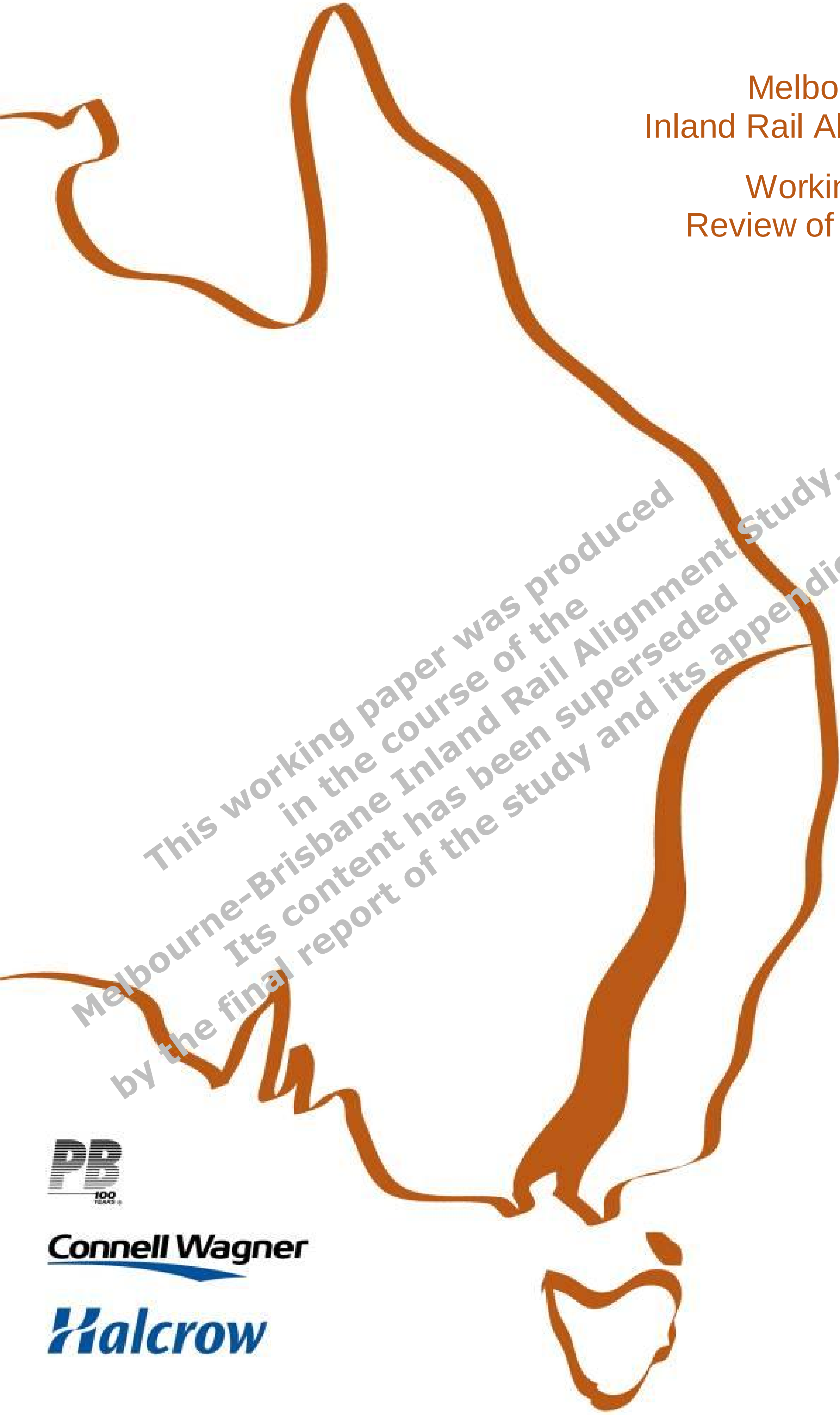
ARTC

Melbourne–Brisbane Inland Rail Alignment Study

Working Paper No. 2 Review of Route Options



PB

Connell Wagner

Halcrow

Contents

List of tables

List of figures

List of appendices

1. Introduction

In March 2008 the Australian Government announced that the Australian Rail Track Corporation (ARTC) had been asked to conduct the Melbourne-Brisbane Inland Rail Alignment Study.

The announcement stated that in developing a detailed route alignment, the ARTC would generally follow the far western sub-corridor identified by the previous North-South Rail Corridor Study (NSRCS) and shown on the map below. This study, completed in June 2006, established the broad parameters for a potential future inland rail corridor between Melbourne and Brisbane.

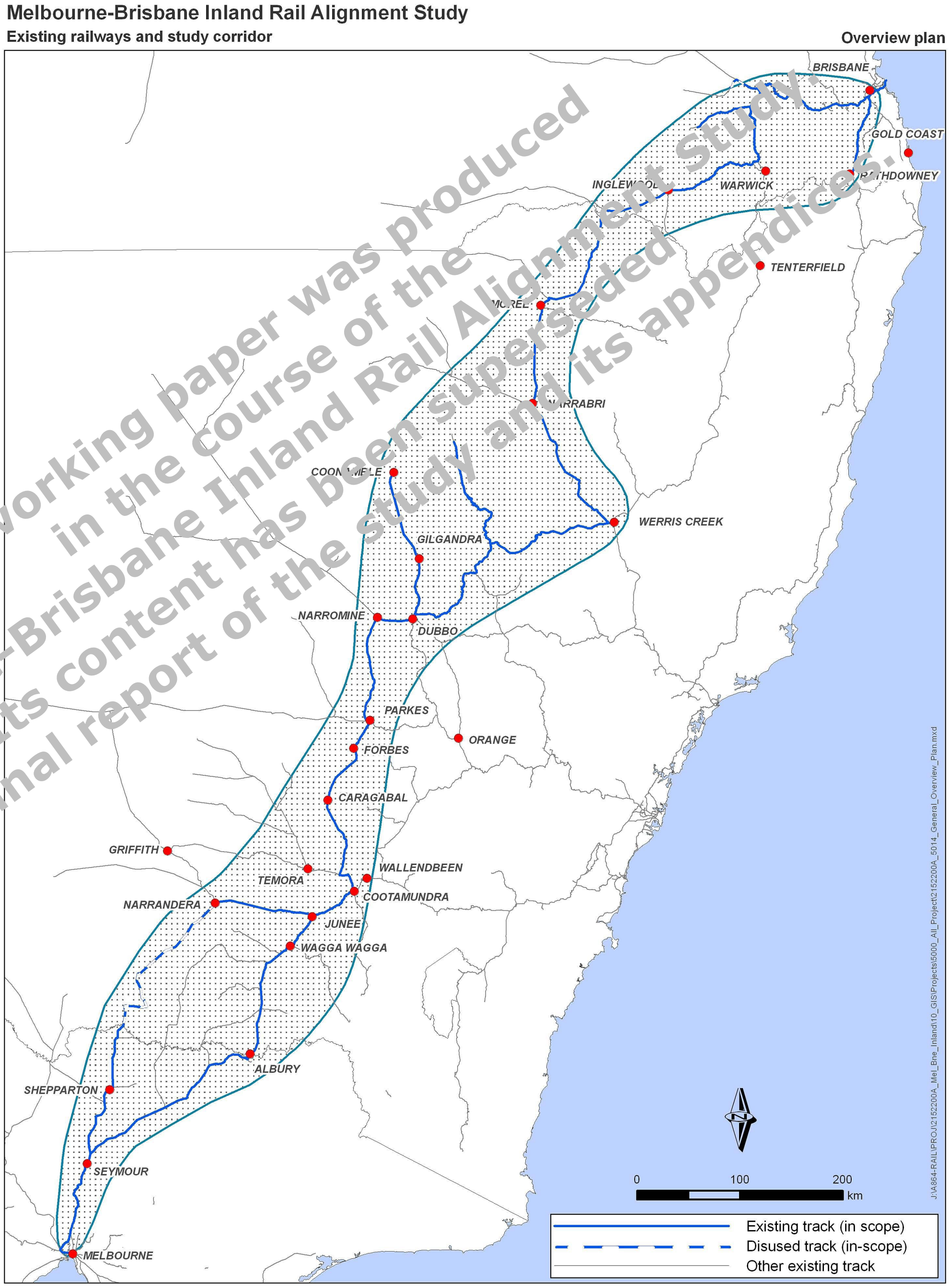


Figure 1-1 Melbourne–Brisbane inland rail corridor

1.1 Background to Melbourne-Brisbane Inland Rail

The railways of NSW, Victoria and Queensland date from the 19th century. They were constructed using different gauges and developed for differing purposes. At present, the only north-south rail corridor in eastern Australia runs through Sydney. North of Sydney it is fairly close to the coast. For that reason, the existing Melbourne-Brisbane rail line is referred to as the coastal route throughout this working paper.

In September 2005 the Australian Government commissioned the North-South Rail Corridor Study which undertook a high level analysis of the various corridors and routes which had been proposed for an inland rail alignment to provide an additional rail line to move freight from Melbourne to Brisbane by rail.

In March 2008 the Australian Government announced that the ARTC had been asked to conduct the Melbourne-Brisbane Inland Rail Alignment Study to build on previous work by undertaking a more detailed engineering, land corridor and environmental assessment, to allow scoping of the project's capital cost. In the announcement, the Minister for Infrastructure, Transport, Regional Development and Local Government requested a customer focused and consultative study involving consultations with state governments, industry, local governments and major rail customers.

1.2 Study objectives, stages and working papers

The objectives of the Melbourne-Brisbane Inland Rail Alignment Study (the study) are to determine:

- the optimum alignment of the inland railway, taking into account user requirements and the economic, engineering, statutory planning and environmental constraints. The alignment will be sufficiently proven up so it can be quickly taken through the statutory planning and approval process and into the detailed engineering design and construction, should a decision be taken to proceed;
- the likely order of construction costs +/-20%;
- the likely order of below-rail (infrastructure) operating and maintenance costs;
- above-rail operational benefits;
- the level and degree of certainty of market take up of the alignment;
- a project development and delivery timetable; and
- a basis for evaluating the level of private sector support for the project.

The study is being carried out in three stages, as follows:

- Stage 1 — Determination of the Route for Further Analysis;
- Stage 2 — Engineering, Environmental and Land Base Analysis; and
- Stage 3 — Development of the Preferred Route.

A series of working papers are being produced within each stage. A list of the planned working papers follows.

Table 1-1 Working papers

Stage		Working paper	Lead Responsibility
Stage 1	WP1	Demand and Volume Analysis	FEC
	WP2	Review of Route Options	LTC
	WP3	Stage 1 Capital Works Costings	LTC
	WP4	Preliminary Operating and Maintenance Cost Analysis	LTC
	WP5	Stage 1 Financial and Economic Assessment and Identification of the Route for Further Analysis	FEC
Stage 2	WP6	Design Standards	LTC
	WP7	Preliminary Environmental Assessment	LTC
	WP8	Preliminary Land Assessment	LTC
	WP9	Engineering Data Collection	LTC
	WP10	Development of Alignment Options	LTC
	WP11	Stage 2 Capital Works Costings	LTC
	WP12	Stage 2 Economic and Financial Analysis and Confirmation of the Preferred Route	FEC
Stage 3	WP13	Preferred Alignments Environmental Assessment	LTC
	WP14	Preferred Alignments Land Assessment	LTC
	WP15	Refinement of Preferred Alignments	LTC
	WP16	Stage 3 Capital Works Costing	LTC
	WP17	Delivery Program	LTC
	WP18	Stage 3 Economic and Financial Assessment	FEC
	WP19	Policy Issues, Options and Delivery Strategies	FEC

1.3 Roles of the Lead Technical Consultant (LTC) and the Financial and Economic Consultant (FEC)

The study's activities are headed by two lead consultants whose activities are coordinated by ARTC.

The Lead Technical Consultant is responsible for engineering and environmental work and associated activities, including railway operational analysis. The Financial and Economic Consultant is responsible for financial and economic analysis. The two consultants work jointly and collaboratively with each other.

The Lead Technical Consultant (LTC) is Parsons Brinckerhoff (PB) and the Financial and Economic Consultant (FEC) is PricewaterhouseCoopers (PwC). Each consultant acts independently and each has a lead responsibility for specific working papers. Whilst this occurs the other consultant plays a support role for that particular working paper.

Parsons Brinckerhoff has engaged Halcrow to support it in alignment development, operations and maintenance costing and Connell Wagner to support it in engineering and alignment development. Connell Wagner has in turn engaged Currie and Brown to assist in capital costing.

PricewaterhouseCoopers has engaged ACIL Tasman to undertake volume and demand analysis and support it in economic review, and SAHA for peer review.

1.4 Working Paper No. 2 objectives

Two of the study's objectives are pertinent to Working Paper No. 2 namely:

- the optimum alignment of the inland railway, taking into account user requirements and
- the economic, engineering, statutory planning and environmental constraints above-rail operational benefits.

This working paper has developed a number of engineering data, environmental constraints and operational measures in relation to the route options under consideration. Some are input factors into the capital costs of Working Paper No. 3 and the operational (below-rail) costs of Working Paper No. 4. Working Paper No. 5 will consider general engineering and environmental aspects, along with specific capital and operational costs for each route, as part of the determination of the preferred route.

A description of the GIS mapping approach is outlined in Section 2; the summary review for each route section is in Sections 4 and 5.

Working Paper No. 2 does not offer a preferred route nor does it rank routes in any particular order. The objective of Working Paper No. 2 is to inform readers of the technical features of each route and provide input into subsequent working papers. A preferred route will be identified in Working Paper No. 5.

The Lead Technical Consultant identified a number of above-rail operational benefits (productivity benefits). These are:

- minimising the rail distance between Melbourne and Brisbane, thereby enabling quicker journey times, lowering energy usage and fuel costs, and improving asset use and labour productivity
- minimising curve and gradient profiles, thereby lowering energy usage and fuel consumption
- increasing track strength in order to accept higher axle loading, and increasing loading gauge thus enabling higher load densities, and double stacking of containers leading to higher wagon use and lower energy usage (and fuel consumption)
- minimising rail access costs by minimising infrastructure capex costs and (infrastructure) maintenance costs (track possessions and non-availability of track are included in maintenance costs.).

The relationship between access pricing, capex, maintenance costs and the benefits to above-rail operators can become complex when different parties, such as track owners, rail operators, governments and private financiers participate in the development of an inland rail line.

Working Paper No. 2 reviews some of the technical efficiencies that cross the rail-wheel boundary. It examines how these can assist the rail operator, putting aside funding and market transactions between above- and below-rail operators (including those of access pricing).

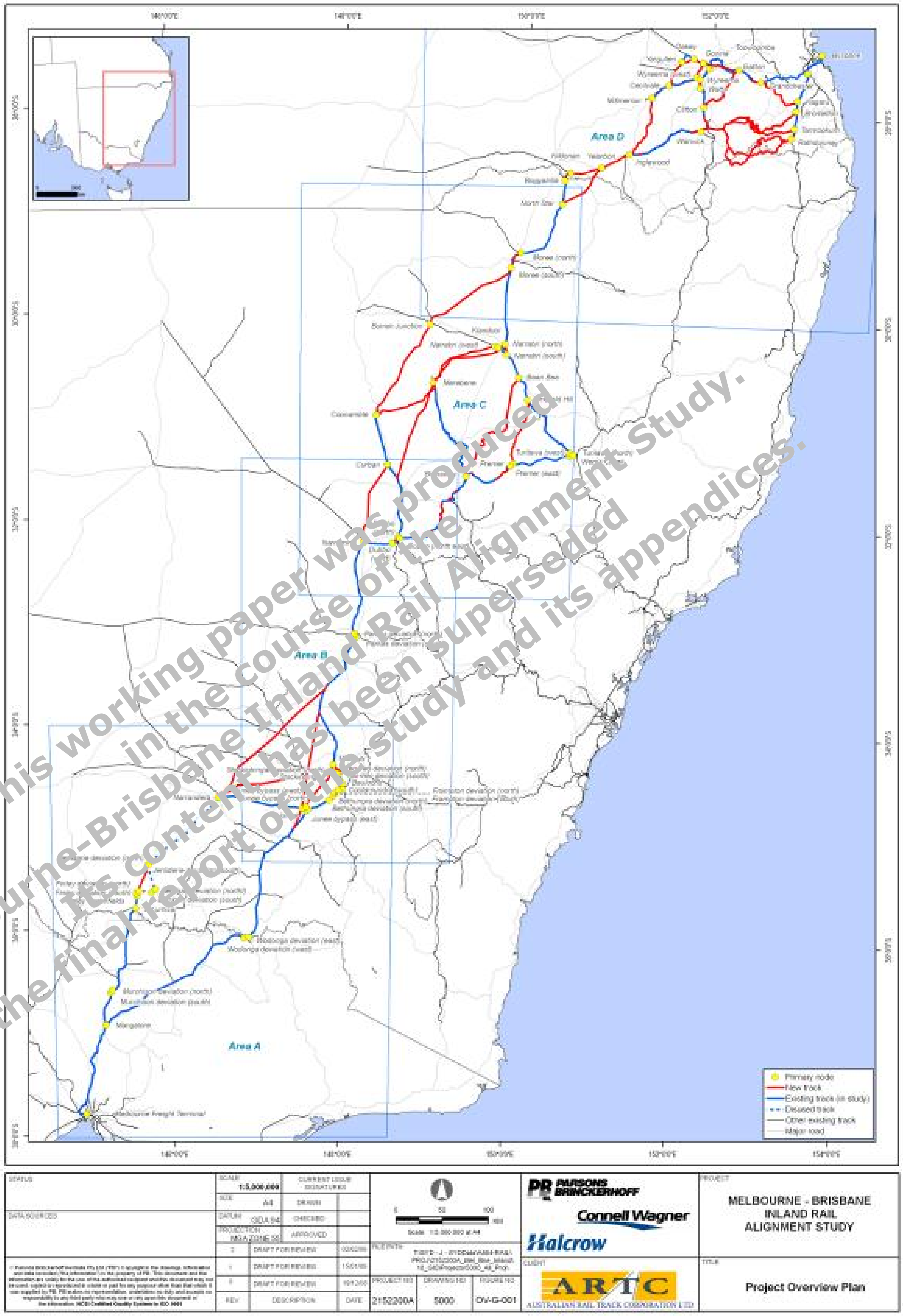


Figure 1-2 Study overview map

2. Overall approach to the study

2.1 Introduction

This section provides an overview of the approach to this study. Refer to Appendix B for further detailed discussion.

Significant track already exists that can be utilised. Some 1,419[1] km of track from Melbourne to Moree (via Albury, Parkes and Werris Creek) could form part of an inland rail route. This previous rail investment represents significant value, not only in rail formation but also in land ownership and rail use entitlement. The amount of value will assessed through price differentials of new build versus upgrade track costs, and land acquisition and assessed in terms of journey time and track performance in WP5.

Working Paper No. 2 (WP2) has been prepared to achieve two primary goals:

- **to review route sections** (within the scope of Working Paper No. 2)
- **to provide supporting data** for other working papers.

The following issues were considered in the development of the Working Paper 2 approach.

2. The significant extent of the study, which included:
   - Melbourne–Brisbane direct distance 1,366 km
   - total track distance studied 6,400 km
   - number of sections (routes) studied 140
3. Stage 1 is essentially an options evaluation process to determine a preferred route between Melbourne and Brisbane. Accordingly, the accuracy of output associated with WP2 must be appropriate for comparison between alternative alignments.
4. Supporting data is required for capex, opex, maintenance, and travel time assessment of alternative sections. Capital works (order of cost estimates) in Working Paper No. 3 are significant Stage 1 deliverables for the LTC. The quality of these estimates is heavily dependent on the accuracy of quantities. The degree of accuracy required for cost estimates influenced the method for preparing Working Paper No. 2.
5. In some instances, different scenarios of track configuration, such as axle load, gradient and curvature, were developed, particularly between Warwick and Acacia Ridge. This was technically outside the scope for Working Paper No. 2, but was necessary to ensure a cost-effective solution could be found for this particularly expensive area. These options were reconciled using experienced engineering judgment, establishing core standards and consulting with the ARTC.
6. Information regarding existing rail corridors and associated infrastructure was of varying quality and degree of completeness. Again, engineering judgment was applied to determine the best use of this information.

WP2's primary goals were achieved within five main activities:

- information collection
- establishment of configuration for the new railway infrastructure
- data mapping

[1] This represents 61% of the longest route.

- quantity generation
- desktop assessment of each section.

An outline of these activities is provided below.

The study was broken into four geographical areas between Melbourne and Brisbane. Figure 1–2 (page 7) indicates the extent of these areas.

Boundaries between areas were located near common nodes of alternative routes. The extent of the four study areas was as follows:

- Area A: Melbourne to Junee
- Area B: Junee to Narromine
- Area C: Narromine to Moree
- Area D: Moree to Brisbane.

The point at which alternative routes diverge were identified as nodes. Study data, such as travel time or quantities, were generated for each route section.

Study data, generated at the route section level, can be rolled up across a number of sections or the total route, depending on the type of evaluation used.

This study uses the following terminologies.

- 'Route' is used to describe paths on a map through several nodes. It is used in a planning context and generally for the collection of data.
- 'Area Route' is a route over an entire area (A, B, C or D). The total route refers to an inland route between South Dynon and Acacia Ridge.
- 'Route Section' is the lowest identified route within an area.
- 'Corridor' is used to describe a wide swathe (several kilometres) of land for a rail track. It is used where there is uncertainty or variability of a route. It is used for broad planning.
- 'Alignment' is used to describe the exact positioning of track. It is used in the context of horizontal and vertical curvature, navigating around topography and other land and environmental features.
- 'Line' is used to describe an existing track section. For example, the Junee to Hay line is the existing track from Junee to Hay.

2.2 Overview of methodology

2.2.1 Information collection

A considerable array of information was required for Stage 1 of this study. It included:

- previous studies
- existing railway infrastructure data
- topographic, environmental, land use/valuation and public infrastructure data
- standards/guidelines
- recent railway maintenance cost data.

Information was gathered from a variety of sources that included:

- ARTC
- other railway owners: RIC, VicTrack and Queensland Rail
- federal and state government departments
- interest groups
- councils and shires
- third party data providers.

The study also had access to electronic data previously gathered for NSRCS (2006).

Detailed field information was not pursued for Stage 1 due the extent of the study, the comparative nature of Stage 1 and cost/time limitations. For example, survey and geotechnical ground condition information was available in a limited degree of accuracy. Ground profiles derived from satellite imaging with an equivalent accuracy of 5 m contours were applied for survey information. Geotechnical assessment was based on local geological maps. In both instances, the quality of available information was suitable to comparatively assess study route sections.

Information was provided in a variety of formats that included:

- hardcopy — plans and reports
- electronic spatial information — CAD or GIS files
- electronic asset registers
- websites.

2.2.2 Infrastructure performance and configuration

A future inland rail line between Melbourne and Brisbane will run on new track (in greenfields) and on existing track. The physical extent and cost of track works is determined by a range of performance criteria that would form the technical configuration of a new railway. The configuration of railway infrastructure significantly affects train operation performance like travel time, energy usage and fuel consumption.

Track configuration

Table 3-1 summarises track configuration details assumed for this working paper. These parameters will be tested and optimised in Working Paper No. 6 (Stage 2) in order to inform further work in the study.

Table 2-1 Track configuration

Issue	Assumed configuration	
Track gauge	Standard (Upgrade existing narrow to dual gauge)	
Track capacity and class	Existing track and bridges 21.5 tonne axle load min. at 115 km/h, i.e. no upgrade for classes 2, 1C, 1XC New track (greenfields or upgraded) Class 1C 25T min. at 115 km/h, i.e. upgrade classes 3, 4 and 5 to class 1C. New bridges (greenfields or upgraded) 32.5 tonne axle load min. at 115 km/h	
Track alignment geometry (new only)	Max. grade — 1 in 80 Min. curvature — 800 m	
Track formation	Width: 7.0 m (excludes access roads) Height: 500 mm minimum	
Structure outline	New track 7.1 m high x 5 m wide (double stack profile)	
Road crossings	Grade separation	for major and minor arterial roads
	Level crossing — active controls	for sub-arterial, collector and local roads
	Level crossing — passive controls	for other roads

Infrastructure elements

Typical infrastructure elements expected for a new railway were identified using engineering judgment. These included:

- track — rail, ballast and sleepers for new, upgraded and dual gauge
- track earthworks (for five different terrain types)
- road crossings
- water crossings, including floodplains
- geotechnical treatments
- fencing.

Sample designs for a range of standard elements were then documented and forwarded to the cost planners for development of unit rates. Details of these sample designs and their application are discussed in Appendix B.

Existing infrastructure, such as bridges and level crossings, was assumed to require an upgrade only if the existing track was to be upgraded.

Quantities for each standard infrastructure element were generated automatically for each route section.

2.2.3 Data mapping

Geographical information systems (GIS) were used to map all electronic spatial data. GIS allow the visual overlay of spatial information for ease of assessment. Two types of information applied within GIS were reference geo-database data and study route sections.

Reference geo-database information is a compilation of spatially related data from a range of sources that act as the background for the study. Examples of this information include:

- land use, e.g. urban, commercial and rural public infrastructure, e.g. roads
- topographical information, e.g. watercourses and elevation contours
- current ARTC infrastructure, e.g. track alignments, road crossings and bridges.

Route sections were generated in GIS by the LTC team. The variety of methods used in the generation of route sections for incorporation into GIS included:

- direct transfer of alignments previously generated in GIS, e.g. ARTC existing track asset data and from the NSCS
- 3D engineering alignment tools, such as 12D (before transfer to GIS)
- 2D CAD alignment drafting (before transfer to GIS).

The combination of the reference geo database and route section data in GIS provided the LTC team with a powerful means of visualisation, quantity generation and assessment of route sections over the study's vast extent.

2.2.4 Quantity generation

GIS was used to generate quantities for each route section. Quantities were generated to provide:

- summary information for each study route section to be documented in Working Paper No. 2
- data tables (refer Appendix C)
- a basis for capital cost estimation of each route section by the cost planners for Working Paper No. 3
- final track data for train modelling, operation and maintenance costings.

