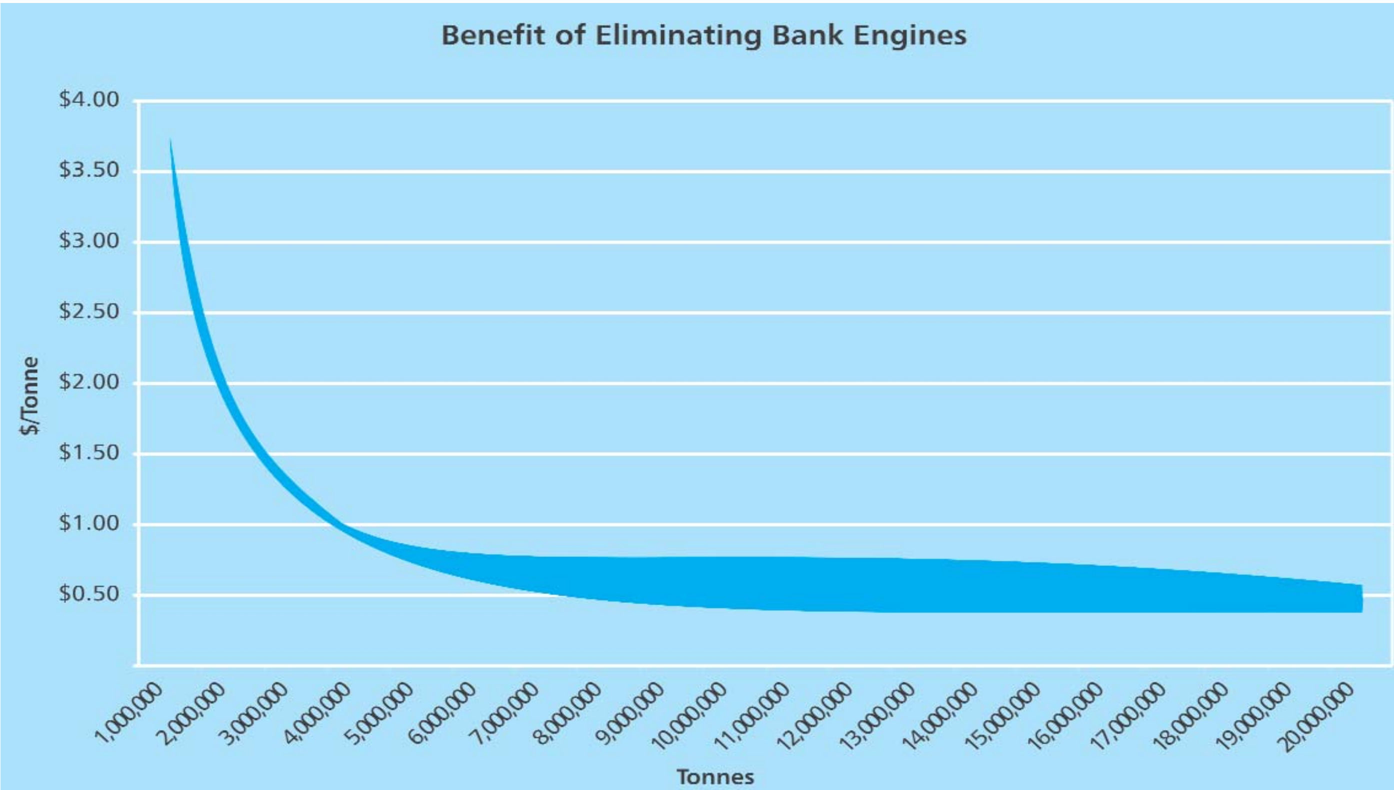
Track type	Corridor	Maintenance cost ($ per km per year)
Single track	Existing	$36,000
Double track	Existing	$56,100
Single track	New surface alignments	$28,000
Single track	Tunnel alignments	$19,600

Tunnel alignments are forecast to have a slightly lower average cost as they are generally straighter than the surface alignments. Track maintenance costs on the existing corridor are higher than typical track maintenance costs due to the highly unstable geology.

From the results table it is apparent that maintenance costs are a minor consideration in the analysis.

Operator cost savings from the elimination of banking

A range of projected operator cost savings from the elimination of banking have been modelled, based on different standard train sizes. The range of results is shown in the graph below.



It is assumed that a set of bank engines is only realistically capable of assisting four trains per day. This results in a sawtooth effect as additional sets of bank engines are required to be added at threshold tonnages. This is smoothed out in the above graph.

The bank engines are assumed to be matched to the train engines (ie if a train requires two locomotives in its standard configuration, it is assumed that two locomotives of the same class are used as bank engines).

For the purposes of this analysis it is assumed that the standard trains are 30 tonne axle load.

The cost savings range from $0.43 to $0.80 per tonne once tonnages exceed 5 million tonnes per year.

It is important to note that these cost estimates are provided for the purposes of gaining an overall sense of the relative merits of a new alignment. It is expected that coal producers will make their own assessment of potential savings in consultation with train operators.

Operator cost savings from longer trains

For the purpose of this calculation it is assumed that 30 tonne axle loads will be introduced before the new alignment is completed. Hence the standard trains on the existing alignment are assumed to be:

- In the case of PN, 60 x 120 tonne wagons.
- In the case of QR, 74 x 120 tonne wagons.

The likely cost saving from increasing standard train length has been modelled. This is zero (where there was no increase in train length) up to $0.20 per tonne, with the result constant across all volumes.

Elevation Reduction

Elevation is a critical issue for fuel consumption and transit time. The elevation reduction has been calculated as the difference in elevation between the current summit in Ardglen tunnel and the highest point on the alternative alignment.

Transit Time Saving

Train operations on each of the routes have been modelled using the train simulation software M-Train. Following consultation with the operators, a range of representative train consists were simulated with the average results being quoted in the results table.

The transit time saving is the difference between the simulated transit time for the current route with bank engines, including attach and detach time, and the simulated transit time for the alternative alignments. Twenty minutes has been allowed for bank engine attach and detach.

It is important to note that transit time is directly related to the amount of power applied to lifting a given weight to a given elevation. As the two surface alignments have the same maximum elevation as the current alignment but apply only half the power, the pure transit time is approximately double. This is of course offset by the removal of the bank engine attach and detach time.

Operator cost savings from reduced transit time

The estimated impact of reduced transit time has been modelled using the same parameters as for the cost savings described above. A one hour reduction in transit time produces a saving of between $0.09 per tonne and $0.12 per tonne depending on train size, with the smaller the train the greater the saving. A benefit of $0.10 per tonne per hour has been used as an approximate average of the results.

Fuel savings

As previously noted, a range of train operations have been simulated with M-Train based on trains of around 1,200 metres. Fuel consumption savings have been derived direct from the simulations. The assumed fuel price to calculate the dollar saving is $1.00 per litre.

As already noted, fuel consumption is closely related to elevation. The surface alignments climb to the same elevation as the existing alignment. However, as they are close to twice the length, there is additional rolling resistance which results in a small increase in fuel consumption.

Resultant Operational Cost Savings

This is the sum of the cost impacts of elimination of bank engines, increasing train length, transit time and fuel consumption.

The range represents the highest and lowest possible outcomes.