Quantification rules were written in GIS scripts that analysed the length of every study section in two ways:

- an infrastructure element type was allocated (and counted) where a route section intersected an existing environmental or built feature. For example, a grade-separated road crossing was allocated and counted when the route intersected with an arterial road; and similarly when a route section crossed a waterway.
- the length of the environment feature (in which each route section traversed) was measured. For example, the total length of track in black soil geology was measured.

Unit rates developed by cost planners from sample designs for standard infrastructure elements were then applied to the quantities to determine capital works cost estimates.

2.2.5 Route section desktop assessment

Teams dedicated to each area assessed each route. Section 6 provides a summary of these assessments. Appendix C provides a detailed description of route section assessments supported by an environmental map, topographical map and data tables with essential statistics.

Commentary for each route section covered the following topics:

- section description, including:
  - terrain
  - alignment
- key constraints and features, including:
  - engineering
  - geotechnical
  - road and water crossings
- environmental
- land use
- construction and access
- opportunities for improvement.

At the completion of route section assessments, each area team was able to prepare area route comparisons. Then the total route option evaluation and selecting a preferred route between Melbourne and Brisbane could take place.

2.3 Previous studies

2.3.1 General

The 2006 North-South Rail Corridor Study has been a focus for the current study. A number of promoters and developers provided route options into the NSRCS. The LTC used GIS electronic files from NSRCS for engineering reviews and as the basis of inputs into Working Paper Nos. 3 and 4. Working Paper No. 2 has used the information from the NSRCS as the basis of its review.

The LTC has not assessed the adequacy of all this information. However, it is apparent that the extent of detailed engineering on different routes varies, and some promoters have further developed engineering detail since the NSRCS.

Studies by GATR, ATEC, Cunningham Rail Link, Greater Shepparton City Council, QR and QT have also been considered in Working Paper No. 2. The LTC appreciates the support of the promoters of this previous work, and the access provided to the information. It has helped the LTC gain a deeper understanding of technical issues associated with the various route options and assisted it in presenting an integrated review and assessment of these options.

Further detailed information may be made available to the LTC and as such the review in Working Paper No. 2 extends only to the information currently available.

2.3.2 Response to specific route proposals

The Great Dividing Range (Warwick/Toowoomba)

The LTC was conscious of the need to ensure an adequate review of the different proposed routes from the Darling Downs to Brisbane occurred. This was because of the likely construction costs resulting from the rugged terrain; distances involved; and their impacts on the viability of an inland railway project.

Although The Cunningham Rail Link report provided useful information, unfortunately the level of technical data was not sufficient for a detail comparative route analysis of options between Warwick and Toowoomba.

To ensure that a comparison was available, and that due regard was given to the claims of proponents of the Warwick options, the LTC developed a number of route options through Warwick. This development exercise was separate from, but run concurrently with the review process for Working Paper No. 2.

The LTC developed three different route options:

1. Warwick to Rathdowney
2. Warwick to Tamrookum
3. Warwick to Bromelton.

Within these route options, 12 different section options were further developed. These sections started with superior 1 in 100 grades but involved deep spirals and 'figure 8', within the Great Dividing Range. This involved extensive tunnelling and viaducts.

Sections were then developed to progressively relax grade performance to that comparable with sections of the Toowoomba option (Fig 60).

All these sections are described in Area D within Section 5.4 and will be priced in Working Paper No. 3.

A further route was developed, which branches off at Clifton (north of Warwick) and heads directly to Gatton.

Horizontal and vertical grading diagrams were produced for each route and section as part the development work for range crossing at Warwick.

The quickest route identified from Moree to Acacia Ridge is via Warwick and Tamrookum but this comes at a very significant engineering cost (12.5 km of tunnels and 14 km of high viaducts compared with a Toowoomba option of 6.5 km of tunnels and 0.3 km of viaducts[2]). The engineering feat required of any of the Warwick routes is substantially more than those of the Toowoomba.

The journey time for a route from Inglewood to Millmerran and Oakey is 38 minutes longer than the quickest route but likely to have additional benefits.

The 'Via Recta' proposal initially developed in 1884 as a direct route from Warwick to the coast remain the shortest and most direct route. However, the costs to achieve this are likely to be very significant, with marginal journey time savings and it is likely to have fewer other benefits.

Great Australian Trunk Railway (GATR)

The LTC was asked to review information provided by GATR.

[2] Another option of Warwick, Clifton and Gatton has 12 km of tunnels and 11.5 km of viaducts. Alignments for range crossings at Warwick were based on 20 m topographical contours for the purpose of comparative analysis with a Toowoomba crossing. Subsequently 5 m contours were procured, which indicate alignments are not optimised for engineering. Nevertheless errors in overall tunnel and viaduct lengths between 5 and 20 m contours are not considered significant in rugged terrain and for the purposes of comparative analysis. No further development work is envisaged.

Elements of the GATR proposal are similar to information provided through the previous study (the North-South Rail Corridor Study), that is, the Gowrie–Grandchester route, Narrabri–Moree, parts of the Moree–Gowrie alignment as well as the Shepparton–Narrandera option.

For those elements, route sections described in Section 5 of this study are broadly considered as common with GATR.

However, there are some very important differences in other areas. Notably, GATR propose a direct route from Narrandera to just south of Forbes and a new line near Parkes heading north towards Narromine and Dubbo and stretching up to Merebene then onto Narrabri.

The GATR track configuration advocates flat track with curves of 10,000 m for a new type of Australian rail operation.

The GATR proposal is a 'clean sheet' approach with basically new build construction or major reconstruction throughout the whole route, including land acquisition.

The overall GATR routes appear in the area maps in Section 5. GIS quantity information has also been developed and sent to the cost planners for capex estimating.

Preliminary curve and gradient diagrams based on 5 m contours and 2000 m radius, have been developed that are loosely based on the GATR routes.

As a way of technically reviewing the significance of GATR with other routes, a general comparative plan and profile review was developed. This comparative review placed elements of existing track with proposed upgrades and new builds, including specific Toowoomba, Warwick and Shepparton options, as well as GATR elements.

This comparative analysis does not endorse any of these particular routes. It merely demonstrates some geographical features, different track upgrade comparisons, and also provides a context for the reader when reviewing detailed information further in this report.

3. Approach to railway operations

3.1 Introduction

Optimising the operational aspects of an inland railway involves the interaction between freight demand; locomotive power; train mass; axle loads; train length; maximum speed track ruling gradient; and curves.

Because of the lumpy nature of rail capacity, initial rail path capacity is expected to exceed demand for some time. Maximising payload, simply to minimise the number of trains for a given capacity, is not considered a determinant of the train design. Infrastructure capacity (the ability to carry enough trains) will be considered in later stages of the study. In Stage 1, it has been assumed that a single track railway with passing loops will be able to carry all likely tonnages.

3.2 Reference train

To provide a base to inform infrastructure design and to help clarify the likely characteristics of the railway operations, a reference train was developed.

The reference train:

- has three 3,220 kW AC drive locomotives
- is 1,800 m long
- has 40% of its containers double stacked
- is capable of 115 km/h on 21 t axle load track
- carries 292 TEU containers weighing 2,920 t and has a trailing load (includes wagon) of 4,456 t gross

The heaviest locomotives currently in service have an axle load of 23 t, and are restricted to 80 km/h on existing routes. Future growth is expected to see demand for wagons capable of running at 115 km/h with 25 t axle loads.

3.3 Ruling gradient

At present, there is a 20 km section of the Melbourne-Albury line[3] approaching Heathcote Junction, between Melbourne and Seymour, where gradients are around 1 in 50. This is likely to be the steepest prolonged section of standard gauge railway on the far western sub-corridor.

3.4 Curvature

Curvature in the track increases the rolling resistance of the train, requiring more power to maintain speed than straight track. In general, curves sharper than 800 m have pronounced effects on permissible line speed and on rolling resistance.

[3] The standard gauge line between Melbourne and Albury is officially called the 'North Eastern Standard Gauge Line (NESG). This study will simply use Melbourne to Albury Line, unless there is any likelihood of confusion.

3.5 Journey time

3.5.1 Average train speed

The previous NSRCS identified transit time between Melbourne and Brisbane (specifically 27 hours) as a significant factor[4] in moving market share from road to rail transport.

As a starting point, this study considered whether this transit time can be achieved using much of the existing rail corridor from Melbourne to North Star (via Albury, Cootamundra, Parkes, Narromine, Binnaway, Werris Creek and Moree) and new construction from North Star to Brisbane (missing gaps in northern NSW, narrow gauge track in Queensland and tortuous track through the Toowoomba ranges).

If a single reference train were capable of making such a journey, travel time might be 38½ hours.

This particular route requires two reversals (at Binnaway and Werris Creek) and 23 safeworking stops, (where trains must stop to obtain authority to proceed).

Removing these constraints by building short-cuts and installing modern signalling could save four hours, giving a journey time of 34½ hours.

Further time savings will require the use of new alignments. In particular the above times assume new standard gauge track in Queensland using the existing difficult alignment. It is likely that the construction of a standard gauge track will provide the opportunity to construct new routes or alignments from the Darling Downs across the Great Dividing Range into Acacia Ridge (to ease curve and gradient constraints). This could significantly reduce overall journey time.

3.5.2 Journey time benchmarking exercise

A benchmarking exercise with existing coastal infrastructure was used to establish the journey time possible by upgrading the entire existing route to Class 1.

This benchmarking approach was used only in Stage 1 of the study. Sophisticated computer train simulation modelling will be used in Stages 2 and 3 of the study to determine more reliable journey times.

Sections of the existing Class 1 coastal route were studied to document the average speed of an intermodal train over different types of terrain (categorised by curves and gradients).

Track sections, representative of typical categories of curves and gradients over long sections of existing track were identified. The timetable was also studied, to document average speeds on those sections (for intermodal superfreighter trains). This provided an understanding of the effects of terrain on average train speed for Class 1 track with nominal line speed of 115 km/h.

Three distinct route sections were identified.

- The 366 km from Seymour to Junee is categorised as relatively flat and straight. It has a line speed of 115 km/h, but sectional run times for superfreighters indicate an average speed of 88 km/h.
- The 207 km from Cootamundra to Goulburn is categorised as hilly and curved. It has a line speed of 115 km/h, but sectional run times for superfreighters indicate an average of 63 km/h.

[4] There are factors such as reliability.

- The 262 km from Maitland to Wauchope is categorised as gentle gradients and many curves. It has a line speed of 115 km/h, but sectional run times for superfreighters (once stops are removed) indicate an average of 63 km/h.

It was not possible to identify a significant length of hilly railway without curves.

Two benchmarking speeds were thus chosen to represent likely average speeds if any part of the existing route was upgraded to Class 1 standard:

- relatively straight and flat sections were deemed to have an average speed of 88 km/h
- hilly, curved (or both) were deemed to have an average speed of 63 km/h.

The existing far western inland route curve and gradient diagrams were then studied to categorise terrain sections and allocate benchmark average speeds, and thus create notional running times.

If a superfreighter train could run over a theoretically upgraded inland route, then on the same basis as the existing coastal route, the exercise suggested a non-stop inland rail journey time of 26½ hours. (The non-stop average for the whole 2000 km route was 80 km/h).

3.5.3 New route journey time

The benchmarking exercise was then expanded to cover new construction identified by the study.

The terrain and engineering plans (basic curve and gradient diagrams) from the NSRCS where studied (these had been developed by the NSRCS for new route construction).

Each section was allocated a benchmark average speed based on curve and gradient characteristics. The journey time was then calculated by multiplying the benchmark speed by the length of the proposed route section.

3.5.4 Other journey time factors

Crossing time at passing loops

Most of the inland railway between Cootamundra and Brisbane will be single line, and passing loops for trains going in opposite directions will be required. Accordingly, an estimate of the time spent stationary in passing loops must be added to the running time estimates.

In Stage 1 of the study, passing loop location, capacity and timetabling are not studied, and therefore crossing loop delays cannot be directly calculated or modelled. A theoretical approach has thus been adopted.

If loops are evenly spaced in time, and trains are randomly delayed when entering the single line railway, there is an even chance that some crosses will take place perfectly, with one train running through non-stop and the other delayed only by stopping and starting (a study by PB in 2006 estimated this as 14 minutes longer than running through at line speed), whilst the other extreme would be trains meeting in mid-section were it not for the signalling system preventing this.

In the former case, delays would be 7 minutes per train, per cross, by dividing the potential speed penalty between the two trains involved in each cross. In the latter case, one train might be delayed by the time taken for an approaching train to run almost the full length of a single line section, whilst the one coming the other way will not be delayed at all. Sharing that delay between the two trains results in the delay to each being half the length of the section, plus 7 minutes stopping allowance.

The average delay to a train making a crossing move in the above scenario is the average between those two extremes above, i.e. one quarter of the single line section running time, plus 7 minutes.

Preliminary demand information from the FEC, and the creation of a reference train, suggests that there may be six inland railway intermodal Melbourne – Brisbane trains per day, per direction. It is assumed these trains will have priority over all other traffic, and will only be stopped to cross other similar trains.

A graph of potential crossing movements on an inland railway carrying six trains per day suggests that each train might face between eight and 12 crosses on the single lines between Cootamundra and the Acacia Ridge, depending on the timetable used. An average of 10 was used. However, more than 10 passing loops will be required because there will be more traffic than just the inland railway intermodal trains, because operational flexibility is required, and because actual capacity of a single line railway is below the theoretical capacity

The actual loop spacing on the inland railway will be less than ideal and the actual delays due to crossing on a single line railway are likely to be more than the theoretical level. It is suggested an additional 25% delay factor is added to this theoretical value, since the type, timetable and frequency of traffic that the inland railway will carry is not known, nor is the location of passing loops.

The spacing of crossing loops will be analysed as a variable when determining the preferred route in Working Paper No. 5. However, based on the theoretical approach above the crossing delay incurred per trip is shown in Table 3-1 below.

Table 3-1 Crossing delays

Loop spacing (km)	Average delay per cross (mins)	Total delay for 10 crosses	
		mins	hrs:mins
20	10.41	130	2:10
30	12.11	151	2:31
45	14.67	183	3:03
60	17.23	215	3:35
90	22.34	279	4:39

Refuelling

The reference locomotives will need to refuel en-route. Refuelling locomotives at a locomotive depot (such as Parkes) would require detaching, shunting, reattaching and then conducting brake tests. This can typically delay trains by up to four hours.

Refuelling could take place on a line clear of the main line and other traffic. This would require the construction of a loop line with refuelling pad. This infrastructure would avoid shunting and subsequent brake testing required if existing depots were used.

The provision of new refuelling facilities will be the most efficient way of minimising journey time, and should be provided. Note, however, the capital cost of this facility may not be included in the infrastructure capital costs but in the rail operator's capital/operating costs.

In this study, it is assumed that refuelling will take 45 minutes, in a loop line.

The journey time estimate should be increased by a further 45 minutes to allow for refuelling (in addition to crossing move allowances).

Train crew depots

It is likely that crew changeovers, which can be accommodated within a 10 minute stop, will be combined with crossing movements or refuelling stops, so it is not necessary to add further time for crew changeovers.

3.5.5 Benchmarking exercise conclusion

The benchmarking exercise generated a potential journey time via an upgraded existing corridor of 30 hours 50 minutes, made up as follows:

Table 3-2 Benchmarking journey time (upgrading legacy track and in-filling gaps)

Factor	Time estimate, hrs:min
Non-stop journey time	26:30
Crossing other high priority trains	3.35 (assuming 60km loop spacing)
Train crew changeovers	Included in crossing time.
Refuelling	0:45
Total	**30:50**

This high level journey time estimate is based on speeds and delay factors for a service of six high priority superfreighter trains a day.

The study has also identified journey times for new alignments. Later work will use these times as part of the process to identify the preferred route, by summing the journey time over any combination of new and existing sections as part of the route evaluation process.

4. Approach to environmental assessment

4.1 Overview

The purpose of this section is to identify environmental limitations and opportunities to be considered in the selection of a preferred alignment for the Melbourne to Brisbane Inland Railway and to outline the assessment methods used to consider these issues.

In consideration of environmental limitations associated with the planning, design, construction and operation of the railway, the main aims are to select an alignment that minimises impacts to the biophysical and social environment within the railway corridor and identify environmental issues with potential constraints to the project with regards to legislative requirements, time delays and cost implications.

The environmental aspects and the key issues that will be considered in Stage 1 of the study are included in Table 4.1. These issues will be considered in an overarching perspective and/or on each specific route option, if feasible at this stage.

4.1.1 Approach

The approach adopted during Stage 1 includes a broad review of potential environmental aspects over the inland rail corridor. It aims to identify those environmental issues that can be assessed in more detail at the route option level, based on access to relevant information and feasibility of completing the work during Stage 1 of the study. Issues that will require consideration in stages 2 and 3 will be noted and set aside.

Once a series of environmental issues has been identified for further assessment and relevant information sourced, each route option will be assessed in more detail using reference material such as the work by Hyder Consulting (as part of the NSRCS) and GIS datasets. Environmental limitations and opportunities have been included in the route options data sheets (Appendix C).

Where environmental limitations have been identified they have been categorised, based on the degree of impact either to the environment (as a result of the railway), or to the project, (as a result of time and/or costs in managing or mitigating the issue).

Where possible, opportunities will be identified to avoid or minimise impacts or time/cost implications.

4.1.2 Project approval

Once the preferred alignment is chosen, the project proponent would need to negotiate a complex approval pathway incorporating Commonwealth, state (NSW, Victoria and Queensland) and local government legislation, as well as a number of international conventions and agreements to which the Commonwealth is a signatory. Commonwealth, state and international legislative requirements that would need to be considered have been covered in some detail in Chapter 7 (Section 5) of NSRCS and will not be replicated here. However, the statutory framework for project approval will be considered in further detail in the latter stages of the study.

4.2 Identification of key issues

The environmental aspects and key environmental issues that have been assessed in Stage 1 of the study, either at the broad corridor level and/or at a detailed route option level, are listed in Table 4.1.

Table 4-1 Environmental aspect and issues

Aspect	Key environmental issues
Protection areas	World heritage areas Ramsar wetlands Register of the National Estate National parks State forests Natural and conservation reserves
Flora and fauna	Threatened species Wildlife corridors
Heritage	Commonwealth heritage State heritage Railway heritage Indigenous heritage Native title
Water	Waterways Water quality catchments Flood prone land Groundwater resources/sensitive aquifers
Noise and vibration	Noise disturbance Vibration impacts
Soils and contamination	Registered contaminated sites Hazardous facilities Landfill sites Salinity
Land Use	Environmental planning instrument zoning

4.3 Methodology

4.3.1 Assessment level

General corridor assessment

Environmental issues have been considered at a general corridor level where there is a lack of site-specific information or, conversely, there is a mass of information that can be summarised, given the time constraints of this stage of the study.

Issues considered at the broad corridor level include Indigenous heritage, some general comment has been made relating to the potential environmental limitations at the broad corridor level, with recommendations for further assessment as necessary.

Detailed route option assessment

Spatial data sets have been sourced for many of the issues listed in Table 4.1 to be incorporated into the GIS mapping of the study. GIS mapping has been reviewed for each route section to determine whether, and at what level of importance, environmental issues can be considered as 'environmental limitations'.

4.3.2 Environmental limitation categories

Environmental limitations along route sections have been categorised depending on the potential level of impact of the railway operation on the environment, or the level of impact on the environment by the development of the railway. Note that for continuity, the categories are based on terms used in the NSRCS Environmental Overview (Hyder Consulting, 2006). The categories are discussed below.

Major environmental limitation

Major environmental limitations are those that could have a major impact on the project either in the planning, design, construction or operational phase. This could result from:

- potentially high level of environmental impact to listed protection areas, Commonwealth heritage areas or threatened species
- high cost and/or program implications associated with realignment or re-engineering solutions or associated with extensive impact mitigation
- high number of communities/stakeholders impacted, i.e. towns and urban areas, with potential for high number of objections
- major delays associated with obtaining permits and approvals.

Major environmental limitations would likely cause extensive time delays and possibly have large cost implications and could, in the most extreme circumstances, bring work to a complete halt.

Significant environmental limitations

Significant environmental limitations are those that would have an impact on the project. Whilst it would be preferable that these be avoided, they are not considered insurmountable and could be mitigated through engineering design, changes to construction methodologies, and/or environmental compensation.

The environmental and/or social impacts of significant environmental limitations would need to be considered during detailed environmental assessment, including consideration of engineering solutions and community and stakeholder engagement. Costs and time delays associated with these identified limitations would still be significant, although these may not be as significant as the major environmental limitations.

Moderate environmental limitation

Moderate environmental limitations include potential impacts that would require management and/or mitigation during the design, construction and operational phases. These potential impacts are marginal compared to the cost to mitigate or manage them.

Moderate environmental limitations would need to be considered when developing the preliminary and detailed design. These limitations should be mitigated through an iterative design process in conjunction with the environmental impact assessment and stakeholder consultation.

Cumulative impacts

As well as the environmental limitations listed in Table 4.1, there could be two or more environmental constraints along a route option to contribute to cumulative environmental impacts during construction and/or operational phases. Examples include:

- impacts associated with protections areas that have a high number of threatened species or may act as a wildlife corridor
- impacts to urban communities associated noise, air quality and visual amenity impacts and/or severance/access issues to communities or facilities
- construction issues in flood-prone areas and the upstream and downstream effect of altering flood-prone areas.

Where identified, cumulative impacts have been categorised as major, significant or moderate environmental limitations.

Opportunities

Where there are options or methods to avoid or minimise the potential impacts, these have been listed as 'opportunities' for each route option. Opportunities will be considered further during planning and design to minimise or avoid impacts to any of the environmental limitations raised. This may include realignment (or avoidance of realignment), design changes (tunnels, bridges), changes in construction method or implementation of recommended mitigation measures.

4.4 Discussion of environmental issues

The following sections include a discussion of each of the environmental aspects and key issues listed in Table 4.1. This will include a description of the potential impacts associated with each key environmental issue and the level and method of assessment in Stage 1.

4.4.1 Protection areas

For the purposes of this study, the term 'Protection Areas' encompasses lands that have been established or dedicated as areas with a specific purpose or use, particularly associated with conservation/protection of the physical environment or values associated with the environment. This includes areas of environmental and heritage significance, as well as areas set aside for resource harvest or extraction. Particular issues associated with protection areas include:

- direct impacts to sensitive ecological communities ecosystems and fauna habitats
- direct impacts to areas of Aboriginal or cultural significance
- fragmentation of habitat areas and wildlife corridors
- sterilisation of resources
- severance of protection areas from the community or impacts on the amenity of a protection area.

Protection areas have been assessed at a detailed route section level, based on GIS mapping. These areas should be avoided as much as possible and as such, where the railway crosses or is in the vicinity of a protection area, this has generally been categorised as a Major or Significant Environmental Limitation. Types of protection areas are described further below.

Matters protected by the EPBC Act

The *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) is aimed at protecting and managing nationally and internationally important ecological communities, threatened species, heritage places and biodiversity conservation, especially matters of National Environmental Significance (NES).

If a significant impact related to NES or to the EPBC Act were likely as a result of the development of the inland railway, the project would have to be referred to the Commonwealth Department of the Environment, Water, Heritage and the Arts. The 'referral' would be subject to public comment before determination by the Minister as to whether the likely environmental impacts of the project are such that it should be assessed under the Act.

Matters of NES considered in this study include:

- world heritage sites
- national heritage places
- wetlands of international importance or Ramsar wetlands.

Other matters that are protected by the EPBC Act that have been considered include:

- commonwealth heritage
- items listed on the Register of the National Estate (RNE).

Conservation areas

Conservation areas are generally administered by state government agencies. Conservation areas that have been considered in this study include:

- International parks — areas protected for the preservation of untouched landscapes representative ecosystems, flora and fauna species and places of natural or significance. National parks are open to the public for recreation and educational purposes.
- Aboriginal areas — areas of land protected for conservation of Aboriginal culture.
- Nature reserves – areas of land that remain in a predominantly untouched, natural condition and have high conservation value.
- State conservation areas — areas reserved to protect and conserve representative ecosystems, landforms, natural phenomena or places of cultural significance. Mineral and petroleum exploration and mining may be permitted in state conservation areas.
- State forests — areas reserved for forestry, recreation and mineral extraction.

Conservation areas, such as national parks, Aboriginal areas and nature reserves, are, by definition, areas set aside for conservation and protection purposes and as such development is extremely restricted within these areas. Detailed environmental assessment and complex negotiations with the relevant administrative bodies and other stakeholders is unavoidable. Development of the inland railway alignment through these conservation areas should be avoided. However, construction through a state conservation area or state forest may be allowed, pending environmental assessment, stakeholder consultation and consideration of suitable compensatory land.

4.4.2 Flora and fauna

The key areas of concern with regard to flora and fauna are:

- impacts to sensitive ecological communities ecosystems and fauna habitats
- fragmentation of wildlife areas and habitats and severance of wildlife corridors
- reduction in biodiversity.

Threatened species

Threatened species have been assessed at the detailed route section level, based on mapping using information sourced from relevant state government databases, each of which reports on threatened species differently.

In NSW, threatened species databases comprise survey information based on sightings of threatened species. Two shortcomings to this method are firstly that sightings are more concentrated in areas where there have been ecological surveys, or around towns and populous places. Secondly, when mapped, threatened species data points are generally within 1 km of the actual sighting location, but are not accurate to the exact position of the species to protect the location.

In Victoria and Queensland threatened species are mapped by area on a grid and ecological system basis respectively, with the same shortcomings as in NSW with the inability to pinpoint species. A further limitation is that mapping does not provide information on the density or richness of the species in that area.

To provide meaningful interpretation of threatened species mapping across the three states, taking into account the shortcomings discussed above, mapping has been used to identify areas where threatened species are more likely based on higher density or clusters of sightings in NSW and larger more densely plotted areas in Queensland and Victoria. Where possible, aerial photography has been used to identify vegetation and water bodies that could correspond with the presence of threatened species.

Wildlife corridors

Wildlife corridors will generally coincide with vegetated areas, particularly those linking conservation areas, such as national parks and nature reserves. Wildlife corridors have been mapped and assessed at the detailed route option level. Where possible, aerial photography has also been used to identify observe vegetation cover along the route options in the vicinity of identified wildlife corridors.

4.4.3 Heritage

The key issues relating to heritage are:

- direct impacts to listed heritage items/places or decrease in their heritage value
- development necessitates destruction or modification of heritage items
- impacts to potential indigenous heritage places, items or areas of sensitivity or cultural significance.

Non-indigenous heritage

Heritage places and items are generally associated with past land uses and settlement history. This includes places, objects or structures with a cultural or historical significance that gives context to how a place, community or nation has evolved. Non-Indigenous heritage can be listed at a Commonwealth, state and/or local government level.

Commonwealth listed heritage, including National Heritage and items listed on the Register of the National Estate, is protected under the EPBC Act and is discussed in Section 4.4.1. These items have been identified at the detailed route option level through mapping and have generally been identified as either Major or Significant Environmental Limitations if there is any likelihood that they would be compromised by the proposed route options.

State and local government heritage items are listed in state heritage registers and local environment planning instruments respectively. Owing to the magnitude of listings, it is not feasible to search these registers during Stage 1. State and local heritage items will be considered during the next stage of the study, and where identified, will be assessed as potential limitations to the preferred alignment.

Railway heritage

Railway heritage includes structures and items associated with historical railway operations, including bridges, stations, buildings and markers. As with state and local heritage items, the task of searching relevant state heritage databases and railway heritage listings was not feasible at this stage of the study. However, as a general rule, where existing railway sections require upgrading as part of the preferred alignment, railway heritage items could be damaged as a result of these works.

Once a preferred alignment has been selected, there will be a further assessment of railway heritage in the next stage of the study, including reviewing state heritage databases and ARTC asset registers.

Indigenous heritage

Indigenous heritage relates to those places and items that are significant, or contribute to the understanding of Aboriginal and Torres Strait Islanders and their attachment to Australian land before (and during) European settlement. Indigenous heritage is often associated with remnants, evidence of settlement or movement patterns of Aboriginal people, but may also include places of spiritual or ceremonial importance.

Identification of Indigenous heritage on a route section basis is not feasible at this stage due to the combination of:

- size of the study area and potential number of sites
- restriction to indigenous heritage databases
- bias of information towards surveyed areas as opposed to unsurveyed (or undiscovered) areas.

A desktop assessment of potential areas of Aboriginal sensitivity has been made at the broad corridor level by reference to landforms and topographical features that would have a higher likelihood of Aboriginal use - for example, permanent waterways, areas of native vegetation, rocky outcrops, as well as less developed/modified areas where disturbance of sites, if present, is less likely.

This has been applied at a route section level to categorise Indigenous heritage as a potential Environmental Limitation based on a risk assessment of these landform types.

Further assessment of Indigenous heritage sites will be done during the next stage of the study, including searches of available databases to enable mapping of known and potential areas of Aboriginal sensitivity.

Native title

Native title is the legal recognition that Indigenous people have rights and interests to some areas of land through their traditional or historical presence in that area. These rights may include habitation or access for camping, hunting and gathering, teaching of customs or tribal ceremonies. Native title is governed by the *Native Title Act 1993* which states the rights granted under native title are recognised by Australian common law.

The inland railway corridor passes though a number of native title areas of areas where native title applications, or claims, have been lodged. Claimants would need to be consulted before the railway was built through these areas.

4.4.4 Water

The key environmental issues relating to water are:

- direct impacts to water quality and aquatic ecology in rivers, creeks and other waterways during construction and operation of the railway
- alteration or severance of overland flow paths, including dam catchments and environmental flows, with associated downstream implications
- construction on flood-prone land, with potential downstream or upstream impacts during flood events due to changes in flood water regimes or flow
- engineering constraints and costs associated with construction across flood-plains
- impacts to water resources, including catchment areas, aquifers and water storage or extraction areas/zones, especially town water supply resources.

River/creek crossings

Construction of river and creek crossings along new route options will have potential impacts on water quality and aquatic ecology. Similarly, construction in the vicinity of water bodies (e.g. farm dams, waterholes) or through undulating terrain would likely require erosion and sediment controls to minimise water quality impacts. These issues have been assessed at a detailed route option level, with the number of major and minor waterway crossings identified and categorised as an environmental limitation and included in route section data sheets.

Additionally, there may be some cumulative impacts associated with waterways, such as presence of threatened species around rivers, swamps or waterholes, or land-use impacts associated with farm dam catchment areas or irrigation channels.

Flood-prone land

Where alignments cross flood-prone land, the effect on floodwaters would have to be assessed in design to minimise downstream of upstream flooding issues. In addition, construction across flood-prone land would require careful planning and consideration of engineering solutions to minimise cost and program implications and to address operational functionality during flood events.

Where available, flood-prone land has been mapped and identified as an environmental limitation for each route section.

Water resources

Several routes pass through a number of major inland river catchment areas, each with different objectives for management and protection of water resources. Similarly, a number of different groundwater environments and aquifers exist along the alignment. On selection of a preferred route, catchment and groundwater zone maps will be reviewed and where potential impacts may arise during construction and operation of the railway, the objectives and legislative requirements of sensitive aquifers will be considered.

4.4.5 Noise and vibration

Key issues relating to noise and vibration impacts include:

- adverse noise impacts to nearby residences and sensitive receivers (e.g. schools, hospitals, churches) associated with new routes or increased traffic on existing alignments
- construction noise and vibration impacts
- project costs associated with property acquisition where noise and/or vibration impacts are extreme, or where noise abatement is required.

Noise

PB has carried out a desktop noise assessment with predictions of noise levels at a range of distances from the source. This was compared to noise design goals (trigger values) derived from *Interim Guidelines for the Assessment of Noise from Rail Infrastructure Projects* (DECC, 2007). These trigger values have been adopted for the study as they are applicable in NSW and are more conservative than those used in Queensland. There are no noise design goals specified in Victoria.

L_{Aeq} (average noise) and L_{Amax} (maximum noise levels) over a given time period were assessed, with night-time taken as the most sensitive period. The assessment considered the noise impacts of 6, 12 and 18 pass-by events within a 24-hour period.

Note that the NSW Planning goals (55dB(A) $L_{Aeq,\ 9hr}$ and 80dB(A) L_{Amax}) would only apply where the noise levels increase by more than 2dB(A) L_{Aeq} and 3dB(A) L_{Amax}) from pre-development levels. An increase in L_{Aeq} noise levels by 2 dB(A) or more could result from doubling (approximately) the number of pass-by events.

The noise assessment recommended a number of typical buffer zones in mitigating noise impacts on residential dwellings. For the purposes of Stage 1, two buffer zones have been categorised:

- dwellings within 15 m of the railway
- dwellings within 100 m of the railway.

Buffer zones have been selected as a guide for consideration of mitigation of noise impacts (for houses within 100 m of the railway) or, in more extreme cases, property acquisition.

Mitigation can occur either at the receiver, through treatment of residential properties (cladding, double glazing, etc), or at the source, by erecting noise barriers.

These buffer zones have been used to capture, via GIS, the number of residences affected in the area surrounding new or existing routes. Buffer zones are particularly useful in identifying high noise risk zones around regional towns.

This will assist in selection of the preferred route and later refinement of the alignment to avoid the more populous areas.

Residential and village areas, identified through land-use zones or aerial photography, have been identified as Environmental Limitations and as candidates for realignment (to avoid high population density areas).

Further assessment of noise impacts, including construction noise impacts associated with construction, will take place in Stage 2. This will include identifying sensitive receivers, such as hospitals, schools, churches, along route options and incorporate consideration of other factors, such as topography, bridges and pass-by speed, which may influence noise impacts.

Vibration

Vibration impacts are mainly related to ground conditions and the distance from the vibration source. Vibration is considered in terms of potential structural impacts and human exposure impacts.

It is expected a vibration dose level of 0.13 $m/s^{1.75}$ would be the limit for a residential receiver for annoyance/human comfort impacts (*Environmental Noise Management Assessing Vibration: a technical guideline*, DECC 2006).

For the control of structural damage, a peak particle velocity vibration limit of 10 mm/s could be the limit for a 'modern' residential dwelling and 3 mm/s for 'heritage' or 'sensitive' structures (*German Standard DIN 4150: Part 3-1986*).

During construction, vibration would be generated by the operation of plant and machinery, with typical vibration levels ranging up to 3 mm/s at a distance of 5 m, decreasing to less than 0.2 mm/s at 20 m. Vibratory rollers and hydraulic hammers have considerably higher vibration emission levels in the range of 7–9 mm/s at 5 m and less than 3 mm/s at 20 m.

This suggests that at 20 m, vibration impacts are likely to be below the criteria for structural damage.

Where levels are likely to exceed human comfort levels, vibration monitoring and management measures (e.g. respite periods, relocation) would need to be implemented.

Operational vibration impacts are expected to be minor at a distance of 20 m and immeasurable beyond 50 m.

As such, the 15 m buffer used for potential acquisition due to noise impacts will suffice for assessing potential vibration impacts.

Potential vibration issues will require further consideration before the detailed design stage.

4.4.6 Soils and contamination

Key issues associated with soils and contamination mainly relate to the construction phase and include:

- environmental and human health impacts associated with exposure of contaminated soils
- increasing the extent and severity of areas of known dryland salinity

- exposure and oxidisation of acid sulphate soils and potential impacts to aquatic systems from acidic leachate
- risks and costs associated with storage, treatment, transport and disposal of contaminated materials, acid sulphate soils or other non-reusable wastes.

Registered contaminated sites, hazardous facilities, landfills and areas of dryland salinity and acid sulphate soil risk have been assessed on a detailed route option level through the GIS mapping and categorised as environmental limitations.

4.4.7 Land use

The key considerations with regards to land use are:

- route options impacting upon areas zoned for environment protection and residential purposes
- cumulative or indirect impacts around towns and urban areas relating to air quality, noise and visual amenity impacts.

Land use along the alignment has been reviewed, based on local government zoning information obtained from relevant state government planning agencies. To simplify this process, land-use types have been grouped into the following broad categories:

- rural
- residential
- commercial
- industrial
- special uses
- open space
- environmental protection.

A risk based assessment has been done at the detailed route option level, focusing on land-use types as a constraint to developing the railway, for example, high risk land-uses like areas zoned for environmental protection or residential purposes. As a general rule, opportunities for realignment have been identified where alignments pass through, or close to, high-risk land-use zones.

5. Route assessment

5.1 Area A route options — Melbourne to Junee

5.1.1 General description of area

Area A is Melbourne to Junee via Albury or Shepparton as shown in figure 5.1.1.

Melbourne to Junee via Albury

This route uses the existing north-east line between Melbourne and Albury, (for the purposes of this study called the Melbourne to Albury line), and the existing line between Albury and Junee (called the Main South line).

On completion of work currently under way, there will be two broad gauge tracks and one standard gauge track from Melbourne to Mangalore and two standard gauge tracks from Mangalore to Albury – all Class 1. The Main South line is a single Class 1 standard gauge track.

The existing topography is generally undulating with ruling grades of 1 in 50.

The geological conditions are predominately alluvium with some areas of soft and hard rock (sedimentary, metamorphic and igneous). Figure 5.1.4 shows a detailed geological map for this route.

The majority of this route has minimal flooding issues, except for the Wodonga region which is in a flood prone zone. There are various areas where the railway crosses rivers and creeks.

Major infrastructure, including roads, transmission lines and gas lines, is evident along the route. There are several areas where the transmission and gas routes cross the existing rail corridor. The gas route follows the existing rail corridor between Melbourne and Junee.

If double stacking were to be introduced on this route, there are various existing bridges that would require modification. Note: the ARTC in its *2008-2024 Interstate and Hunter Valley Rail Infrastructure Strategy Executive Summary* has plans to lift clearances to 6.8 m on this section, finishing in 2016.

Melbourne to Junee via Shepparton

This route uses four existing lines; Melbourne–Albury line, Shepparton–Tocumwal line, Narrandera–Tocumwal line and Junee–Hay line. The four lines have varying track classes and gauge:

- Melbourne–Albury line— Class 1 standard gauge track
- Shepparton–Tocumwal line — Class 3 and 4 broad gauge track
- Narrandera–Tocumwal line — disused Class 5 standard gauge track
- Junee–Hay line — Class 3 standard gauge track.

All four lines are single track with some loops.

The existing topography is generally undulating over all of the four lines with varying ruling grades; 1 in 50 on the Melbourne to Albury line (between Melbourne and Mangalore), 1 in 100 on the Shepparton–Tocumwal line, generally level on the Tocumwal–Narrandera line with 1 in 50 in the vicinity of Narrandera and 1 in 50 on the Junee–Hay line (between Narrandera and Junee).

Between Melbourne and Tocumwal the geological conditions are predominately alluvium with some areas of soft and hard rock (sedimentary, metamorphic and igneous). From Tocumwal to Narrandera the conditions change to predominately soil with pockets of Aeolian. The section between Narrandera and Junee reverts to alluvium with some areas of soft and hard rock (sedimentary, metamorphic and igneous).

The section between Melbourne and Tocumwal has minimal flooding issues, except for Murchison, which is on a flood plain. From Tocumwal to Narrandera there are several areas with flooding issues, notably Finley, Berrigan and Jerilderie, which are on flood plains or contain irrigated farmland. There are several areas where rivers and creeks cross the proposed or existing railway.

Major infrastructure, including roads, transmission lines and gas lines, is evident along the route. There are several areas where the transmission and gas routes cross the proposed or existing rail corridor. The gas route follows the existing rail corridor between Junee and Narrandera.

Figure 5-1 Area A overview plan

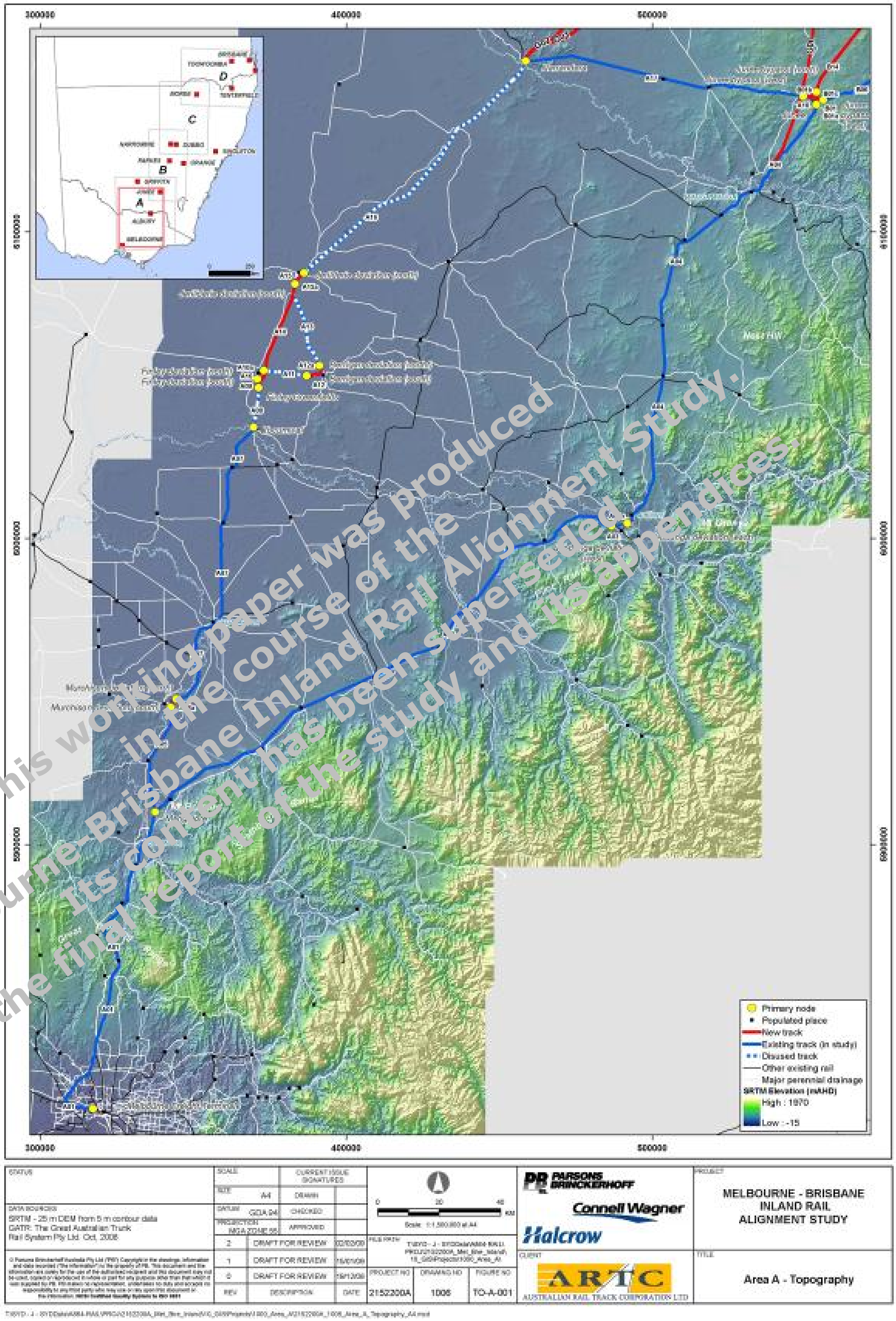


Figure 5-2 Area A topography

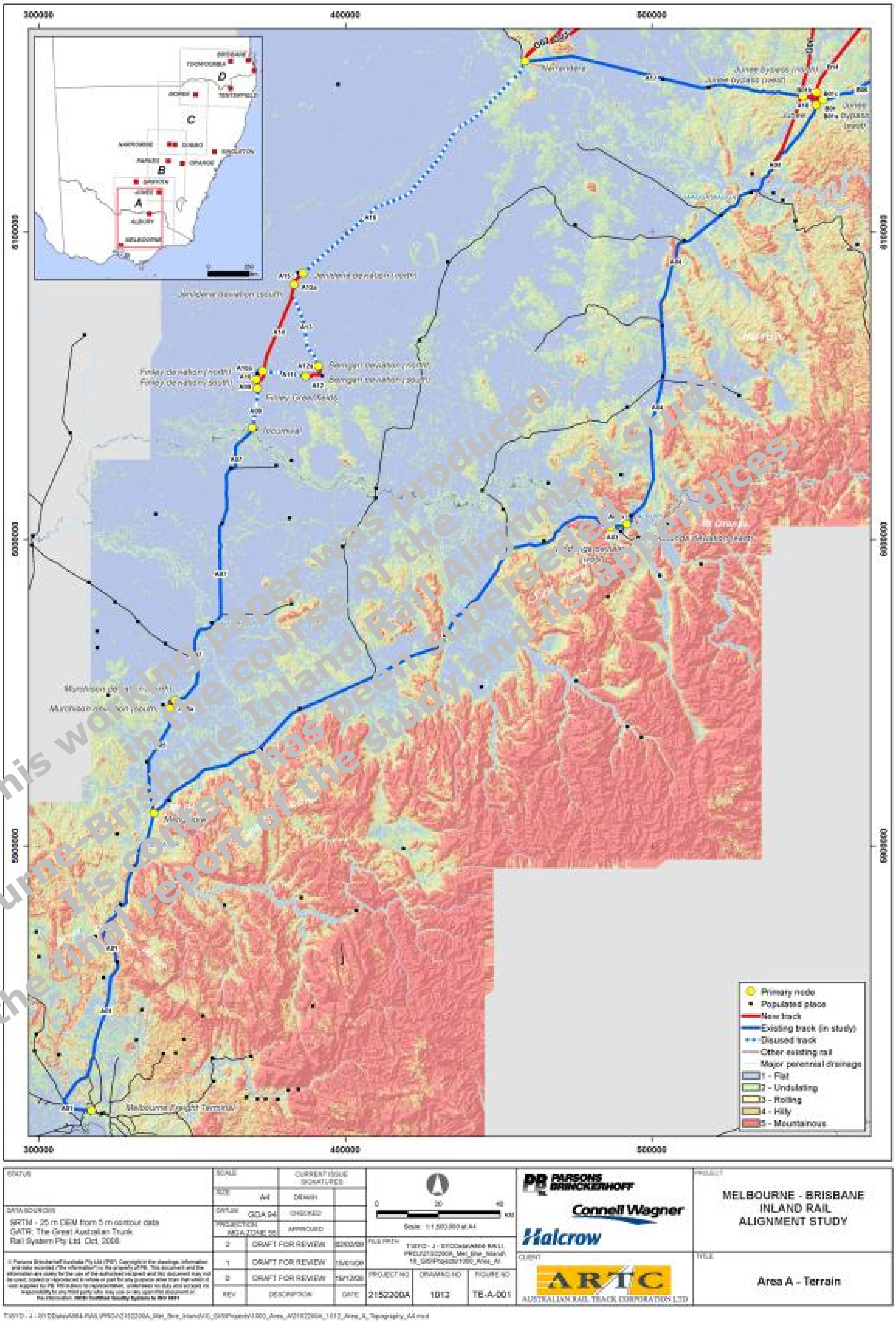


Figure 5-3 Area A terrain

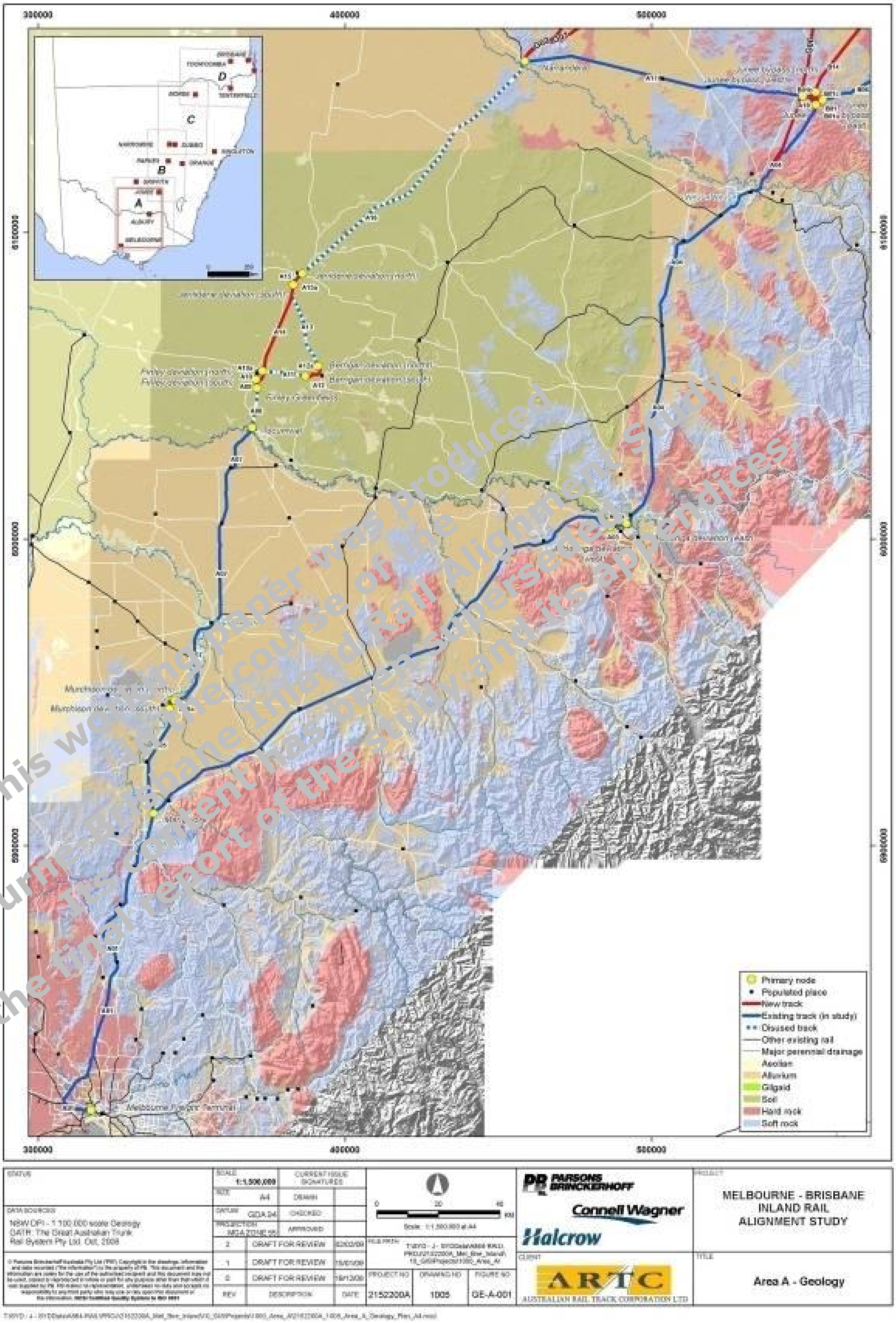


Figure 5-4 Area A geology

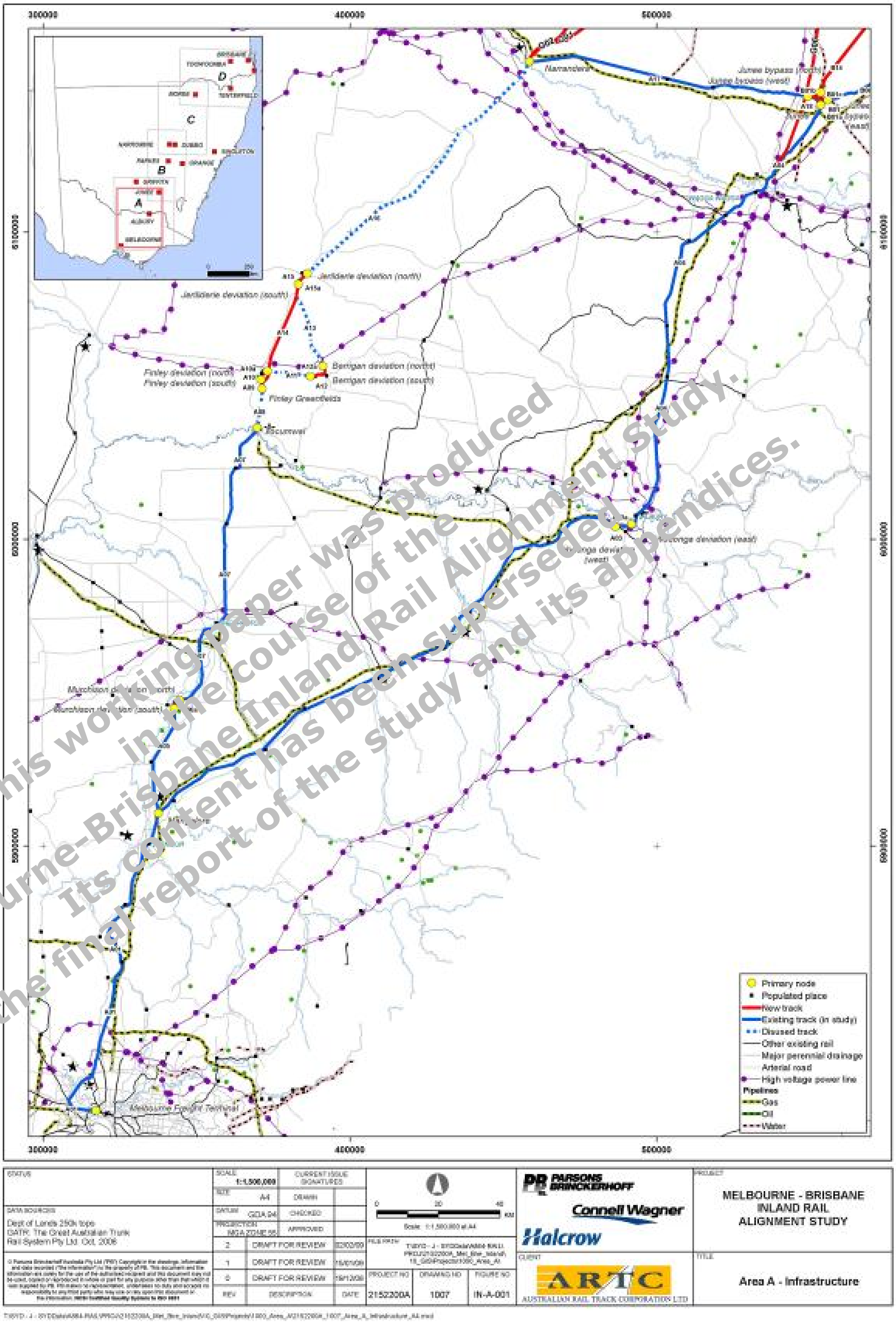


Figure 5-5 Area A infrastructure

5.1.2 Definition of sections and area routes

There are three potential routes from Melbourne to Junee, which are a combination of 13 route sections. These area routes and route sections are listed in Tables 5–1 and 5–2 below.

Table 5-1 Area A routes

Area route	Description	Route sections
AA01	Melbourne–Junee via Albury	A01+A02+A03+A04
AA02	Melbourne–Junee via Shepparton–Tocumwal (new Finley deviation), Narrandera.	A01+A05+A06+A07+A08+A14+ A15+A16+A17+A18
AA03	Melbourne–Junee via Shepparton–Tocumwal (no Finley deviation), Narrandera.	A01+A05+A06+A07+A08+A09+ A10+A11+A12+A13+A15+A16+ A17+A18

Table 5-2 Area A sections

Section	Existing/new	Description	Line
A01	Existing	Melbourne–Mangalore	North East
A02	Existing	Mangalore–Wodonga Deviation Sth	North East
A03	Existing	Wodonga Deviation South–Wodonga Deviation Nth	North East
A03a	Existing	Wodonga Deviation	North East
A04	Existing	Wodonga Deviation Nth–Junee	North East
A05	Standardise	Mangalore–Murchison Deviation Sth	Shepparton–Tocumwal
A06	Standardise	Murchison Deviation Sth–Murchison Deviation Nth	Shepparton–Tocumwal
A06a	New build — minor	Murchison Deviation	Shepparton–Tocumwal
A07	Standardise	Murchison Deviation nth–Tocumwal	Shepparton–Tocumwal
A08	Rebuild — major	Tocumwal–Finley Deviation Nth	Tocumwal–Narrandera
A09	Rebuild — major	Finley Greenfield–Finley Deviation Sth	Tocumwal–Narrandera
A10	Rebuild — major	Finley Deviation Sth–Finley Deviation Nth	Tocumwal–Narrandera
A10a	Rebuild — minor	Finley Deviation	Tocumwal–Narrandera
A11	Rebuild — major	Finley Deviation Nth–Berrigan Deviation Sth	Tocumwal–Narrandera
A12	Rebuild — major	Berrigan Deviation Sth–Berrigan Deviation Nth	Tocumwal–Narrandera
A12a	New build — minor	Berrigan Deviation	Tocumwal–Narrandera
A13	New build	Berrigan Deviation Nth–Jerilderie Deviation Sth	Tocumwal–Narrandera
A14	New build — minor	Finley Greenfield–Jerilderie Deviation Nth	Tocumwal–Narrandera

Section	Existing/new	Description	Line
A15	New build — minor	Jerilderie Deviation Sth–Jerilderie Deviation Nth	Tocumwal–Narrandera
A15a	New build — minor	Jerilderie Deviation	Tocumwal–Narrandera
A16	Rebuild — major	Jerilderie Deviation Nth–Narrandera	Tocumwal–Narrandera
A17	Upgrade	Narrandera–Junee By-pass West	Junee–Hay
A18	Upgrade	Junee By-pass West–Junee	Junee–Hay

5.1.3 Review of sections

Section A01 — Melbourne to Mangalore (existing — BAU[5])

The Melbourne–Mangalore section of track is part of the Melbourne to Albury line and consists of Class 1 standard gauge track. The track is approximately 117 km long and runs through various towns and crosses various roads, rivers and creeks.

This section of the Melbourne–Albury line would not be upgraded as part of this study, as the existing condition of Class 1 is considered adequate for the required axle load.

The ruling grade for this section is 1 in 50.

There are nine existing crossing loops along this section.

Multiple bridges, level crossings, culverts and other structures are located along the Melbourne–Mangalore section.

Section A02 and A03 — Mangalore to Wodonga (existing — BAU)

The Mangalore–Wodonga section of track is part of the Melbourne to Albury line and consists of Class 1 standard gauge track. The track is approximately 195 km long and runs through various towns and crosses roads, rivers and creeks.

The existing condition of Class 1 is considered adequate for the required axle load.

The ruling grade for this section is 1 in 50.

There are eight existing crossing loops along this section.

Multiple bridges, level crossings, culverts and other structures are located along the Mangalore–Albury section.

Section A03a — Wodonga Deviation (existing – BAU)

The Wodonga deviation by-passes the Wodonga town centre and is currently being built by ARTC.

Section A04 – Wodonga to Junee (existing – BAU)

The Albury to Junee section of track is part of the Main South line and consists of Class 1 standard gauge track. The track is approximately 163 km long and runs through various towns and crosses roads, rivers and creeks.

[5] Business-as-usual. No specific measures are contemplated in this study, However, ARTC may be upgrading routes as part of another business case.

This section of the Main South line is being improved by the ARTC. It would not be upgraded further as the existing condition of Class 1 is considered adequate for the required axle load.

The ruling grade for this section is 1 in 80.

There are two yards, Albury and Junee, as well as 12 existing crossing loops along this section.

Multiple bridges, level crossings, culverts and other structures are located along the Mangalore to Albury section.

Section A05, A06 and A07 — Mangalore to Tocumwal (standardise)

The Mangalore–Tocumwal section of track is part of the Shepparton–Tocumwal line and consists of Class 3 and 4 broad gauge track. The track is approximately 142 km long and runs through various towns and crosses various roads, rivers and creeks.

The upgraded section of track would consist of Class 1 standardised track.

The ruling grade for this section is 1 in 100.

Two new crossing loops would be constructed along this section.

Multiple existing structures would require strengthening to allow heavier axle loads along the Mangalore to Tocumwal section.

Section A06a — Murchison Deviation (new build — minor)

The Murchison deviation by-passes the Murchison town centre, which is located on the Shepparton–Tocumwal line. This deviation is option 0907 from the report. The purpose of the deviation is to remove low speed curves at Murchison. The new deviation would consist of approximately 4 km of Class 1 standard gauge.

The proposed ruling grade for this section is 1 in 500.

One new turnout, one level crossing and several new road and water crossings are likely to be required for the Murchison deviation.

There are threatened fauna in the vicinity and threatened flora on the deviation. There is also a river conservation area and wetland in the vicinity.

Section A08, A09, and A10 — Tocumwal to Finley (rebuild — major)

The Tocumwal–Finley section of track is part of the Tocumwal–Narrandera line and is a disused standard gauge track. The track is 21 km long and crosses various roads, rivers and creeks.

The upgraded section of track would consist of Class 1 standard gauge track.

The ruling grade for this section is level.

New crossing loops would be constructed along this section.

Multiple structures would require renewal or strengthening to allow heavier axle loads.

There are flooding issues at Finley where the area is on a flood plain.

Section A10a — Finley Deviation (new build — minor)

The Finley deviation by-passes the Finley town centre, which is located on the Tocumwal–Narrandera line and is a disused standard gauge track. This deviation is option 0902 from the NSRCS report. The purpose of the deviation is to remove low speed curves at Finley. The new deviation would consist of approximately 4 km of Class 1 standard gauge track.

The proposed ruling grade for this section is 1 in 125.

One level crossing is likely to be required for the Finley deviation.

There are vulnerable and endangered species in the vicinity of the deviation as well as flood liable land along the deviation.

Section A11, A12, A13 and A15 — Finley–Jerilderie (rebuild — major)

The Finley–Jerilderie section of track is part of the Tocumwal–Narrandera line and is currently a disused standard gauge track. The track is 57 km long and crosses various roads, rivers and creeks.

The upgraded section of track would consist of Class 1 standard gauge track.

The ruling grade for this section is 1 in 300.

Multiple structures would require renewal or strengthening to allow heavier axle loads.

The existing line is located approximately 1 km east of the Mairjimmy State Forest, and 500 m east of the Jerilderie Nature Reserve.

Section A12a — Berrigan Deviation (new build — minor)

The Berrigan deviation by-passes the Berrigan town centre, which is located on the Tocumwal–Narrandera line and is a disused standard gauge track. This deviation is Option 0903 from the report. The purpose of the deviation is to remove low speed curves at Berrigan. The new deviation would consist of approximately 7 km of Class 1 standard gauge track.

The proposed ruling grade for this section is 1 in 700.

Two level crossings and one river and creek crossing are likely to be required for the Berrigan deviation.

There are vulnerable and endangered species in the vicinity of the deviation as well as flood liable land along the deviation.

Section A14 — Finley to Jerilderie (new build — major)

The Finley–Jerilderie section is a new greenfield section of track located on the Tocumwal–Narrandera line. This new route is option 0901 from the report. The purpose of the option is to provide a direct route from Finley to Jerilderie by by-passing Finley, Berrigan and Jerilderie.

The new route section would consist of approximately 41 km of Class 1 track.

The proposed ruling grade for this section is level.

There are numerous vulnerable species in the vicinity (within 2 km of alignment around the townships of Finley and Jerilderie) of the new section and flood liable land on the section.

Section A15a — Jerilderie Deviation (new build — minor)

The Jerilderie deviation by-passes the Jerilderie town centre, which is located on the Tocumwal–Narrandera line and is currently a disused standard gauge track. This deviation is option 0904 from the report. The purpose of the deviation is to remove low speed curves at Jerilderie. The new deviation would consist of approximately 5 km of Class 1 standard gauge track.

The proposed ruling grade for this section is 1 in 350.

One level crossing and two road, river and creek crossings are likely to be required for the Jerilderie deviation.

There are vulnerable and endangered species in the vicinity of the deviation as well as flood liable land along the deviation.

Section A16 — Jerilderie to Narrandera (rebuild — major)

The Jerilderie–Narrandera section of track is part of the Tocumwal–Narrandera line and is a disused standard gauge track. The track is 102 km long and crosses various roads, rivers and creeks.

The renewal of this section of the Tocumwal–Narrandera line would provide an alternative route to the Albury–Melbourne Main Line and Main South line.

The upgraded section of track would consist of new Class 1 standard gauge track.

The ruling grade for this section is 1 in 50.

New crossing loops would be constructed along this section.

Multiple structures would require renewal or strengthening to allow heavier axle loads.

Section A17 and A18 — Narrandera–Junee (upgrade)

The Narrandera–Junee section of track is part of the Junee–Hay line and consists of Class 3 standard gauge track. The track length is approximately 98 km and crosses various roads, rivers and creeks.

The renewal of this section of the Narrandera–Hay line would provide an alternative route to the Albury–Melbourne Main Line and Main South line.

The upgraded section of track would consist of standard gauge Class 1 track.

The ruling grade for this section is 1 in 50.

Multiple structures would require renewal or strengthening to allow heavier axle loads.

5.1.4 Railway operations

Operations overview

The 300km section from Melbourne (South Dynon Yard) to Albury is part of the ARTC north-south corridor. It is a Class 1 railway throughout, with maximum speeds of: 115 km/h for 20 t axle load trains; 110 km/h for 21 t axle load trains; and 80 km/h for 23 t axle load trains. Significant investment is being made to provide higher speeds, axle loads, capacity and reliability, with large traffic growth expected. The route is generally constructed with a ruling gradient of 1 in 50, notably the 20 km climb approaching Heathcote Junction from the north. There are less than 30 curves that restrict speed below 100 km/h.

From Seymour to Shepparton a 153 km broad gauge line carries three passenger trains a day to Shepparton, and perhaps daily general, intermodal and occasional grain traffic to Tocumwal, on the NSW border. Beyond Shepparton the line is limited to 65 km/h or less.

Table 5-3 Benchmarking (existing infrastructure upgraded to class 1)

Route	Description	Track class	km	Average speed	Est hr:min
A01	Melbourne–Mangalore	1	117	actual av 50 km/h	2:20
A02	Mangalore–Wodonga Deviation Sth	1	188	actual av 88 km/h	2:08
A03a	Wodonga Deviation	1	5	88	0:03
A04	Wodonga Deviation Nth–Junee	1	163	actual av 77 km/h	2:07
A05	Mangalore–Murchison Deviation Sth	1	36	88	0:24
A06	Murchison Deviation Sth–Murchison Deviation Nth	1	4	88	0:02
A06a	Murchison Deviation	1	4	88	0:02
A07	Murchison Deviation nth–Tocumwal	1	102	88	1:09
A08	Tocumwal–Finley Deviation Nth	1	13	88	0:08
A09	Finley Greenfield–Finley Deviation Sth	1	3	88	0:02
A10	Finley Deviation Sth–Finley Deviation Nth	1	5	88	0:03
A10a	Finley Deviation	1	4	88	0:02
A11	Finley Deviation Nth–Berrigan Deviation Sth	1	14	88	0:09
A12	Berrigan Deviation Sth–Berrigan Deviation Nth	1	8	88	0:05
A12a	Berrigan Deviation	1	7	88	0:04
A13	Berrigan Deviation Nth–Jerilderie Deviation Sth	1	29	88	0:19
A14	Finley Greenfield–Jerilderie Deviation Nth	1	41	88	0:27
A15	Jerilderie Deviation Sth–Jerilderie Deviation Nth	1	6	88	0:04
A15a	Jerilderie Deviation	1	5	88	0:03
A16	Jerilderie Deviation Nth–Narrandera	1	102	88	1:09
A17	Narrandera–Junee By-pass West	2	93	88	1:03
A18	Junee By-pass West–Junee	2	5	63	0:03

Train crew depots

Given the proximity to the Melbourne termini it is unlikely that new train crew depots would be created.

Area A Summary table

Table 5-4 Area A summary

Area route	Description	Route length (km)	Journey time hr:min
AA01	Melbourne–Junee via Albury	475	6:39
AA02	Melbourne–Junee via Shepparton–	519	6:49

Area route	Description	Route length (km)	Journey time hr:min
	Tocumwal (new Finley deviation), Narrandera.		
AA03	Melbourne– to Junee via Shepparton–Tocumwal (no Finley deviation), Narrandera.	537	7:00

5.2 Area B route options — Junee to Narromine

5.2.1 General description of area

Area B is Junee–Narromine and uses the existing Main South line, Cootamundra–Lake Cargelligo line, Parkes–Stockinbingal line and Parkes–Narromine line, as shown in Figure 5-6.

All four lines are currently Class 2 standard gauge single track, except the Main South line (between Junee and Cootamundra), which is Class 1 standard gauge double track. ARTC is to upgrade the section Cootamundra–Parkes from Class 2 to Class 1, starting in 2009.

The existing topography is generally undulating over all four lines with varying ruling grades; 1 in 40 on the Main South line (between Junee and Cootamundra), 1 in 75 on the Cootamundra–Lake Cargelligo line, 1 in 100 on the Parkes–Stockinbingal line and 1 in 100 on the Parkes–Narromine line.

The geological conditions are predominately alluvium with large sections of soft and hard rock as well as soil. The area between Junee and Cootamundra is predominately soft and hard rock with some alluvium. From Cootamundra to Maleeja the conditions are mainly alluvium with some soft and hard rock. Between Maleeja and Narromine the geotechnical conditions are mainly alluvium with large sections of soil and some areas of soft and hard rock. Figure 5-9 shows a detailed geological map for this route.

The majority of this route has minimal flooding issues, with the exception of some locations between Junee and Stockinbingal, as well as Yeo Yeo and Maleeja. There are various areas where rivers cross the proposed or existing railway.

Main infrastructure, including roads, transmission lines and gas lines, is evident along the route. There are several areas where the transmission routes cross the proposed or existing rail corridor. The gas route follows the existing rail corridor between Junee and Cootamundra.

There are several significant environmental areas along this route: land zoned as environmental protection at Junee and Bethungra, Yeo Yeo State Forest and Bethungra Conservation Reserve Park.

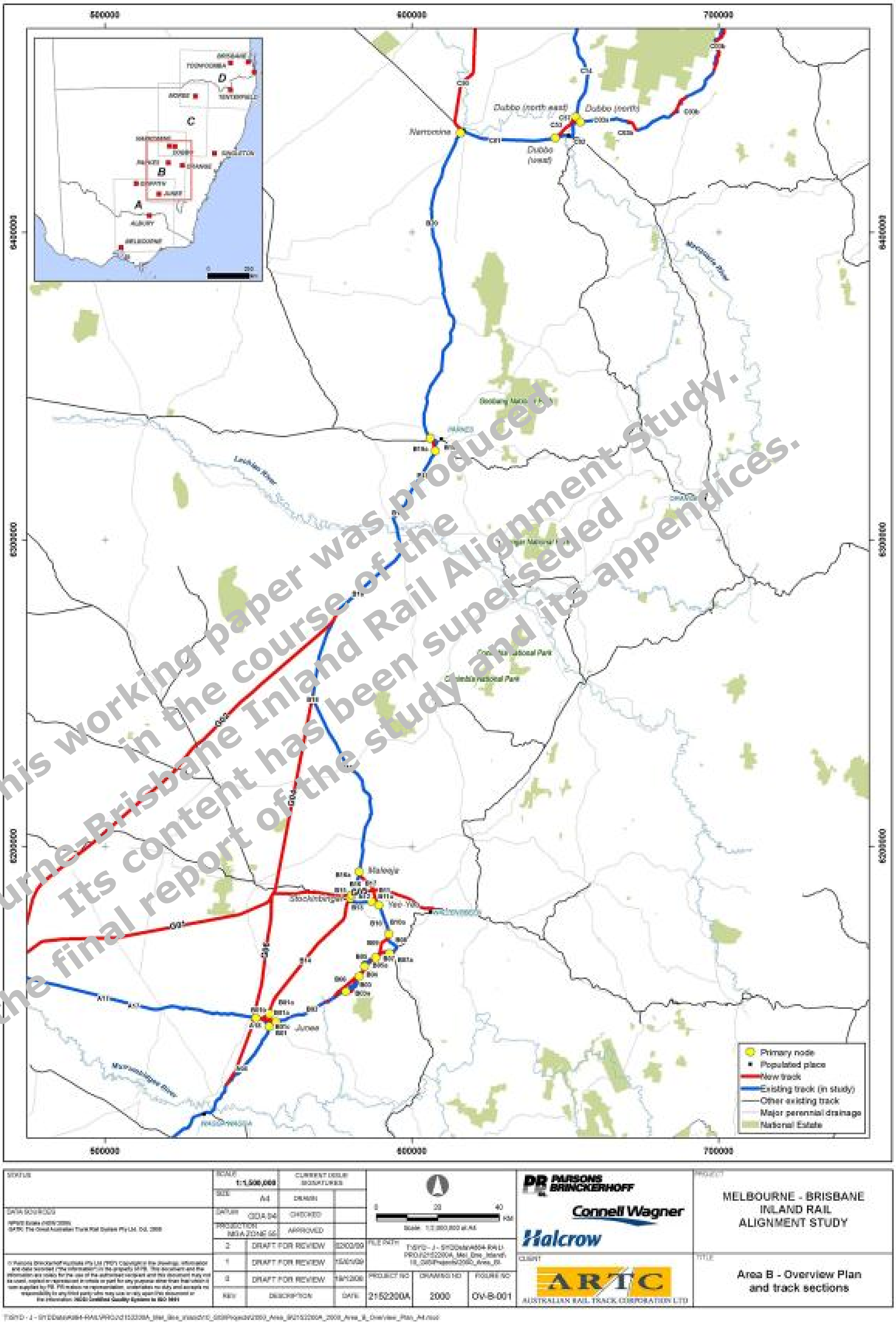


Figure 5-6 Area B overview plan

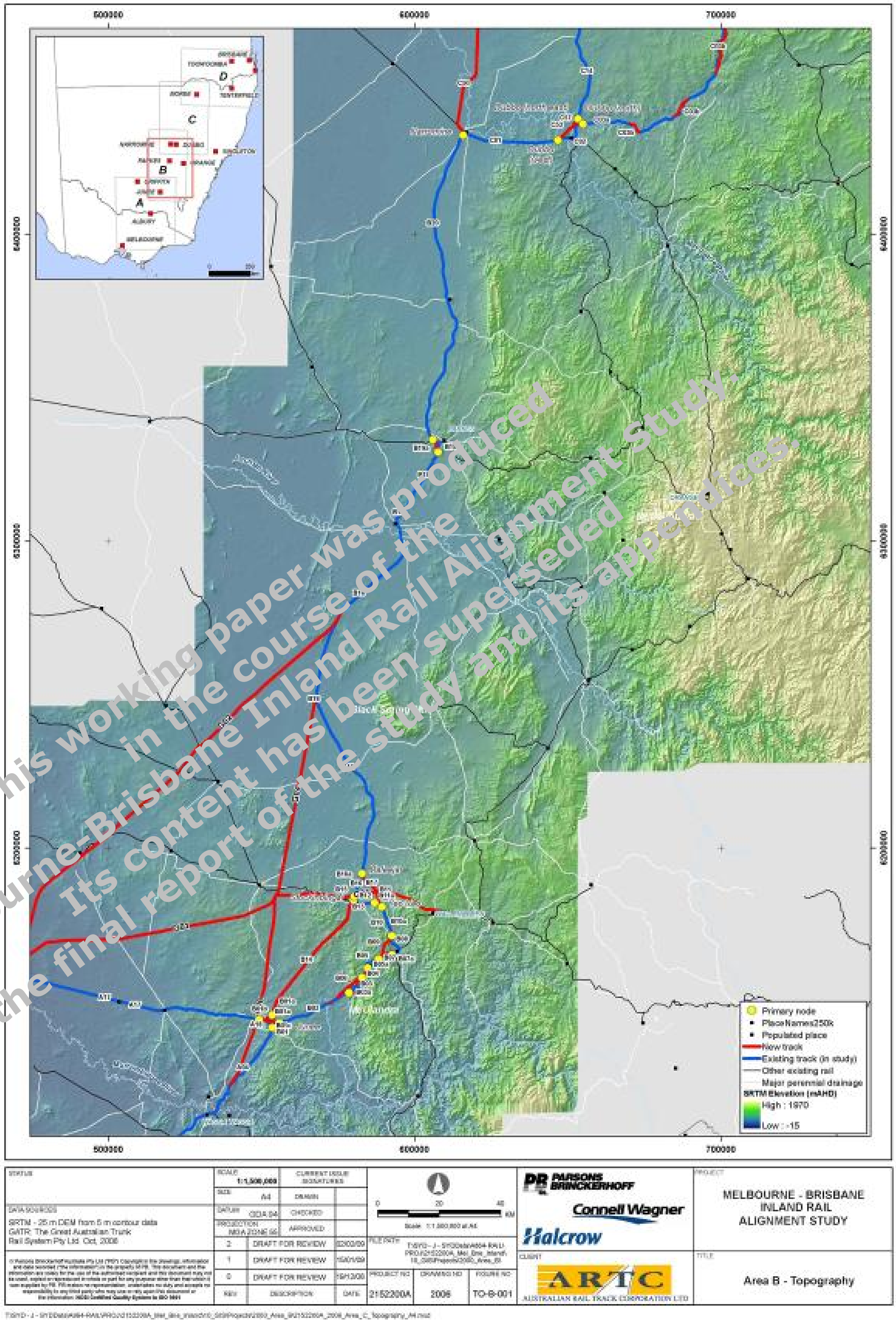


Figure 5-7 Area B topography

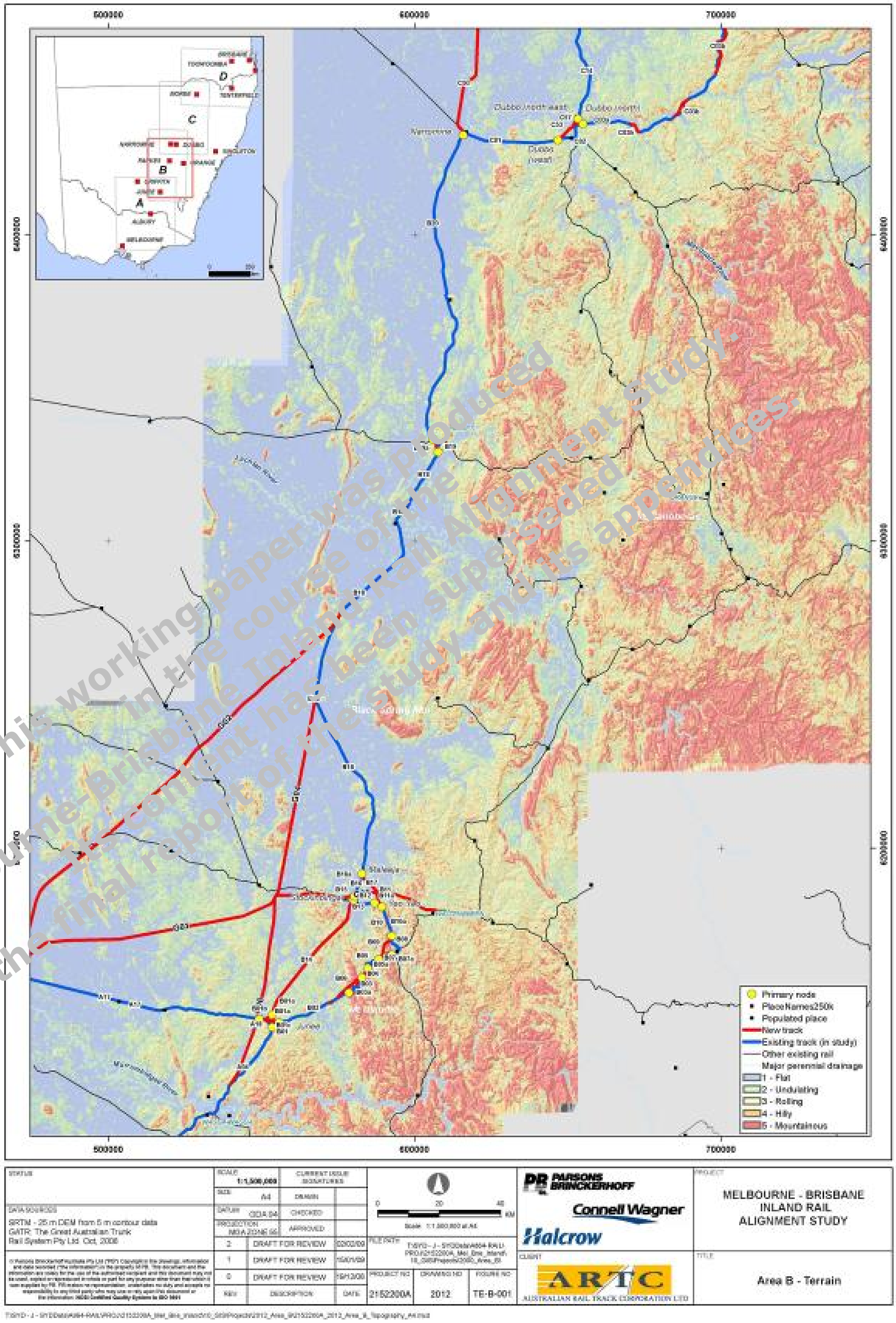


Figure 5-8 Area B terrain

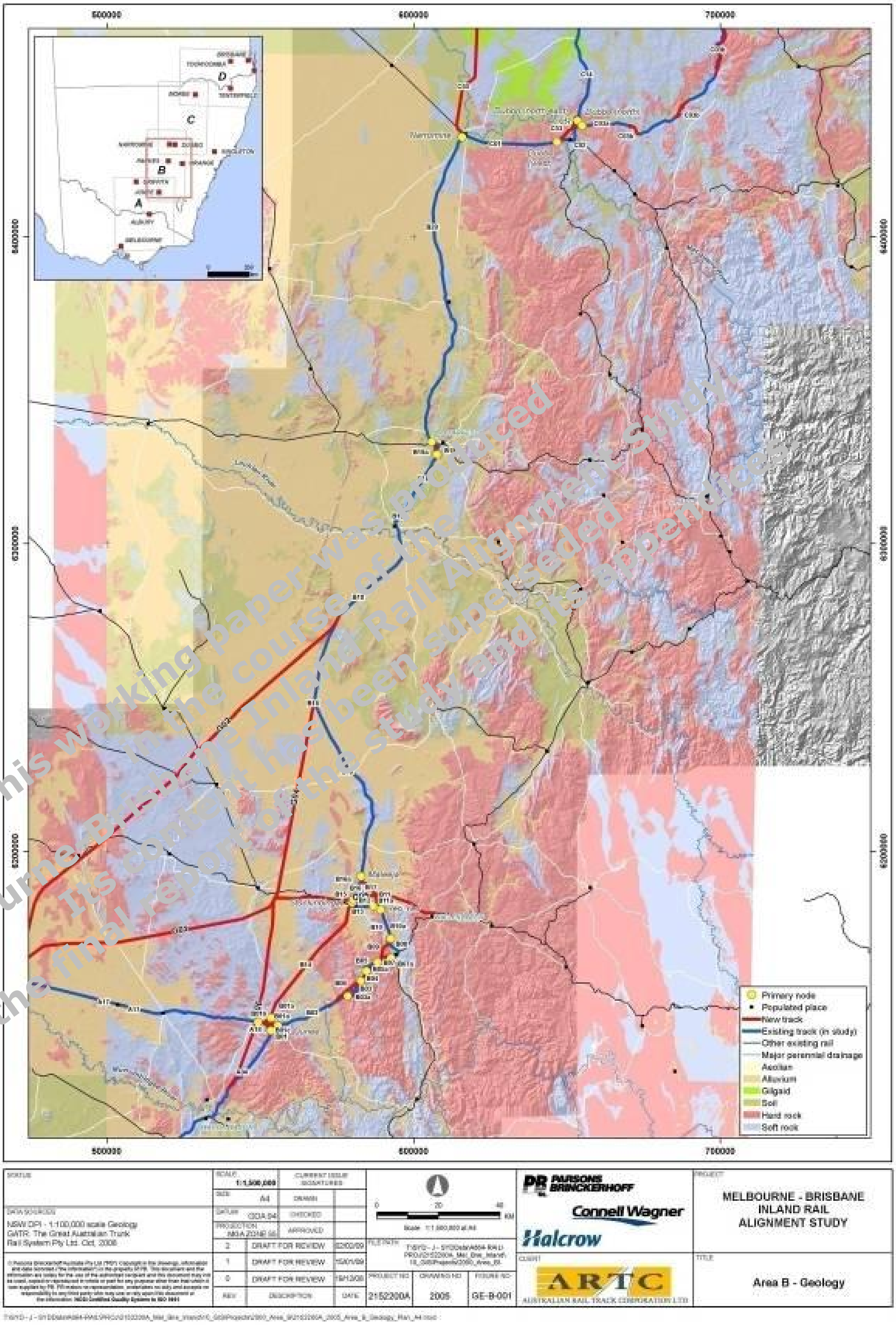


Figure 5-9 Area B geology

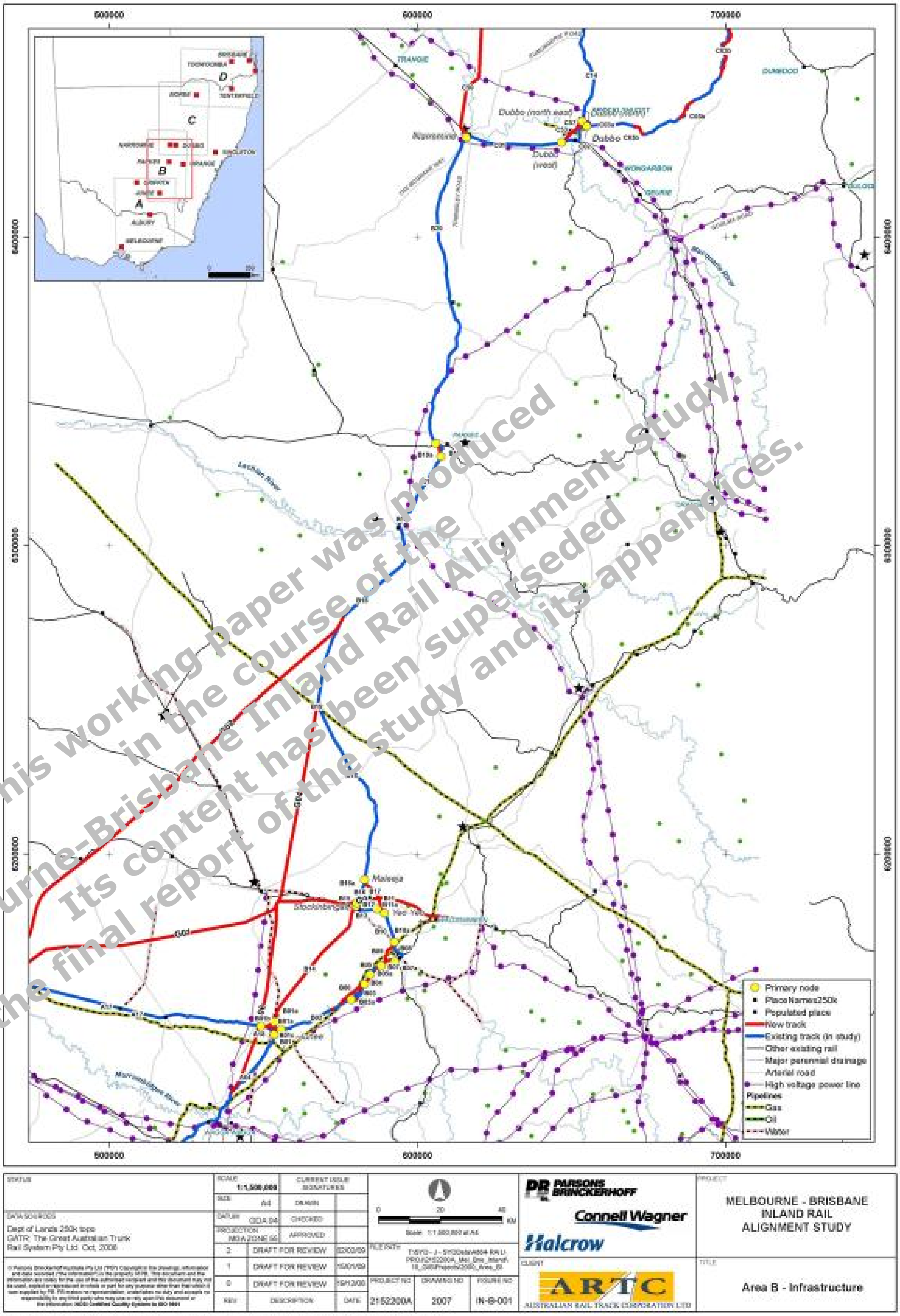


Figure 5-10 Area B infrastructure

5.2.2 Definition of sections and area routes

There are 13 potential area routes from Junee to Narromine, which are a combination of 20 sections. These routes and route sections are listed in Table 5-5 below.

Table 5-5 Area B routes

Area route	Description	Route sections
BB01	Junee–Narromine via Cootamundra, Stockinbingal and Parkes	B01+B02+B03+B04+B05+B07+B08+B10+B11+B12+B15+B16+B18+B19+B20
BB02	Junee–Narromine via Cootamundra, Stockinbingal (deviation between Yeo Yeo and Stockinbingal) and Parkes	B01+B02+B03+B04+B05+B07+B08+B10+B11+B13+B15+B16+B18+B19+B20
BB03	Junee–Narromine via Stockinbingal (deviation at Cootamundra) and Parkes	B01+B02+B03+B04+B05+B07+B09+B10+B11+B12+B15+B16+B18+B19+B20
BB04	Junee–Narromine via Stockinbingal (deviation at Cootamundra and between Yeo Yeo and Stockinbingal) and Parkes	B01+B02+B03+B04+B05+B07+B09+B10+B11+B13+B15+B16+B18+B19+B20
BB05	Junee–Narromine via Cootamundra (new route between Yeo Yeo and Maleeja) and Parkes	B01+B02+B03+B04+B05+B07+B08+B10+B17+B18+B19+B20
BB06	Junee–Narromine (new route between Yeo Yeo and Maleeja) via Parkes	B01+B02+B03+B04+B05+B07+B09+B10+B17+B18+B19+B20
BB07	Junee–Narromine via Cootamundra (deviations between Junee and Frampton), Stockinbingal and Parkes	B06+B07+B08+B10+B11+B12+B15+B16+B18+B19+B20
BB08	Junee–Narromine via Cootamundra (deviations between Junee and Frampton, Yeo Yeo and Stockinbingal), Stockinbingal and Parkes	B06+B07+B08+B10+B11+B13+B15+B16+B18+B19+B20
BB09	Junee–Narromine via Stockinbingal (deviations between Junee and Frampton and at Cootamundra) and Parkes	B06+B07+B09+B10+B11+B12+B15+B16+B18+B19+B20
BB10	Junee–Narromine via Stockinbingal (deviations between Junee and Frampton, at Cootamundra and Yeo Yeo and Stockinbingal) and Parkes	B06+B07+B09+B10+B11+B13+B15+B16+B18+B19+B20
BB11	Junee–Narromine via Stockinbingal (deviations between Junee and Frampton and new route between Yeo Yeo and Maleeja) and Parkes	B06+B07+B08+B10+B17+B18+B19+B20
BB12	Junee–Narromine via Stockinbingal (deviations between Junee and Frampton and at Cootamundra, new route between Yeo Yeo and Maleeja) and Parkes	B06+B07+B09+B10+B17+B18+B19+B20
BB13	Junee–Narromine via Stockinbingal (new route between Junee and Stockinbingal) and Parkes	B14+B15+B16+B18+B19+B20

Table 5-6 Area B sections

Section	Existing/new	Description	Line
B01	Existing	Junee to Junee By-pass East	Main South Line
B01a	New build — minor	Junee By-pass (Cootamundra)	New
B01b	New build — minor	Junee By-pass (Stockinbingal)	New
B01c	New build — minor	Junee to Junee By-pass North	New
B02	Existing	Junee By-pass East–to Bethungra Deviation Sth	Main South Line

Section	Existing/new	Description	Line
B03	Existing	Bethungra Deviation Sth–Bethungra Deviation Nth	Main South Line
B03a	New build — minor	Bethungra Deviation	Main South Line
B04	Existing	Bethungra Deviation North–Frampton Deviation Sth	Main South Line
B05	Existing	Frampton Deviation Sth–Frampton Deviation Nth	Main South Line
B05a	New build — minor–	Frampton Deviation	New
B06	New Build — major	Junee–Frampton Deviation Nth	New
B07	Existing	Frampton Deviation Nth–Cootamundra Deviation Sth	Main South Line and Cootamundra–to Stockinbingal Line
B07a	New build — major	Cootamundra Deviation Sth	New
B08	Existing	Cootamundra Deviation Sth–Bauloora	Cootamundra–Stockinbingal Line
B09	New build — major	Cootamundra Deviation	New
B10	Existing	Bauloora–Yeo Yeo Deviation Sth	Cootamundra–Stockinbingal Line
B10a	New build — major	Bauloora -Yeo Yeo Deviation	New
B11	Existing	Yeo Yeo Deviation Sth-Yeo Yeo Deviation Nth	Cootamundra–Stockinbingal Line
B11a	New build — major–	Yeo Yeo Deviation	New
B12	Existing	Yeo Yeo Deviation Nth–Stockinbingal	Cootamundra–Stockinbingal Line
B13	New build —major-	Yeo Yeo Deviation Nth–Stockinbingal Deviation	New
B14	New build — major	Junee By-pass Nth–Stockinbingal (Greenfield)	New
B15	Existing	Stockinbingal–Stockinbingal Deviation Nth	Stockinbingal–Parkes Line
B16	Existing	Stockinbingal Deviation Nth–Maleeja	Stockinbingal–Parkes Line
B16a	New build — major–	Stockinbingal Deviation Nth–Maleeja Deviation	New
B17	New build — major	Yeo Yeo–Maleeja (Greenfield)	New
B18	Existing	Maleeja–Parkes Deviation Sth	Stockinbingal–Parkes Line
B19	Existing	Parkes Deviation Sth–Parkes Deviation Nth	Orange–Broken Hill Line
B19a	New build — minor	Parkes Deviation	New
B20	Existing	Parkes Deviation Nth–Narromine	Parkes–Narromine Line

Note: route sections above in grey are directly affected by the ATRC's planned upgrade of Cootamundra–Parkes section.

5.2.3 Review of sections

Section B01, B02 and B03 — Junee to Bethungra (existing — BAU)

The Junee to Bethungra section of track is part of the Main South line and consists of Class 1 standard gauge track. The track is approximately 37 km and runs through various towns and crosses roads, rivers and creeks.

This section of the Main South line would not be upgraded as part of this study, as the existing condition of Class 1 is considered adequate for the required axle load.

The ruling grade for this section is 1 in 40.

Multiple bridges, level crossings, culverts and other structures are located along the Junee to Bethungra section.

Section B01a — Junee By-pass (Narrandera–Cootamundra) (new build — minor)

The Junee By-pass (Narrandera–Cootamundra) by-passes the Junee town centre, which is on the Junee–Hay line. This new route is Option 0905 from the NSRCS report. The purpose of the option is provide a connection from the Junee–Hay line to the proposed alignment Junee to Stockinbingal line via Cootamundra, by-passing low speed curves, infrastructure and the town of Junee.

The new section would consist of approximately 5 km of Class 1 track.

The proposed ruling grade for this section is 1 in 80.

Two turnouts, one level crossing and four creek crossings are likely to be required for the Junee By-pass.

Section B01b — Junee By-pass (Narrandera to Stockinbingal) (new build — minor)

The Junee By-pass (Narrandera to Stockinbingal) by-passes the Junee town centre, which is on the Junee–Hay line. This new route is Option 0906 from the NSRCS report. The purpose of the option is provide a connection from the Junee–Hay line to the proposed alignment Junee–Stockinbingal line, by-passing low speed curves, infrastructure and the town of Junee.

The new section would consist of approximately 5 km of Class 1 track.

The proposed ruling grade for this section is 1 in 80.

One turnout, seven level crossings and one creek crossing are likely to be required for the Junee By-pass.

Section B01c and B14 — Junee to Stockinbingal (new build — major)

The Junee–Stockinbingal route section is a new greenfield section. This new route is Option 0201 from the NSRCS report. The purpose of the option is to provide a direct route from Junee on the Main South line to Stockinbingal on the Stockinbingal to Parkes line. This option by-passes low speed curves and steep grades at the Bethungra spiral and Cootamundra and low speed curves on the Cootamundra–Stockinbingal line.

This new section would provide an alternative route to the existing Junee–Stockinbingal route. The new section would consist of approximately 51 km of Class 1 track.

The proposed ruling grade for this section is 1 in 70.

Endangered species and areas of dry salinity are located in the vicinity of the section.

Section B03a — Bethungra deviation (new build — minor)

The Bethungra deviation by-passes the existing Bethungra spiral, which is located on the Main South line. This deviation is Option 0203 from the NSRCS report. The purpose of the deviation is to remove low speed curves and steep grades at the Bethungra spiral. The new deviation would consist of approximately 8 km of Class 1 standard gauge track, as well as two tunnels with a total approximate length of 3 km.

The proposed ruling grade for this section is 1 in 80.

Four level crossings and six river and creek crossings are likely to be required for the Bethungra deviation.

Endangered and vulnerable species as well as state forest are in the vicinity of the deviation.

Section B04 and B05 — Bethungra to Frampton (existing — BAU)

The Bethungra to Frampton section of track is part of the Main South line and consists of Class 1 standard gauge track. The track is approximately 9 km long and runs through various towns and crosses roads, rivers and creeks.

This section of the Main South line would not be upgraded as the existing condition of Class 1 is considered adequate for the required axle load.

The ruling grade for this section is 1 in 40.

Some bridges, level crossings, culverts and other structures are located along the Bethungra to Frampton section.

Section B05a — Frampton deviation (new build — minor)

The Frampton deviation by-passes low speed curves after the Frampton town centre, which is located on the Main South Line. This deviation is Option 0204 from the NSRCS report. The purpose of the deviation is to remove low speed curves at Frampton. The new deviation would consist of approximately 5 km of Class 1 standard gauge track.

The proposed ruling grade for this section is 1 in 80.

Three level crossings and several river and creek crossings are likely to be required for the Frampton deviation.

Vulnerable and protected species have been identified nearby to the deviation.

Section B06, B07a, B10a, B11a and B13 — Junee–Stockinbingal deviation (new build — minor)

The proposed ARTC upgrade of the Cootamundra to Parkes section will directly affect most of these minor route section improvements.

The Junee–Stockinbingal deviation route section is a new section adjacent to the existing line and is part of the Main South line and the Cootamundra–Stockinbingal line. This new route is option 0202 from the NSRCS report. The purpose of the option is to remove low speed curves and steep grades at the Bethungra spiral and low speed curves at Frampton, Cootamundra, Yeo Yeo and Stockinbingal. The Bethungra spiral will also be replaced with a tunnel and a tunnel will by-pass Cootamundra.

This new section would provide an alternative route to the existing route from Junee–Stockinbingal and would consist of approximately 67 km of Class 1 track.

The proposed ruling grade for this section is 1 in 80.

Eight turnouts, four level crossings and many river and creek crossings are likely to be required for the Junee–Stockinbingal deviation.

Endangered and vulnerable species as well as state forest and dryland salinity are in the vicinity and on the deviation.

Section B07 and B08 — Frampton to Bauloora (existing — BAU)

The Bauloora to Yeo Yeo section of track is part of the Cootamundra–Stockinbingal line and consists of Class 2 standard gauge track. The track is approximately 15 km long and runs through various towns and crosses roads, rivers and creeks.

This section of the Cootamundra–Stockinbingal line would not necessarily be upgraded as the existing condition of Class 2 is considered adequate for the required axle load.

The ruling grade for this section is 1 in 75.

Some bridges, level crossings, culverts and other structures are located along the Frampton–Bauloora section.

Section B09 — Cootamundra deviation (new build — major)

The Cootamundra deviation by-passes the Cootamundra town centre, which is located on the Cootamundra–Lake Cargelligo line. This deviation is part of Option 0202 from the NSRCS report. The purpose of the deviation is to remove low speed curves at Cootamundra and by-pass the town of Cootamundra. The new deviation would consist of approximately 9 km of Class 1 standard gauge track, as well as two tunnels with a total approximate length of 1.5 km.

The proposed ruling grade for this section is 1 in 80.

Several creek crossings are likely to be required for the Cootamundra deviation.

Section B10 and B11 — Bauloora to Yeo Yeo (existing — BAU)

Proposed ARTC upgrade of the Cootamundra to Parkes section will directly affect these route section improvements.

The Bauloora–Yeo Yeo section of track is part of the Cootamundra–Stockinbingal line and consists of Class 2 standard gauge track. The track is approximately 14 km long and runs through various towns and crosses roads, rivers and creeks.

This section of the Cootamundra–Stockinbingal line would not necessarily be upgraded as the existing condition of Class 2 is considered adequate for the required axle load.

The ruling grade for this section is 1 in 75.

Multiple bridges, level crossings, culverts and other structures are located along the Bauloora–Yeo Yeo section.

Section B12 — Yeo Yeo to Stockinbingal (existing — BAU)

Proposed ARTC upgrade of the Cootamundra to Parkes section will directly affect this route section.

The Yeo Yeo–Stockinbingal section of track is part of the Cootamundra–Stockinbingal line and consists of Class 2 standard gauge track. The track is approximately 8 km long and runs through various towns and crosses various roads, rivers and creeks.

This section of the Cootamundra–Stockinbingal line would not be upgraded as the existing condition of Class 2 is considered adequate for the required axle load.

The ruling grade for this section is 1 in 75.

Multiple bridges, level crossings, culverts and other structures are located along the Yeo Yeo–Stockinbingal section.

Section B13, B15 and B16a — Yeo Yeo to Maleeja deviation (new build — major)

Proposed ARTC upgrade of the Cootamundra to Parkes section will directly affect these route section improvements.

The Yeo Yeo–Maleeja deviation by-passes low speed curves at Yeo Yeo and Stockinbingal, which is located on the Cootamundra–Stockinbingal line. This deviation is part of Option 0102 from the NSRCS report. The purpose of the deviation is to remove low speed curves at Yeo Yeo and Stockinbingal and reconfiguration of turnouts at Stockinbingal to connect into the Stockinbingal–Parkes line. The new deviation would consist of approximately 18 km of Class 1 standard gauge track.

The proposed ruling grade for this section is 1 in 80.

Two turnouts and several creek crossings are likely to be required for the Yeo Yeo–Maleeja deviation.

Vulnerable species are in the vicinity of the deviation.

Section B15 and B16 — Stockinbingal to Maleeja (existing — BAU)

The proposed ARTC upgrade of the Cootamundra to Parkes section will directly affect these route section improvements.

The Stockinbingal-Maleeja section of track is part of the Stockinbingal–Parkes line and consists of Class 2 standard gauge track. The track is approximately 9 km long and runs through various towns and crosses various roads, rivers and creeks.

This section of the Stockinbingal–Parkes line would not be upgraded as the existing condition of Class 2 is considered adequate for the required axle loads.

The ruling grade for this section is 1 in 100.

Multiple bridges, level crossings, culverts and other structures are located along the Stockinbingal to Maleeja section.

Section B17 — Yeo Yeo to Maleeja (new build — major)

The Yeo Yeo–Maleeja section is a new greenfield section. This new route is option 0101 from the NSRCS report. The purpose of the option is to provide a direct route from Yeo Yeo on the Cootamundra–Stockinbingal line to Maleeja on the Stockinbingal– Parkes line. This option by-passes low speed curves at Yeo Yeo and the town of Stockinbingal.

This new section would provide an alternative route to the existing route from Yeo Yeo–Maleeja. The new route section would consist of approximately 13 km of Class 1 track.

The proposed ruling grade for this section is 1 in 80.

One turnout, one level crossing and several creek crossings are likely to be required for the Yeo Yeo–Maleeja Greenfield section.

Vulnerable species are located in the vicinity of the section.

Section B18 and B19 — Maleeja to Parkes (existing — BAU)

Proposed ARTC upgrade of the Cootamundra to Parkes section will directly impact B18 and possibly B19.

The Maleeja–Parkes section of track is part of the Stockinbingal–Parkes line and consists of Class 2 standard gauge track. The track is approximately 165 km long and runs through various towns and crosses various roads, rivers and creeks.

This section of the Stockinbingal–Parkes line would not be upgraded as the existing condition of Class 2 is considered adequate for the required axle loads.

The ruling grade for this section is 1 in 100.

Multiple bridges, level crossings, culverts and other structures are located along the Maleeja–Parkes section.

Section B19a — Parkes deviation (new build — minor)

The Parkes deviation by-passes the Parkes town centre, which is located on the Orange–Broken Hill line. This deviation is option 1201 from the report. The purpose of the deviation is to provide a connection from the Parkes–Stockinbingal Line to the Parkes–Narromine line with connections to the Orange–Broken Hill line. The new deviation would consist of approximately 5 km of Class 1 standard gauge track.

The proposed ruling grade for this section is 1 in 80.

Four turnouts, one level crossing and one creek crossing are likely to be required for the Parkes deviation.

Section B20 — Parkes to Narromine (existing — BAU)

The Parkes–Narromine section of track is part of the Parkes–Narromine line and consists of Class 2 standard gauge track. The track is approximately 106 km long and runs through various towns and crosses various roads, rivers and creeks.

This section of the Parkes–Narromine line would not be upgraded as the existing condition of Class 2 is considered adequate for the required axle loads.

The ruling grade for this section is 1 in 100.

Multiple bridges, level crossings, culverts and other structures are located along the Goobang Junction–Narromine section.

Section G01 — Narrandera to Temora Junction and G06 — Temora Junction South to Existing near Wagga Wagga[6]

It is feasible to develop a direct route from Narrandera to the Stockinbingal-Forbes railway south of Forbes. However, by adding 17 km to the route length, a route can be provided that allows the trunk route to be used for Sydney–Melbourne via Narrandera, Sydney-Melbourne via Wagga, Sydney–Perth, and Brisbane–Melbourne via Wagga journeys, thus adding significantly to the traffic likely to use the trunk route and to the operating economies of that traffic. This route goes via a major interchange south-east of Temora. Both configurations are shown on the map (Figure 5-6).

The principal route follows open country throughout and avoids both the state forests and outbreaks of hilly country in the otherwise flat plain.

[6] Description provided by GATR submission.

The alternative, more direct route has to get through the Walleroobie Range and, like the Newell Highway, it does so at Ardlethan. However, it is difficult to see how to do that without a double crossing of the highway because to keep to the north of it would take the route either through the town or into the hills in several places, including the Willows State Forest. Elsewhere the route is in open flat country.

Section G02 — Narrandera to existing line north of Caragabal (direct)[7]

The alternative shorter route from Narrandera rejoins the existing Stockinbingal–Forbes line at Wirrinya. After leaving the corridor of the Roto Branch east of Ardlethan, it goes straight to the Rankin Springs Branch which it crosses 12.3 km (direct) west of Barmedman. It then crosses the Lake Cargelligo railway near Yiddah, about 13 km north of Barmedman. It has deviated somewhat from straight in this area to minimise the number of road crossings. It is located to rejoin the Stockinbingal-Forbes line south of where a proposed Forbes by-pass leaves that line, but its actual point of rejoining is influenced somewhat by the desirability of staying clear of the Currowong Hills, which it passes to the east.

Section G04 —Temora junction north to existing near Caragabal[8]

The whole region is generally flat with scattered hills rising up to 150 m above the plain (Tallabung Mountain, just west of the route SW of Forbes, rises 300 m above the plain). The lowest area is along the Lachlan River through Forbes where the levels are about 230 m, compared with nearly 300 m near Temora Junction.

The preferred route skirts east of the Narraburra Hills and the Boginderra Hills and rejoins the Stockinbingal-Forbes line 0.3 km south of Caragabal. It remains on this line, apart from two curve easings to 3.3 km north of Wirrinya.

Section C05 —Temora junction east to existing near Wallendbeen[9]

The preferred route has a major junction centred about 10 km to the south east of Temora. Its location is an attempt to optimise the lengths of:

- Melbourne–Brisbane via Tocumwal
- Melbourne–Brisbane via Albury
- Sydney–Melbourne via the GATR option through Tocumwal
- Sydney–Melbourne via Albury that avoids the Bethungra spiral and provides a high quality but not longer route between Wallendbeen and Wagga
- Sydney–Perth via the Riverina line
- Brisbane–Canberra via the GATR.

However, the junction location is constrained by the town of Temora; the desire to avoid Temora and Currajong State Forests, both to the south-west of the town, the Narraburra State Forest, Narraburra Hills and Boginderra Hills, all north-east of the town; and the common objectives to minimise road crossings, stay in flat country (the route chosen stays around 300 m in elevation throughout), position the routes joined by the junction for their own optimal location (particularly in this case the Wagga connection) and maximise the use of and links to existing rail corridors (in this case the line between Stockinbingal and Temora).

[7] Description provided by GATR submission.

[8] Description provided by GATR submission.

[9] Description provided by GATR submission.

At Temora Junction the trunk line swings north on a 10 km radius curve while the link to the Sydney south connection goes straight ahead. The link between the Sydney south connection and the Wagga connection (which together provide the alternative route — by-passing the Bethungra spiral — for the existing Sydney-Melbourne line) has been shown with a 10 km radius curve as well. The link between Brisbane and the Wagga connection is straight and crosses the Sydney south connection with a grade separation. The Brisbane–Sydney south connection (the GATR Brisbane–Canberra route) link is shown with a non-standard radius of about 1.5 km (allowing maximum speeds of up to only 150 km/h) because traffic is likely to be lightest on this link. However, there is no physical constraint to any curve up to a full 10 km radius curve if traffic is likely to warrant it.

5.2.4 Railway operations

Operations overview

The 216 km section from Albury–Cootamundra is part of the ARTC north–south corridor. It is a Class 1 railway, with a maximum speed of 115 km/h for 21 t axle load trains and 80 km/h for 23 t axle load trains. Significant investment is being made to provide higher speeds, axle loads, capacity and reliability, with large traffic growth expected. The route is generally constructed with gradients of up to 1 in 60, although the ruling gradient is 1 in 40, notably due to a 1.5 km section at Bomen. The Bethungra spiral is a 6 km section of line northbound with 1 in 70 gradients and 65 km/h speed restrictions. There is a 13 km section outside Cootamundra with a speed restriction of 80 km/h due to curves and gradients.

Between Cootamundra and Stockinbingal the 24 km route is Class 2. Maximum speed is 100 km/h for 19.5 t axle loads, and 80 km/h for 21 t axle loads. This route is being upgraded to Class 1 by ARTC as part of their east–west corridor strategy, which includes the ability to handle 1,800 m long double stack trains with 21 t axle loads at 115 km/h. This section has curves of less than 800 m radius and a ruling gradient of around 1 in 75.

From Stockinbingal to Parkes the 175 km route is Class 2, and is also part of ARTC's east–west corridor upgrade plans above. The line is generally straight and flat, with no gradients steeper than 1 in 100 and only eight speed restrictions, generally associated with curves near towns.

From Parkes (Goobang Junction) to Narromine the 111 km route is Class 2, but does not form part of ARTC's east–west improvement plans. The line allows 19.5 t axle load trains to operate at 100 km/h, and 21 t axle load trains at 80 km/h. Ore and grain traffic uses the line a few times per week.

Table 5-7 Benchmarking exercise, existing infrastructure upgraded to class 1

Route	Description	Track class	km	Average speed	Est hr:min
B01	Junee–Junee By-pass East	1	4	63	0:03
B01a	Junee By-pass (Cootamundra)	1	5	63	0:04
B01b	Junee By-pass (Stockinbingal)	1	5	63	0:04
B01c	Junee–Junee By-pass North	1	4	63	0:03
B02	Junee By-pass East–Bethungra Deviation Sth	1	25	actual av 63 km/h	0:23
B03	Bethungra Deviation Sth–Bethungra Deviation Nth	1	8	63	0:07

Route	Description	Track class	km	Average speed	Est hr:min
B03a	Bethungra Deviation	1	8	63	0:07
B04	Bethungra Deviation North– to Frampton Deviation Sth	1	4	actual av 63 km/h	0:03
B05	Frampton Deviation Sth–Frampton Deviation Nth	1	5	63	0:04
B05a	Frampton Deviation	1	5	63	0:04
B06	Junee–Frampton Deviation Nth	1	40	63	0:38
B07	Frampton Deviation Nth–Cootamundra Deviation Sth	1	6	actual av 63 km/h	0:05
B07a	Cootamundra Deviation Sth	1	5	63	0:04
B08	Cootamundra Deviation Sth to Bauloora	1/2	9	63	0:08
B09	Cootamundra Deviation	1	9	63	0:08
B10	Bauloora–Yeo Yeo Deviation Sth	2	10	63	0:09
B10a	Bauloora–Yeo Yeo Deviation	2	10	63	0:09
B11	Yeo Yeo Deviation Sth–Yeo Yeo Deviation Nth	2	4	63	0:03
B11a	Yeo Yeo Deviation	1	3	63	0:02
B12	Yeo Yeo Deviation Nth–Stockinbingal	2	8	63	0:07
B13	Yeo Yeo Deviation Nth to Stockinbingal Deviation	1	9	63	0:08
B14	Junee By-pass Nth–Stockinbingal (Greenfield)	1	47	63	0:44
B15	Stockinbingal–Stockinbingal Deviation Nth	2	1	63	0:01
B16	Stockinbingal Deviation Nth–Maleeja	2	8	88	0:05
B16a	Stockinbingal Deviation Nth–Maleeja Deviation	1	8	88	0:05
B17	Yeo Yeo–Maleeja (Greenfield)	1	13	88	0:08
B18	Maleeja–Parkes Deviation Sth	2[10]	159	88	1:48
B19	Parkes Deviation Sth–Parkes Deviation Nth	2	6	63	0:05
B19a	Parkes Deviation	1	5	63	0:04
B20	Parkes Deviation Nth–Narromine	2	106	88	1:12

Train crew depots

There is a train crew and locomotive depot at Parkes, where crew and fuelling are likely to take place, although trains on the inland railway are likely to by-pass both the existing locomotive depot and station, and will require new facilities built.

[10] This section is planned to be upgraded to Class 1 by the ARTC, finishing in 2010.

Area B summary table

Table 5-8 Area B summary

Area route	Description	Route length (km)	Journey time hr:min
BB01	Junee–Narromine via Cootamundra, Stockinbingal and Parkes	363	4:23
BB02	Junee–Narromine via Cootamundra, Stockinbingal (deviation between Yeo Yeo and Stockinbingal) and Parkes	364	4:24
BB03	Junee–Narromine via Stockinbingal (deviation at Cootamundra) and Parkes	363	4:23
BB04	Junee–Narromine via Stockinbingal (deviation at Cootamundra and between Yeo Yeo and Stockinbingal) and Parkes	364	4:24
BB05	Junee–Narromine via Cootamundra (new route between Yeo Yeo and Maleeja) and Parkes	355	4:15
BB06	Junee–Narromine (new route between Yeo Yeo and Maleeja) via Parkes	355	4:15
BB07	Junee–Narromine via Cootamundra (deviations between Junee and Frampton), Stockinbingal and Parkes	357	4:21
BB08	Junee–Narromine via Cootamundra (deviations between Junee and Frampton, Yeo Yeo and Stockinbingal) Stockinbingal and Parkes	358	4:22
BB09	Junee–Narromine via Stockinbingal (deviations between Junee and Frampton and at Cootamundra) and Parkes	357	4:21
BB10	Junee–Narromine via Stockinbingal (deviations between Junee and Frampton, at Cootamundra and Yeo Yeo and Stockinbingal) and Parkes	358	4:22
BB11	Junee–Narromine via Stockinbingal (deviations between Junee and Frampton and new route between Yeo Yeo and Maleeja) and Parkes	349	4:13
BB12	Junee–Narromine via Stockinbingal (deviations between Junee and Frampton and at Cootamundra, new route between Yeo Yeo and Maleeja) and Parkes	349	4:13
BB13	Junee–Narromine via Stockinbingal (new route between Junee and Stockinbingal) and Parkes	327	3:55

5.2.5 Comparative routes

Two routes have been chosen to demonstrate the differing engineering features of this area, shown in Figure 5-11:

- via Albury, Junee and Cootamundra (using the existing railway), and
- via Shepparton and Narrandera (utilising the existing corridor) and a new section of railway between Narrandera and near Caragabal.

Profiles have been developed to illustrate the differing terrain these routes traverse; these are provided in Figure 5-12.

Figure 5-11 Melbourne to Parkes plan

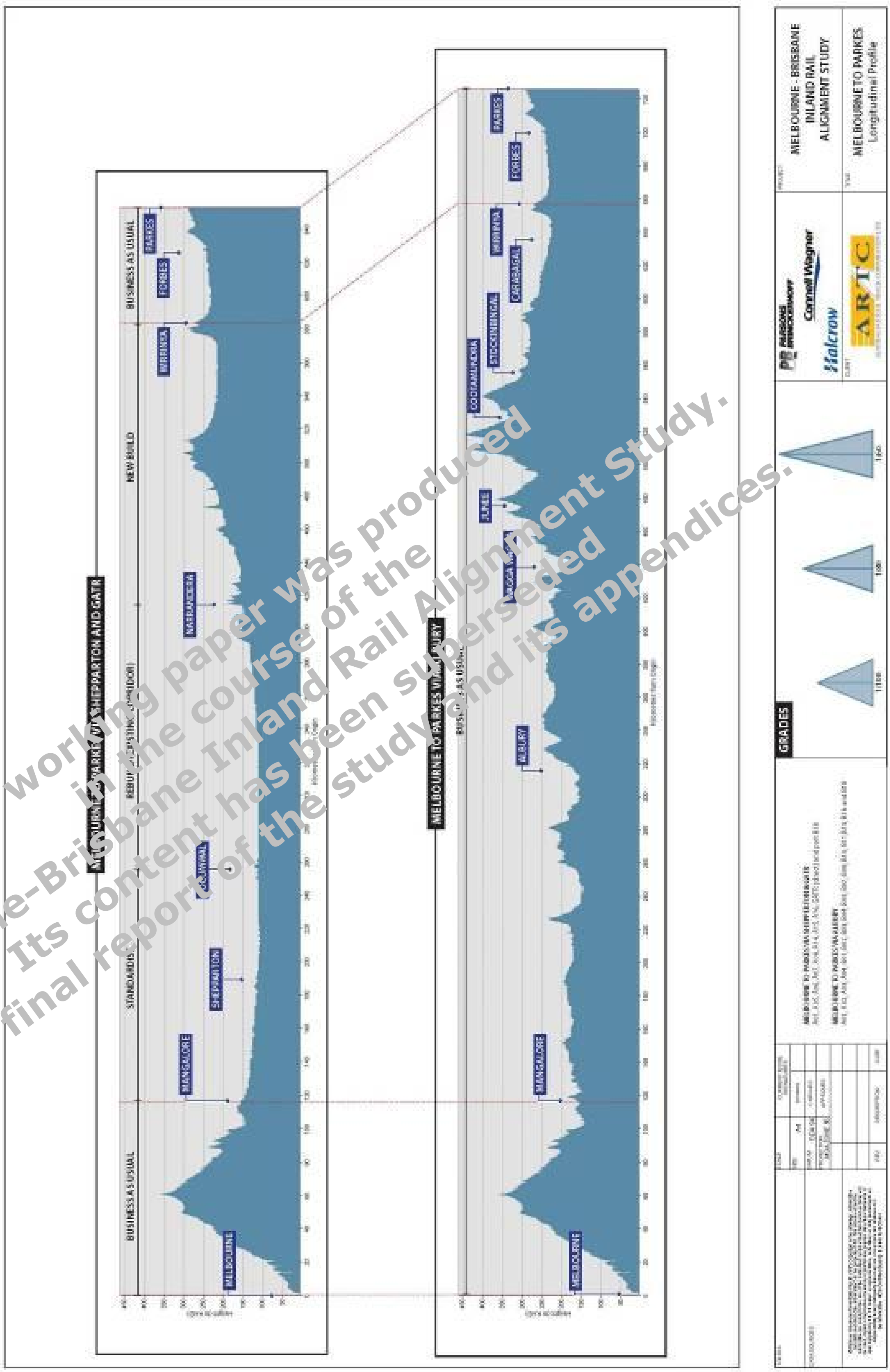


Figure 5-12 Illustrative profiles, Melbourne to Parkes

5.3 Area C route options — Narromine–Moree

5.3.1 General description of Area C

Area C is presented in Figure 5-13. It is bounded by:

- the Main West line railway from Narromine, through Dubbo, Binnaway, Premer, to Werris Creek
- along the eastern edge, the existing Werris Creek to Moree railway line, which passes through Gunnedah, Boggabri and Narrabri
- on the western side, potential new railway alignments linking Narromine to Coonamble, Burren Junction and Moree
- several alternative railway alignments through the centre of Area C comprising new railway and upgrades of existing (infrequently used) lines.

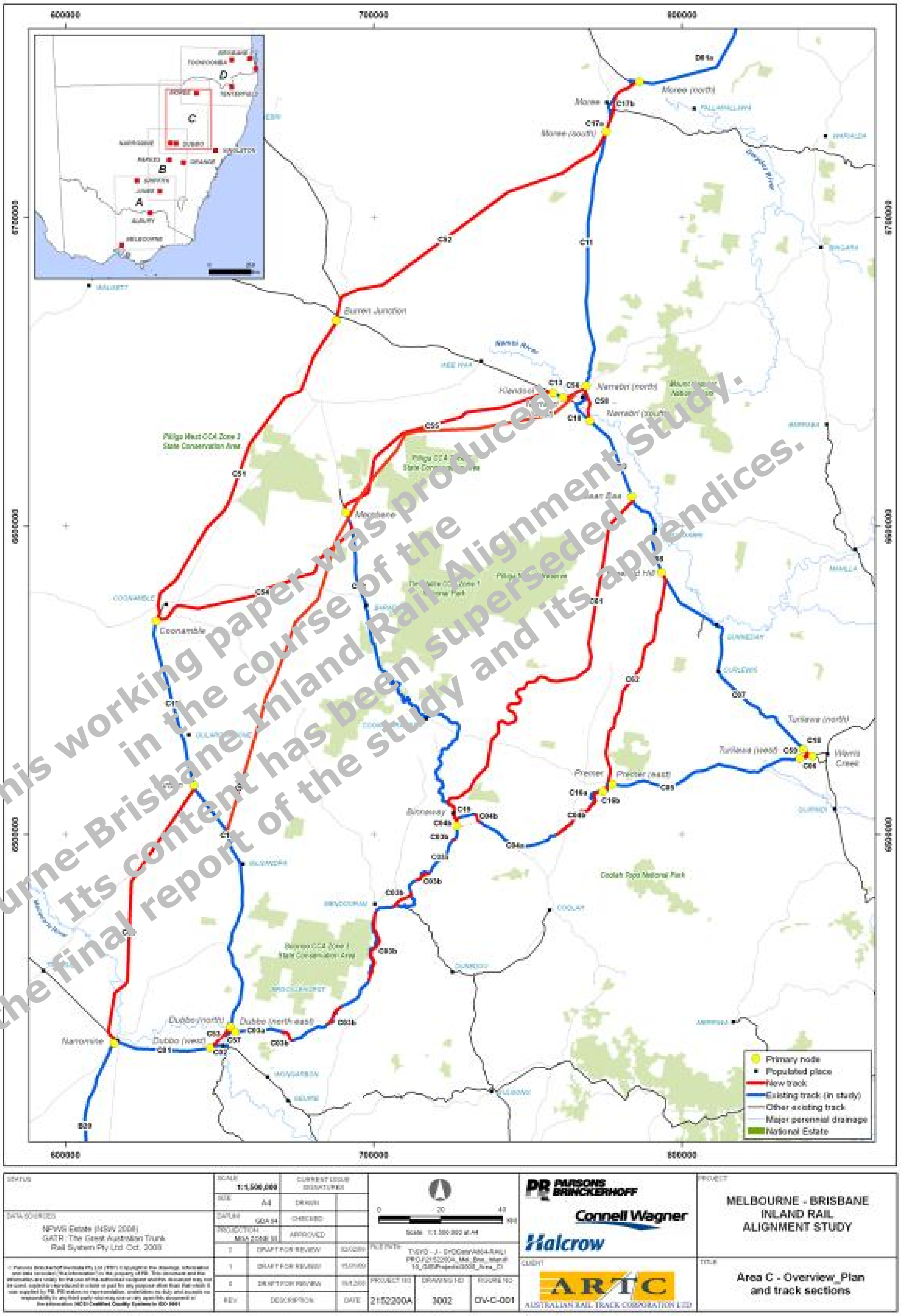


Figure 5-13 Area C overview plan

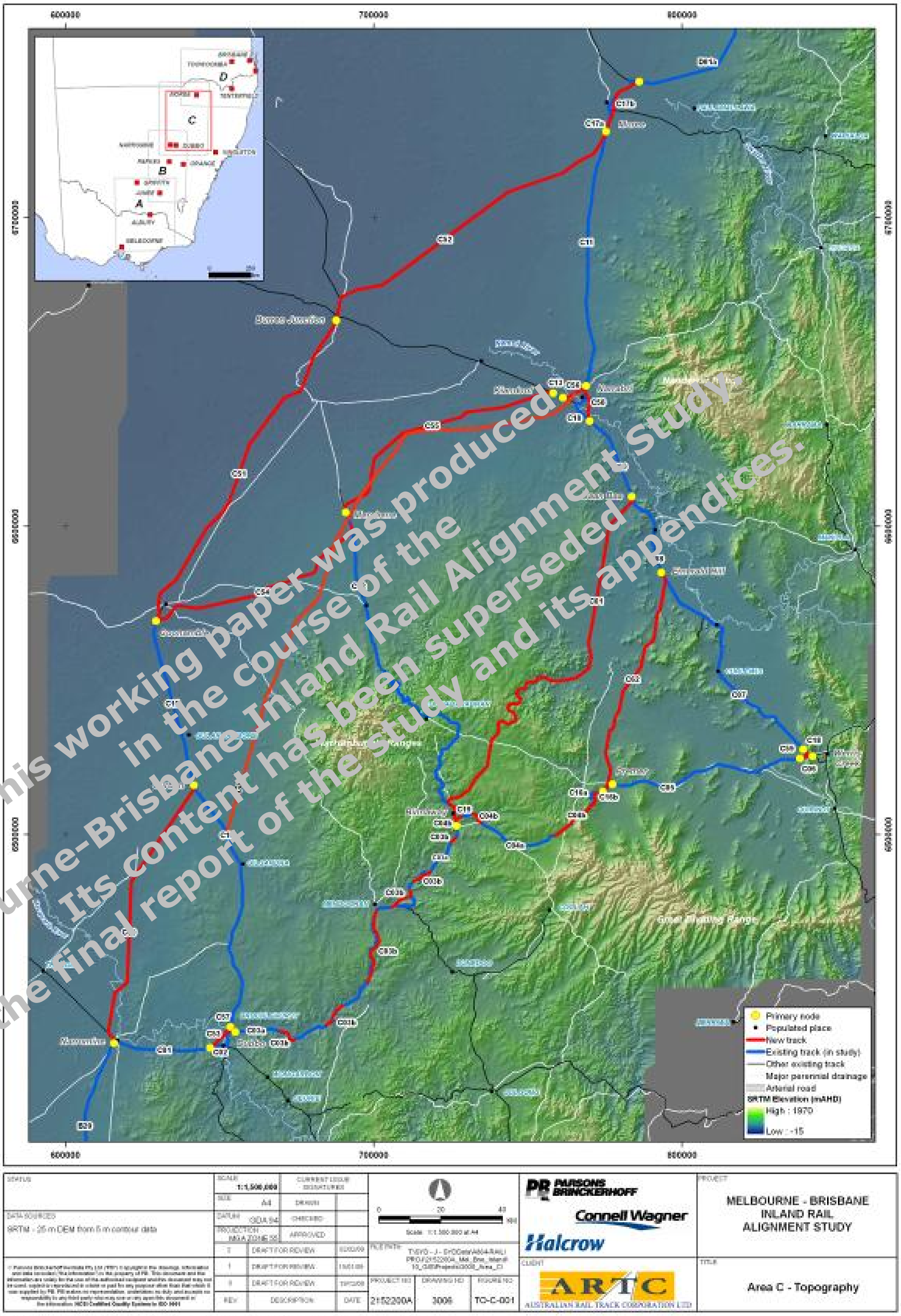


Figure 5-14 Area C topography

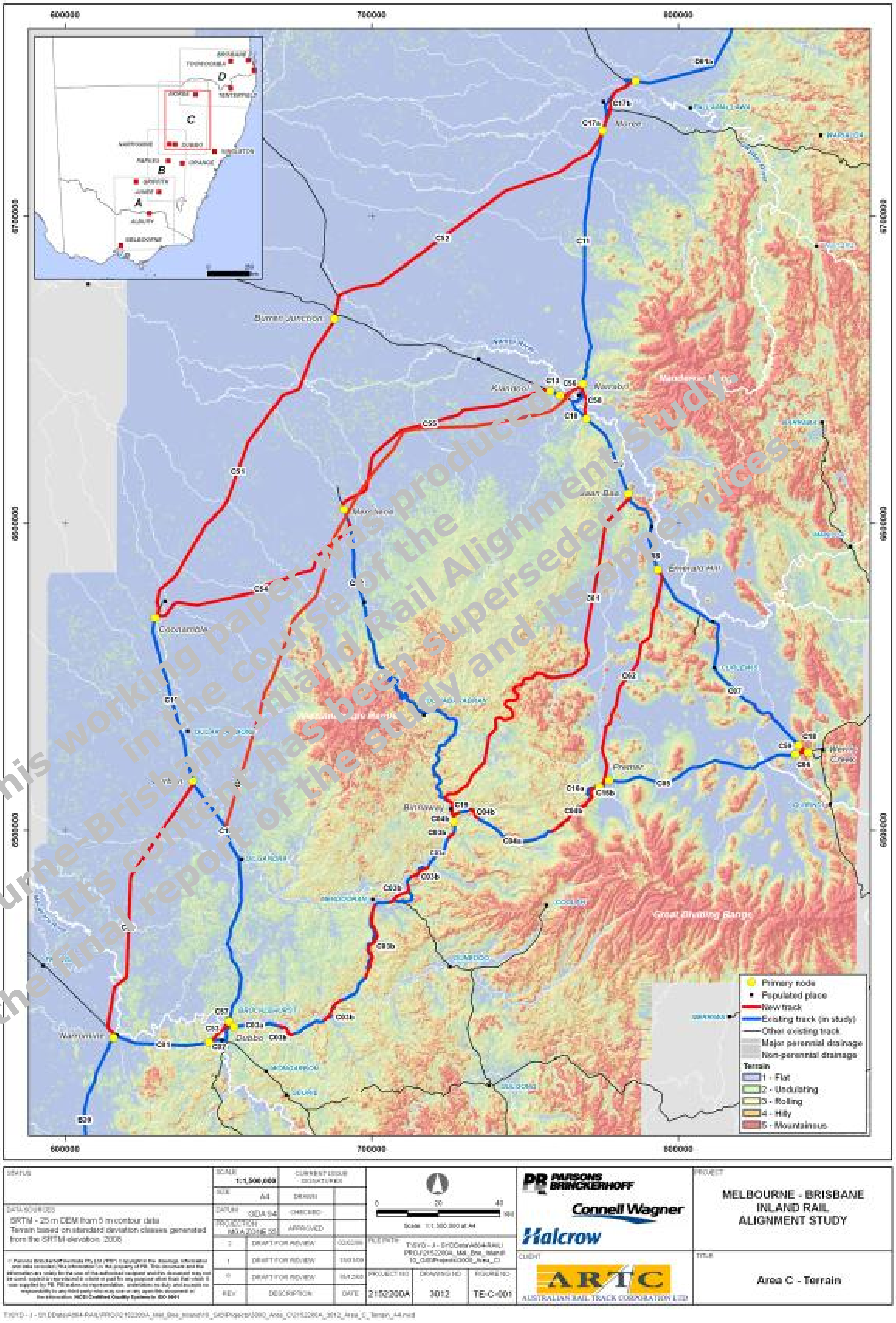


Figure 5-15 Area C terrain

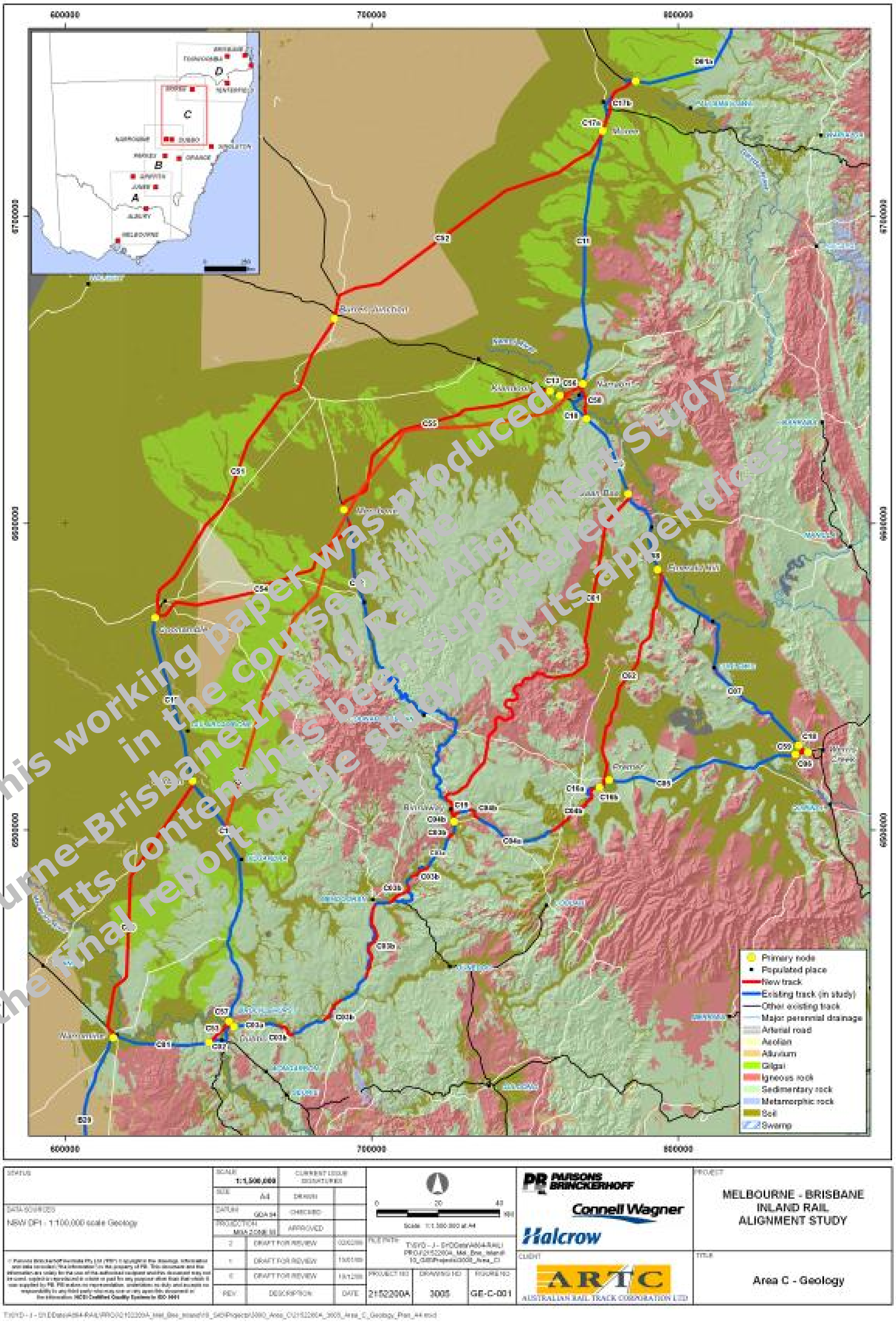


Figure 5-16 Area C geology

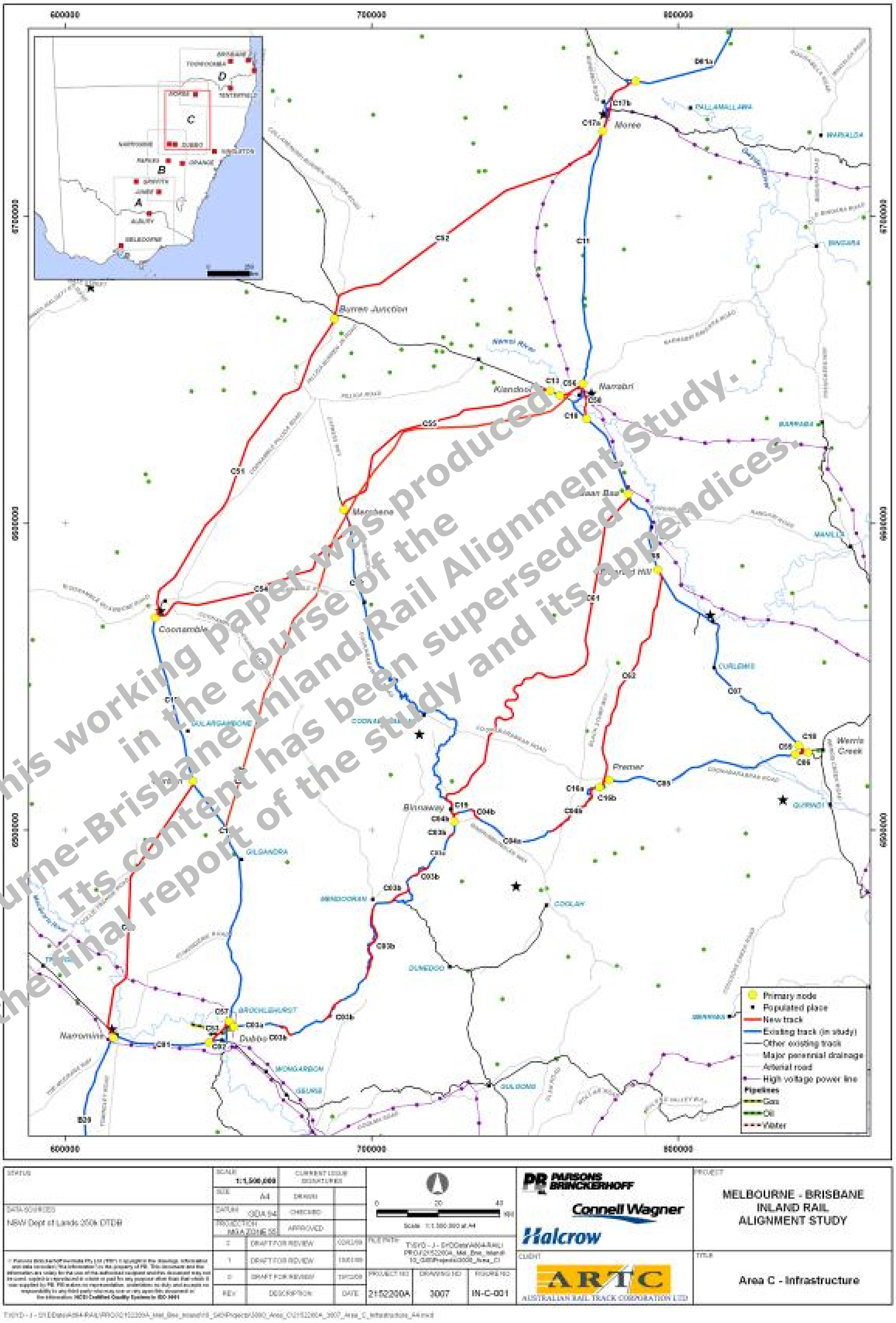


Figure 5-17 Area C infrastructure

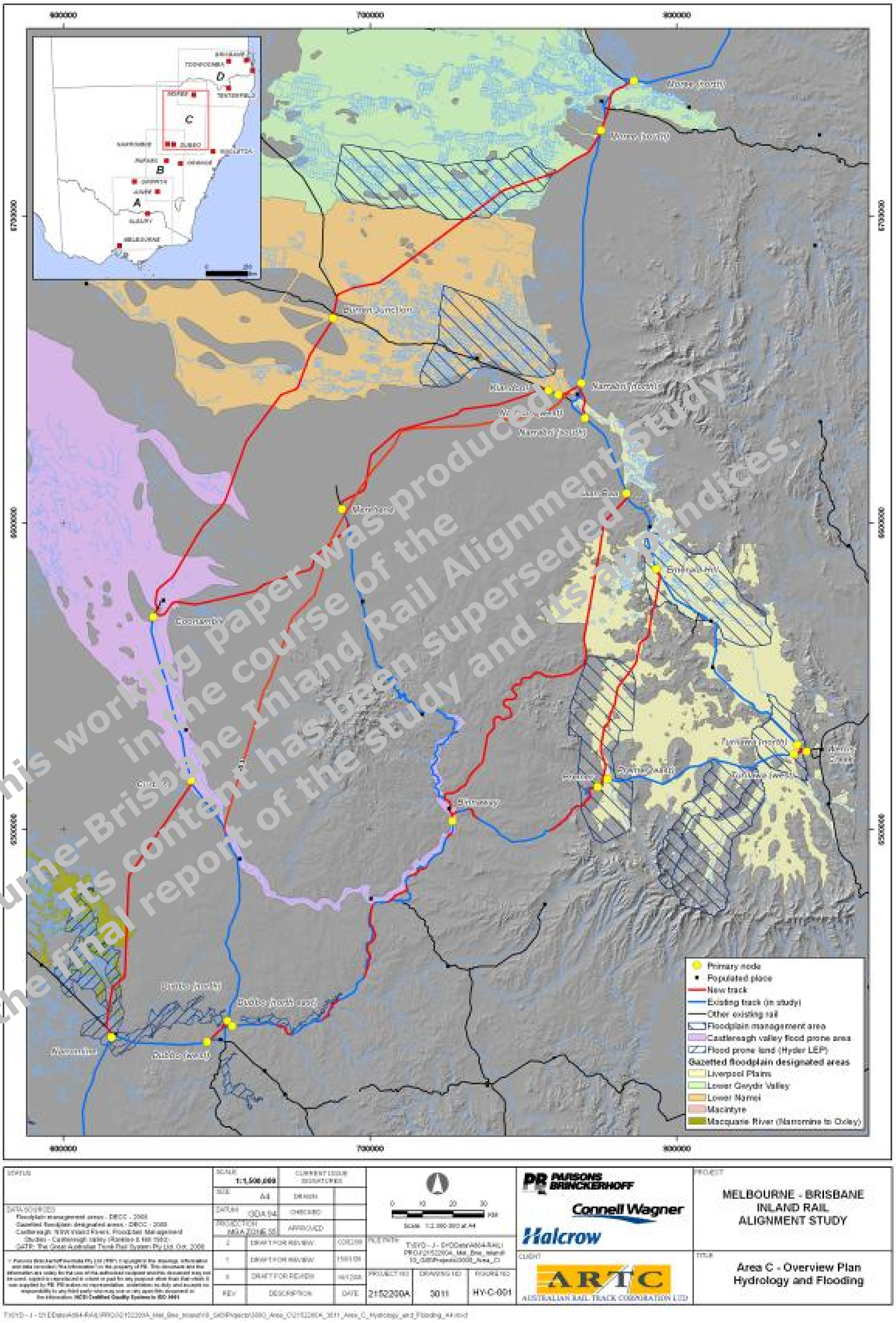


Figure 5-18 Area C hydrology and flooding

5.3.2 Review of sections

The sections of new and existing track in Area C are described in the following sections.

The sections of new track are the alignments presented in the previous NSRCS. Some small modifications have been necessary, for example at the connection of new track to existing, but changes have been kept to a minimum for the Stage 1 analysis.

A section of GATR route near Gilgandra direct to Merebene and Narrabri is also reviewed. (GATR sections between Gilgandra and Parkes have not been reviewed as part of Stage 1 as the route substantially follows the existing alignment. Stage 2 will refine alignments and GATR will be considered within this review.)

New sections of track have codes C50 to C62 and comprise long greenfield routes or shorter sections that by-pass major towns. Existing sections of track have codes C01 to C18. Short lengths of new track (deviations) along existing sections have been combined with the existing track given an alphanumeric code (e.g. C03a), and the section comprising the deviations plus the adjoining existing track having a separate code (e.g. C03b).

There are over 23 permutations of area routes. An extract of the more significant area routes and all the sections are provided in the table below. Other permutations represent small variations from those listed below so have been omitted from this table for the sake of clarity.

Table 5-9 Area C routes (summary of key route alternatives)[11]

Area route	Description	Route sections
Base case	Narromine–Moree via, Dubbo, Binnaway, Premer, Turilawa, Werris Creek, Emerald Hill, Baan Baa and Narrabri	C01+C02+C03a+C16a+C05+C06+C18+ C07+C08+C09+C10+C11+C17a
CC01	Narromine–Moree via Curban, Coonamble and Burren Junction	C50+C15+C51+C52+C17b
CC02	Narromine–Moree via Dubbo, Curban, Coonamble and Burren Junction	C01+C53+C14+C15+C51+C52+ C17b
CC03	Narromine–Moree via Curban, Coonamble, Merebene (Gwabegar), Kiandool and Narrabri	C50+C15+C54+C55+C13+C11+C17b+ C56
CC04	Narromine–Moree via Dubbo, Curban, Coonamble, Merebene (Gwabegar) Kiandool and Narrabri	C01+C53+C14+C15+C54+C55+C13+ C56+C11+C17b
CC15	Narromine–Moree via Dubbo, Binnaway, Baan Baa and Narrabri	C01+C02+C03a+C61+C09+C58+C11+C17b
CC19	Narromine–Moree via Dubbo, Binnaway, Premer, Emerald Hill, Baan Baa and Narrabri	C01+C02+C03a+C04a+C62+C08+C09+C58 +C11+C17b
CC21	Narromine–Moree via Dubbo, Binnaway, Merebene (Gwabegar), Kiandool and Narrabri	C01+C02+C03a+C12+C55+C13+C11+C17b
CC24	Narromine–Moree via Dubbo, Binnaway, Premer, Turilawa, Emerald Hill, Baan Baa and Narrabri (Base case with reversals at Werris Creek and Binnaway removed.)	C01+C02+C03a+C04a+C16a+C05+C60 +C07+C08+C09+C10+C11+C17a
CC20 +deviations	Base case with reversal at Binnaway removed plus deviations, plus new construction Premer–Emerald Hill	C01+C57+C03b+C04b+C62+C08+C09+C58 C11 +C17b

[11] Minor variations of the above routes maybe possible and will be considered in stage 2.

Table 5-10 Area C sections

Section	Existing/new	Description
C50	New build — major	Narromine–Curban
C51	New build — major	Coonamble–Burren Junction
C52	New build — major	Burren Junction–Moree (south)
C17b	New build — major	Moree (south –Moree (north)
C53	New build — major	Dubbo (west)–Dubbo (north–Talbragar)
C54	New build — major	Coonamble–Merebene (Gwabegar)
C55	New build — major	Merebene (Gwabegar)–Kiandool
C56	New build — minor	Narrabri (west)–Narrabri (north)
C57	New build — minor	Dubbo (west)–Dubbo (north east)
C58	New build — major	Narrabri (south)–Narrabri (north)
C59	New build — minor	Turilawa (south)–Turilawa (north) (high speed option)
C60	New build — minor	Turilawa (south)–Turilawa (north) (low speed option)
C61	New build — major	Binnaway–Baan Baa
C62	New build — major	Premer (south)–Emerald Hill
C03b part	New build — minor	Barbigal deviation
C03b part	New build — minor	Muronbung deviation
C03b part	New build — minor	Boomley deviation
C03b part	New build — minor	Merrygoen deviation
C03b part	New build — minor	Toogarlan deviation
C03b part	New build — minor	Piambra deviation
C04b part	New build — minor	Binnaway deviation (high speed)
C04a part	New build — minor	Binnaway deviation (low speed)
C04b part	New build — minor	Ulinda deviation
C04b part	New build — minor	Oakey Creek–Premer (south) deviation
C16b	New build — minor	Premer (south)–Premer deviation
Existing alignments		
C01	Existing	Narromine–Dubbo (west)
C02	Existing	Dubbo (west)–Dubbo (north east)
C03a	Existing	Dubbo (north east)–Binnaway
C04a	Existing	Binnaway–Premer (south)
C05	Existing	Premer (south)–Turilawa (west)
C06	Existing	Turilawa (west)–Werris Creek
C18	Existing	Werris Creek–Turilawa (north)
C07	Existing	Turilawa (north)–Emerald Hill
C08	Existing	Emerald Hill –Baan Baa
C09	Existing	Baan Baa–Narrabri (south)
C10	Existing	Narrabri (south)–Narrabri (north)
C11	Existing	Narrabri (north)–Moree (south)

C12	Upgrade	Binnaway–Merebene
C13	Upgrade	Kiandool–Narrabri (west)
C14	Upgrade	Dubbo (north–Talbragar)–Curban
C15	Upgrade	Curban–Coonamble
C16a	Existing	Premer (south)–Premer
C17a	Upgrade	Moree (south)–Moree (north)

5.3.3 Review of sections

Section C50 — Narromine–Curban (new build — major)

Section C50 leaves the Parkes to Narromine Line on the western side of Narromine and joins the Main West line for just over 1 km before travelling along the perimeter of Narromine Airport and cross-country to join the Dubbo to Coonamble line north of Curban. The section is about 92 km. The route does not pass through or near to any major settlements with the exception of its proximity to Narromine and Burroway (about 23 km from Narromine).

The section crosses flat to undulating topography with generally flat gradients and levels ranging between about 220 m and 260 m above datum. There are no significant vertical alignment constraints on the section from the natural topography, although the alignment will need to be developed to provide for grade-separated crossings, such as the Narromine to Ceres road. Generally there appears to be flexibility to develop the horizontal alignment and there may be scope for some realignment to the west to minimise the impacts on flood-prone areas.

It is expected that the section will be extended southwards during design development to enable connection to a straight section of the Parkes–Narromine line; a crossing of Backwater may be required.

The section is affected by flooding associated with the floodplain of the Macquarie River near Narromine where flows occur across the general floodplain and local flooding from the tributaries of the adjacent slopes. The first 21 km of the section will require the railway to be raised on an embankment to prevent overtopping of the line and significant lengths of openings will also be required to allow the overland flooding to pass relatively unimpeded, thereby not impinging on the local community and the overall flood distribution. Potential impacts exist for construction.

The geotechnical conditions along the alignment are expected to include:

- about 18 km of deep soft soils requiring deep-piled foundations for bridges and consideration of settlements and stability of embankments
- about 10 km near-surface rock potentially requiring special excavation techniques
- about 51 km of clays (black soil) requiring specific design and construction treatment.

A major environmental constraint on the section is the presence of some carved trees, which are a listed Indigenous site, within 600 m of the alignment at 24 km. Noise impacts in and around the town of Narromine are likely to require mitigation.

The section predominantly passes through land zoned for 'Rural Purposes' (under Narromine LEP 1997, Gilgandra LEP 1998 and Warren Interim Development Order No.1), with the exception of the flood liable land around Narromine. Channels and apparent artificial waterways to the west of the alignment suggest irrigation properties, which should be avoided due to potential acquisition and compensation costs.

Section C51 — Coonamble–Burren Junction (new build — major)

Section C51 leaves the Dubbo–Coonamble line to the south of Coonamble and passes to the west of the town. The route section is about 115 km and passes across country to join the Burren Junction–Pokartaroo line on the western outskirts of Burren Junction. The route does not pass through or near to any major settlements with the exception of its proximity to Coonamble and Burren Junction. Between 45 km and 73 km the route passes to the west of state forest.

The terrain starts at about RL 190 m, descends very gently over the first 5 km and then continues flat to undulating between RL 160 m and 180 m to Burren Junction. The proposed railway alignment has small gradients of typically less than 1:500 or the whole section and there are no significant vertical alignment constraints from the natural topography.

Development of the alignment is required at Burren Junction, including potentially a grade-separated crossing of the Narraban to Walgett line. Grade-separated major roads near Coonamble are also required.

Major potential flooding issues exist near the Castlereagh River at Coonamble and the Namoi River Floodplain adjacent to Burren Junction; the Namoi floodplain is likely to require a significant effort in minimising the impact of flooding. At around 25 km, section C51 crosses what is considered floodplain and is expected to require an elevated track above the floodplain and waterway structures to allow the orderly passage of floodwater. Drainage patterns at chainage 95 to 96 suggest irrigation canals.

The geotechnical conditions along the alignment are expected to include:

- about 9 km of deep soft soils requiring deep-piled foundations for bridges and
- consideration of settlements and stability of embankments
- about 61 km of clays (black soil) requiring specific design and construction treatment
- a further 45 km of deep clay soils.

A Major Environmental Limitation is that the alignment passes directly adjacent to the Pillaga West National Park (chainage 64 to 72 km). The alignment also passes within 2 km of the Pillaga West State Conservation Area and a number of clusters of listed, but not protected, flora species most likely associated with waterholes or isolated stands of vegetation. The alignment also runs alongside the Coonamble racecourse and golf course.

The alignment predominantly passes through land zoned for 'Rural Purposes' within Coonamble LGA and 'Non-Urban A' and 'Non-Urban B' (adjacent to road reserves) in the Walgett LGA, under the Walgett Interim Development Order No. 1. At chainage 4 km and 5.5 km the alignment passes directly adjacent to land zoned for Open Space under the Coonamble LEP 1997. The nearby Pillaga West National Park and Pillaga West State Conservation Area are zoned for Forestry (Coonamble LEP 1997). The alignment passes within 750 m of land zoned as 'Village or Urban' under the Coonamble LEP 1997 and within 1 km of land zoned as 'Village or Township' under the Walgett Interim Development Order No. 1 at Burren Junction (114 km).

Section C52 — Burren Junction–Moree (south) (new build — major)

Section C52 starts on the south-western outskirts of Burren Junction and joins the existing (Class 5) Burren Junction–Pokataroo line on the western side of Burren Junction. The Section is about 111 km long and passes across country to join the Werris Creek to Mungindi line to the south of Moree.

The terrain starts at about RL 162 m at Burren Junction, rises at a shallow gradient (less than 1:500) to a high point of about 220 m at the end of the section. There are no significant vertical alignment constraints on the section from the natural topography.

Development of the alignment is required at Burren Junction to connect to the Burren Junction–Pokataroo line. A grade-separated crossing of the Narrabri to Walgett line, existing road and major water feature may be required.

The majority of the route section travels across a significant floodplain of the Namoi and Gwydir Rivers and the creeks flowing from the Nandewar Ranges. Significant flooding has occurred in a number of years, including 1955, 1971, 1974, 1984, 1998, 2000 and 2001. Including the adjacent section C17b, about 100 km of floodplain is estimated to be affected and the railway will need to be elevated above the floodplain with waterways designed for flooding. The alignment also crosses or is close to large surface irrigation properties, which influence the final railway alignment.

The geotechnical conditions along the alignment are expected to include:

- about 42 km of clays (black soil) requiring specific design and construction treatment
- a further 69 km of deep clay soils.

Significant Environmental Limitations for the section are mainly associated with populations of threatened species within short distance of the alignment, particularly around chainage 100 km (Tycannah Creek) and 109 km. Another crucial consideration is the extent of irrigation land that the alignment appears to cross. This should be avoided to minimise land acquisition costs and negotiations.

The alignment predominantly passes through land zoned as 'Non-Urban A' and 'Non-Urban B' (adjacent to road reserves) in the Walgett LGA, under the Walgett Interim Development Order No. 1, through land zoned as 'General Rural' under the Narrabri LEP 1992 and the Moree Plains LEP 1995.

Section 17b — Moree (south) –Moree (north) (new build — major)

The 23 m section leaves the existing Werris Creek to Mungindi line to by-pass Moree on the east side of the town before rejoining the existing railway. A further deviation is planned at Camurra.

The topography is generally flat to undulating and descends gently to about RL 205 m near Moree and rises again to about 220 m. There are no significant vertical alignment constraints on the section from the natural topography.

To the west of Tycannah, the route crosses and runs approximately parallel to a major road. Design development of the alignment and road is expected and grade separation may be required.

The geotechnical conditional along the alignment are expected to include:

- about 6 km of deep soft soils requiring deep piled foundations for bridges and consideration of settlements and stability of embankments

- about 17 km of clays (black soil) requiring specific design and construction treatment.

Significant Environmental Limitations in the area are mainly associated with populations of threatened species within short distance of the alignment in the adjacent Section 52, particularly around Tycannah Creek and 109 km.

Land is zoned as 'General Rural' under the Narrabri LEP 1992 and the Moree Plains LEP 1995, except for parts of the alignment around the town of Moree which are passed through or adjacent to zoned for 'Industrial Use' (at 110 km and between 114 km and 117 km) and 'Private Open Space' (at 117 km) under the Moree Plains LEP 1995. The alignment runs adjacent to Industrial zoned land.

Section C53 — Dubbo (west) — Dubbo (north–Talbragar) and Section C57 — Dubbo (west)–Dubbo (north-east) (new build — major)

Section C53 starts approximately 5 km to the west of Dubbo with a turnout from the Narromine–Dubbo line and passes in a north easterly direction before joining the Dubbo–Coonamble line on the northern outskirts of Dubbo. The route is about 9.7 km long and crosses the Macquarie River and a tributary near the northern end. It crosses the Mitchell Highway and Bourke Street.

Route section C57 is similar to C53 except the northern end joins the Troy Junction–Merrygoen line giving a length of about 11.3 km.

The terrain for C53 and C57 falls from about RL 220m to RL 260m over the first 6 km of the route. C53 remains at about RL 260 m to the connection with the existing railway, whilst C57 rises to about RL 280 m at its end. The topography and need for grade separation of the railway from existing infrastructure is expected to be a significant constraint to the development of the railway alignment. The connection of C53 to the existing railway in Talbragar may require significant development to achieve a turnout on straight track. The treatment of the existing minor road network is expected to require development; the impacts of truncated roads or road overbridges will need to be considered in the urban context. This alignment passes through the Troy Junction sewage treatment plant and requires development.

Flooding in this area is predominantly from the Macquarie River, which passes through Dubbo. As the crossing is immediately downstream of Dubbo, care will be required in allowing for the passage of floodwaters to ensure negligible impact and increase in flood levels. It could be expected that a bridge structure at least the size of the Main Western railway bridge in Dubbo may be required. Elevation of the track on embankment will be required to prevent the track from over topping during periods of flooding.

Cumulative impacts of noise and air pollution associated with the alignment passing predominately through 'Urban/Rural Buffer' and 'Urban Expansion' land zones are considered a Significant Environmental Limitation. The alignment also passes through an area of flood-liable land with potential impacts for construction as well as impacts associated with floodwaters. There are a number of recorded threatened species around the Macquarie River/Talbragar Creek crossings.

The alignment passes through a range of land zonings under the Dubbo LEP 1998–'Urban Areas', including, 'Urban/Rural Buffer' (2.5 to 3 km, 4 to 7.5 km), 'Urban Expansion' (0 to 2.3 km, 3 to 4 km, 9.5 to 10 km), 'Private Open Space' (7.8 to 8.3 km), 'Utilities' (Troy Junction STP) (8.5 to 9.2 km), 'Institutional' (2.3 to 2.5 km and adjacent at 9.5 km) and

'Industrial' (small sections around 2.5 km, 8.4 km and 9.4 km). Between 7.5 km and 7.8 km the alignment also passes through land zoned as for 'Other Purposes' (including Environmentally Sensitive Land, Flood Affected (Indicative) and Intensive Agriculture) under the Dubbo LEP 1997–Rural Areas. Re-alignment of this option between 2 and 5 km should consider the land zoned for Institutional purposes and the airfield.

Section C54 — Coonamble–Merebene (Gwabegar) (new build — major)

The 76 km section leaves the Dubbo–Coonamble line about 6 km south of Coonamble, passes on the south side of Coonamble and across country, joining the Wallerawang (via Binnaway)–Gwabegar line and ending shortly after Merebene (about 6 km south of Gwabegar). The Binnaway–Gwabegar line is a Class 5 line with no passenger service.

The section does not pass through or near to any major settlements with the exception of its proximity to Coonamble and Merebene.

The section crosses generally flat to undulating terrain for the first 15 km before rising at a gentle gradient to the State Forest. There is a very gentle decline to Merebene. There are no significant vertical alignment constraints on this section from the natural topography, although grade-separated crossings of two major roads near Coonamble, plus one at 38 km and one on the approach to Merebene are expected and road diversions may be required.

The most significant river crossing is the Castlereagh River and associated floodplain near Coonamble. The other rivers and creeks mainly drain flows from the Pilliga Forest and there are no significant floodplains, as in the Macquarie or Namoi Valleys. The alignment contains approximately 10 river crossings and includes an 11 km stretch running alongside a (Noonbar) creek. A number of threatened species have been sighted in the vicinity of the alignment in some areas. The drainage pattern south of the alignment at chainage 16 to 20 km (below Noonbar Creek) suggests irrigation canals which should be avoided.

The ground conditions along the section are generally clays (black soil) requiring specific design and construction treatment. About 1 km of deep soft soils are expected on the Castlereagh Floodplain where deep piled foundation will be required for bridges and settlement and stability of embankments will be considered.

A Major Environmental Limitation of section C54 is that the alignment dissects the adjoining Pilliga West State Forests and Merriwindi State Conservation Area near Merebene (at chainage 67 km). This includes land zoned as Environmental Protection under the Coonamble LEP 1997. An opportunity may exist to realign south of Merriwa Conservation Area/State Forest, joining the existing Coonabarabran–Gwabegar line between Baradine and Kenebri (avoiding Merriwa State Forest); this may also reduce the number of river crossings. Other mitigation measure may include a tunnel (at chainage 67 km) under state forest/ conservation areas.

The section predominantly passes through land zoned for 'Rural Purposes' (under Coonamble LEP 1997 and Coonabarabran LEP 1990), except between chainage 65 km and 65.3 km where the land is zoned for 'Environment Protection' (under the Coonabarabran LEP 1990).

Section C55 — Merebene (Gwabegar)–Kiandool (new build — major)

Section C55 starts about 6 km south of Gwabegar with a turnout from the Wallerawang–Gwabegar line. It passes across country to join the Narrabri–Walgett line near Kiandool, about 85 km from Merebene.

The route does not pass through or near to any major settlements with the exception of its proximity to Merebene and Kiandool. Major roads are not affected, although several minor roads are crossed.

The terrain is generally flat to undulating for the whole length of the section with the proposed railway having gentle gradients between RL 195 m and 220 m.

The alignment crosses several creeks and drainage lines that flow from the Pilliga Forest. Flooding is only likely to be localised, being confined mainly to the creek sections and standard crossings can be expected.

About 29 km of the section is expected to comprise clays (black soil) requiring specific design and construction treatment. Sand over clays along 44 km will also require design consideration. About 10 km is expected to cross deep soft soils requiring deep-piled foundations and consideration of settlement and stability of any embankments; although high embankments are generally not anticipated on this section.

An opportunity exists to improve the alignment near Merebene if the inland rail line passes via Coonamble; including by-passing Merebene and providing a grade-separated crossing of the existing road and railway (as part of route section C54). Realignment to the east of Merebene could have environmental and cost advantages but would result in not providing a connection to the existing railway.

A *Major Environmental Limitation* of section C55 is it passes through the Quegolba State Forest (at chainage 10.5 km). The alignment includes a large number of creek and river crossings and numerous threatened species have been sighted in the vicinity of the alignment in some areas, in particular in adjacent state forest or state conservation areas or nearby waterholes.

The section predominantly passes through land zoned for 'Rural Purposes' (under Narrabri LEP 1992 and the Coonabarabran LEP 1990).

Section G06 — Near Gilgandra to Narrabri[12]

The GATR trunk joins the Coonamble branch briefly, to maximise rail connectivity, 6 km north of Gilgandra, after first crossing the Oxley Highway just west of Gilgandra Airport. After staying on a straight section of the Coonamble branch for 3 km, the trunk swings right across the Castlereagh River at about 270 m elevation and then heads slightly east of north, gradually rising to rejoin the 300 m contour on the western side of the Warrumbungles. It skirts just to the west of Tenandra Hill at which point two important options arise.

Around or through the Pillaga Forest?

Between Gilgandra and Narrabri there is a feasible direct route through the Pilliga Forest. It is nearly 16 km shorter than the alternative around the forest.

The direct route crosses the Gwabegar branch just south of Baradine, before getting to Baradine it has to negotiate perhaps 10 km of hilly country and rise to about 400 m before sinking back again to the 300 m contour. It is argued that a railway through the forest would create fewer environmental problems than the many roads that already traverse it. Specific animal crossings could be created in association with railway cuttings (as already demonstrated on some French TGV lines). Topographically the route is straightforward and further away from flood country than the alternative.

[12] Description provided by GATR submission.

The alternative route (shown as G03 in Figure 5-13), misses all of the declared State Forest areas except for the north-west corner of the Merriwindi State Forest, which may require a slight adjustment to the State Forest boundary where it touches the Pilliga West State Forest. The elevation of the preferred route becomes lower than the Pilliga Forest route and is always below 300 m after the routes diverge, gradually falling to under 200 m as it approaches Narrabri.

This route crosses the Gwabegar line only 10 km south of Gwabegar and suitable junction arrangements are shown.

Both routes join on the south western outskirts of Narrabri.

However, the route avoiding the forest delivered the option of going directly to Bellata close to Wee Waa rather than going right into Narrabri. This would shorten the trunk route by 20 km or so but it would have the disadvantage of having to cross a wide area of highly flood-prone country with extensive irrigation infrastructure, and it would not create such a good link for a Sydney-North Connection via the existing Main North line. The route just on the western side of Narrabri has been developed in conjunction with Narrabri Council, particularly with reference to its flood records, and so is believed to be the most flood-proof route available.

Thus there is a choice of two routes between Gilgandra and Narrabri. Which is chosen depends very much on the attitude of environmental authorities to penetration of the Pilliga Forest. From a railway operating and operating cost point of view, it is highly likely that the through-forest route will deliver lower operating costs and shorter trip times. It will also be less susceptible to flood (although the other route is able to be located clear of most flooding).

Section C56 — Narrabri (west)–Narrabri (north) (new build — major)

Section C56 is 8.7 km in length and passes to the north-west of Narrabri to join the Gwabegar–Narrabri line to the Narrabri–Moree line. The section crosses a major flood plain and one major road across generally flat terrain between RL 220 m and RL 200 m.

There are no significant vertical alignment constraints on this section from the natural topography, although further development of the alignment and/or existing roads is anticipated to provide grade-separated crossings of the major road.

The alignment is located on the Namoi flood plain close to Narrabri, which is a flood-prone town with extensive inundation from the Namoi River. The alignment crosses both the Namoi River and Narrabri Creek, which are both significant carriers of flows and could affect flooding in the area. Detailed investigation will be required to ensure that this alignment does not affect the pattern in flooding by either increasing the height of flooding or the redistribution of flows in the area. The track will be required to be raised in this area and depth of flows may be greater than 1 m.

The ground conditions along the section are generally deep soft soils requiring deep-piled foundations to structures and consideration of settlement and stability of any embankments.

There are numerous Significant Environmental Constraints associated with this alignment option, including a requirement for two major river crossings, and associated potential water quality impacts, and the recording of several threatened species in the area. In addition, as the alignment passes close to the town of Narrabri, there would be some concerns over noise and general public amenity.

The alignment predominantly passes through land zoned for 'Rural Purposes' under the Narrabri LEP 1992. However, the alignment passes within 700 m of land zoned for 'Residential Purposes' and directly adjacent to land zoned for 'Light Industry'.

Section C58 is upstream of both Narrabri and the bifurcation of the Narrabri Creek. It potentially may reduce the size of waterway structures across the floodplain.

Section C58 — Narrabri (south)–Narrabri (north) (new build — major)

Section C58 leaves the Werris Creek to Narrabri line about 7 km south of Narrabri. A new route 10.5 km long is proposed to the east of Narrabri and joins the Narrabri–Moree line on the northern outskirts of the town. Existing track about 1.5 km long will be used at the northern end of the section.

The terrain descends about 20 m over the first 2.5 km and remains relatively flat for the remainder of the section. The sloping terrain at the southern end of the alignment is expected to be a significant vertical constraints if, as expected, grade-separated crossings are developed for the two major roads near the connections to the existing railway.

The alignment is located on the Namoi Floodplain crossing the Namoi River relatively close to Narrabri, which is a flood-prone town with extensive inundation. The track will be required to be raised in this area and waterway openings provided to prevent inundation; depth of flows may be greater than 1 m.

The geotechnical conditions along the section generally range from rock, which may require blasting to deep soft soils and demand deep-piled foundations for bridges, as well as consideration of settlements and embankment stability.

Significant Environmental Limitations for the section include recorded sightings of up to 10 threatened flora and fauna species within 1 km of the alignment between 5.5 km and 7.5 km and the proximity to the adjacent Narrabri Racecourse. These may cause significant increased noise disturbance and air pollution impact and potential community opposition.

The alignment predominately passes through land zoned for 'Rural Purposes' under the Narrabri LEP 1992, with the exception of land zoned for 'Special Uses' between 8.8 and 9 km and 'Existing Open Space' between 8.3 and 8.8 km.

Section C59 — Turilawa (south)–Turilawa (north) (high speed option) (new build — minor)

The section C59 is located at Turilawa, about 8 km west of Werris Creek, and connects the Binnaway–Werris Creek line with the Werris Creek–Mungindi line. The section is about 4.5 km in length, with about 1 km at each end appearing to be along existing track. The terrain appears to be generally flat to undulating and railway gradients up to 1 in 80 are proposed.

The alignment is located on the Liverpool Plains floodplain, which has highly erodible soils. Additional consideration will therefore be required to ensure that the capacity of the waterway structures, such as across Werris Creek, is sufficient to minimise erosion. Some consideration may need to be given to raising the track to cater for general overland flow emanating from Werris Creek and the Melville Range.

A Significant Environmental Limitation is the potential for reactive soils, which will be considered during later stages.

The section passes through land zoned for 'Rural Purposes' (under Quirindi LEP 1991) and General Agricultural (Parry LEP 1987).

Section C60 — Turilawa (south)–Turilawa (north) (low speed option) (new build — major)

Section C60 is located at Turilawa, about 8 km west of Werris Creek, and connects the Binnaway–Werris Creek line with the Werris Creek–Mungindi line. The section is about 5.9 km long, comprising about 0.9 km of new track and 2.5 km of existing track at each end. The terrain appears to be generally undulating as the alignment generally crosses a dip in the natural topography with some earthworks or structures being required. A railway gradient of about 1 in 100 is proposed.

It appears the proposed alignment may connect to curved track, which is not expected to be a preferred solution. The proposed alignment appears to have a horizontal curve of radius less than 1000 m and a speed-restricted line with operational and maintenance impacts can be expected, even if the section forms part of the mainline (with turnouts to existing track).

The alignment is located on the Liverpool Plains floodplain and similar concerns exist as for Section C59 about highly erodible soils, the capacity of the waterway structures, possible raising of the track to cater for general overland flow and potential for reactive soils.

The section passes through land zoned for 'Rural Purposes' (under Quirindi LEP 1991) and 'General Agricultural' (Parry LEP 1987).

Section C61 — Binnaway–Baan Baa (new build — major)

Section C61 starts about 4 km west of Binnaway and leaves the Wallerawang–Gwabegar line. The route appears to rejoin the existing line after about 2 km before passing through Binnaway and across country (on an extension to the line) to Baan Baa, giving a total length of about 148 km.

The terrain along the alignment is generally assumed to be undulating to rolling for the southern half with a rolling to hilly section between 43 km to 55 km, which is a significant constraint to the alignment and seven short tunnels are proposed. The second half of the alignment is generally flat to undulating. The section starts at RL 400 m and rises to a high point of RL 600m at 49 km before descending to RL 240m at the connection to the existing railway at Baan Baa. About 27 km of the proposed alignment have gradients between 1 in 100 and 1 in 60. The gradients are steeper than the preferred gradient of 1 in 80.

Further investigation and development of the alignment near Binnaway is required, including consideration of a by-pass to the town, which may be required on environmental grounds.

The second half of the section runs along the Coxs Creek floodplain, which has areas of generalised flooding and breakouts from a number of creeks. The soils are also highly erodible and care and special provisions are needed with design.

The geotechnical conditional along the alignment are expected to include:

- about 12.5 km of deep soft soils requiring deep-piled foundations for bridges and consideration of settlements and stability of embankments
- about 44 km of hard rock where deep cuttings may require blasting
- about 56 km where gentle batters may be required to cuttings.

A Major Environmental Limitation of this alignment is that is passes close to the Binnaway Nature Reserve at chainage 17 km. There are also Significant Environmental Limitations associated with a significant number of sightings of threatened species within 1 km of the alignment and the large number of creek crossings of both major and minor creeks as the route winds its way around the Warrumbungle Ranges.

The alignment predominantly passes through land zoned for ‘Rural Purposes’ under the Coonabarabran LEP 1990, Narrabri LEP 1992 and Gunnedah LEP 1998. Within the township of Binnaway the alignment goes through land zoned under the Coonabarabran LEP 1990 for ‘Village or Urban’ and ‘Rural–Small Holdings Purposes’ and is adjacent to land zoned ‘Environmentally Sensitive’.

Section C62 — Premer (south)–Emerald Hill (new build — major)

The 75 km-long section C62 starts about 1 km south of Premer on the Binnaway–Werris Creek line and a new alignment crosses country to join the Werris Creek–Mungindi line a few kilometres north of Emerald Hill. The terrain is generally undulating to rolling, although the proposed alignment is flatter where it runs parallel to creeks. The section descends from RL 380 m to about RL 250 m near Emerald Hill. The proposed gradients of the railway are generally less than 1 in 100, with the exception of three short sections of up to 2 km that have proposed gradients of 1 in70 (at 18 km), 1 in 77 (at 23 km) and 1 in 53 (at 50 km).

Development of the alignment is required to provide grade-separated crossings of the Oxley Highway and a major road at Premer. Design development may also consider an alignment that by-passes Premer by a more significant distance to the existing proposal and reduces the steeper gradients.

This route passes through the Liverpool Plains, which due to its geographical nature and land use is prone to both flooding and erosion. Care and special provisions are needed with design along the Coxs Creek floodplain on the first half of the section.

The geotechnical conditional along the alignment are expected to include:

- about 18 km of deep soft soils requiring deep piled foundations for bridges and consideration of settlements and stability of embankments
- about 25 km of rock where deep cuttings may require blasting.

A *Significant Environmental Limitation* is the proximity of the Trinky State Conservation Area at chainage 10 km, as well as recorded sightings of koalas and endangered Finger Panic Grass within 500 m of the alignment, approximately 560 m and 300 m east of the alignment at 44 km and 0.5 km respectively. The alignment passes through and adjacent to areas of dry land salinity, which must be considered during design.

The section predominantly passes through land zoned for ‘Rural Purposes’ under Gunnedah LEP 1998 and Quirindi LEP 1991, with the exception of land zoned ‘Village’ in Premer (Quirindi LEP 1991).

Section C03b — Dubbo–Binnaway deviations

The deviations between Dubbo and Binnaway are summarised in the following table. Further consideration will be required of potential environmental impacts on settlements close to the alignment.

Table 5-11 Dubbo to Binnaway deviations

Deviation name	Length	Key features	Terrain and flood risk.	Proposed alignment
Barbigal	6.75 km	1.6 km new alignment in plan, 5.15 km rebuild on existing plan alignment, passes through Barbigal, crosses Golden highway near turnout.	Generally flat to undulating with some minor hillocks and a 15 m rise. Levels between RL 280 m and 310 m. No specific flooding issues are known in this area.	1 in 80 max gradient over about 1.5 km length. Alignment requires development for grade-separation of highway.
Muronbung	8.14 km	2 x 1.7 km of new alignment in plan, 4.74 km rebuild close to existing plan alignment, passes through Muronbung.	Generally flat to undulating with some ground profiles steeper than 1 in 80. No specific flooding issues are known in this area.	Undulating track with 1 in 80 max gradients. Alignment may require development where it is along a major road.
Boomley	25.1 km	2 + 1 km rebuild close to existing plan alignment, 23.1 km new plan alignment with 12 km along existing creek line, by-passes existing settlements.	Generally flat land rising from about RL 355 m to 475 m and falling to 360 m. The alignment follows along a number of creeks and will require careful consideration to ensure that it does not encroach into the riparian zone of the creeks or affect flooding.	Track rising at max gradient of 1 in 80 and falling at max 1 in 90. Alignment development expected to manage potential impacts on creeks.
Merrygoen	8.6 km	New alignment, by-passes Merrygoen, crosses Castlereagh Highway.	Generally flat to undulating with some ground profiles about 1 in 100 and steeper near eastern connection; generally rising from RL 345m to 375 m. No specific flooding issues are known in this area.	Track rising at max gradient of about 1 in 100. Alignment development expected to grade-separate over Castlereagh Highway; extension of route section may be required.
Toogarlan–Neilrex	6.1 km	1 + 0.5 km rebuild close to existing plan alignment, 4.6 km new plan alignment, deviation is between settlements, hence existing track passes through settlements.	Generally flat to undulating with some ground profiles greater than 1 in 80; generally between RL 370m and 400 m. No specific flooding issues are known in this area.	Undulating track with 1 in 80 max gradients. Development of alignment to raise it above creek crossings required. Extension to by-pass Toogarlan and Neilrex to be considered.
Piambra	1.8 km	New alignment including tunnel, deviation begins after Piambra, hence existing track passes through settlement.	Across a hill with slopes up to about 1 in 20. No specific flooding issues are known in this area.	Track falling at gradients up to 1 in 80. Development could consider other alignment(s) and engineering solutions potentially avoiding a tunnel.

Section C04b — Binnaway to Premer deviations

The deviations between Binnaway to Premer are summarised in the following table. Further consideration will be required of potential environmental impacts on settlements close to the alignment.

Table 5-12 Binnaway to Premer deviations

Deviation name	Length	Key features	Terrain	Proposed alignment
Binnaway (high speed)	3.6 km	1.4 km new alignment in plan, 2.2 km rebuild on existing plan alignment, by-passes Binnaway, crosses Warrumbungles Way and suitability of existing infrastructure should be checked.	Generally flat to undulating with some minor gradients greater than 1 in 80 Initially at RL 400 m rising to 420 m. No specific flooding issues are known for this area.	1 in 80 max gradient over about 1 km of length. Further assessment required of effects of Warrumbungles Way and creeks.
Binnaway alternative (low speed)	0.85 km	New alignment in plan, by-passes Binnaway.	Ground profiles steeper than 1 in 40. No specific flooding issues are known for this area.	Track with 1 in 40 max gradient with low radius curve. Connection to existing line through Binnaway may be a problem (if required).
Ulinda	4.0 km	1 km rebuild close to existing plan alignment, 3 km new plan alignment, west of Ulinda, hence existing track passes through settlement.	Generally undulating land descending from about RL 450 m to 425 m. No specific flooding issues are known for this area.	Track descending at max gradient of 1 in 80. Clearances required to creeks.
Oakey Creek to Premer	22.5 km	7 km of rebuild close to existing alignment, 15.5 km new plan alignment, passing through Coonemarra, and Bomera (by-passes the centre of Premer as Section 16b below).	Generally undulating to rolling with some ground profiles steeper than 1 in 80; starting at about RL 525 m rising to 550 m and descending to RL 370 m. No specific flooding issues are known for this area	Track rising and falling at max gradient of up to 1 in 80. Alignment to be developed to grade-separate over Black Stump Way; connection at Premer towards Werris Creek and development required for Route Section to Emerald Hill.

Section C16b — Premer Deviation (new build — minor)

Section 16b is a 4.5 km-long deviation that leaves the existing railway to the west of Premer and by-passes the town on the south-eastern side before rejoining the existing railway to the east of the town centre. Further consideration will be required of potential environmental impacts on the Premer town centre. The new alignment descends at gradients of up to 1 in 80 across undulating to rolling terrain.

C01 — Narromine–Dubbo (west) (existing — BAU)

The 35 km section from Narromine–Dubbo is Class 2, and can carry 19.5 t axle load trains at 100 km/h and 21 t axle load trains at 80 km/h. Curves are gentle, with the two speed restrictions en route probably due to bridges. Several kilometres of track have 1 in 70 gradients. There is daily ore traffic on the line.

The section begins as a single track at a point to the south-west of the centre of Narromine on the Parkes–Narromine line where it crosses Backwater Road. It continues north for a short distance before connecting with the Main Western to the west of Narromine.

The single track formation changes to a double track to allow for a silo siding within Narromine, the double track changes back to a single alignment on the west side of Dandaloo Street crossing. The section leaves Narromine in an easterly direction initially following the Mitchell Highway and climbing approximately 36 m through a combination of gradients for 17 km. It continues through open country side and descends to Minore (476.695 km) and Delroy Gardens before terminating on the east side of Dubbo at chainage 466.95 km. The section runs through open, relatively flat countryside with the track bed elevated slightly above the surrounding fields. There are signs that the local area may be subject to flooding during heavy rain.

Increased environmental impacts, primarily relating to noise but potentially also entailing vibration, air quality and visual amenity impacts, can be expected due to increased freight operations through the centre of Narromine and within rural homesteads in the vicinity of the alignment. Further investigation will be required in stages 2 and 3 of this study; a by-pass of the centre of Narromine may be needed.

The existing crossings of the railway include six at-grade vehicular crossings of varying construction, some with footbridges, two ballasted under-bridges over highways and a range of drainage culverts. Consideration of heritage impacts should be given to any bridges or built railway infrastructure (e.g. stations) that may need upgrading or replacement.

C02–Dubbo (west) Dubbo (north-east) (Existing–BAU)

Section C02 is about 12 km and passes through the centre of Dubbo, which contains a yard area. The route is heavily graded leaving the Macquarie River Valley from Dubbo. There is a CountryLink passenger train crew depot at Dubbo.

The section begins on a summit to the west of Dubbo (at chainage 466.95 km) dropping on a single track ballasted formation and at a mean gradient of around 1 in 63 for approx 3.8 km to where it crosses the Macquarie River and adjacent highway on a viaduct and passes through Dubbo station. The alignment then curves to the north through the most northerly point of the triangular junction to the east of the station and onwards to Troy Junction (455.669 km) where the railways from Dubbo to Coonamble and Merrygoen diverge. The vertical profile is undulating from Dubbo station to Troy Junction.

From Troy Junction to Beni, the alignment runs east on the Dubbo-Merrygoen railway on a single track ballasted track bed, with a number of unmade vehicle crossings and, in places, culverts crossing under the alignment. The section passes through open, slightly undulating countryside with the track bed elevated slightly above the surrounding fields. The route leaves the townscape of Dubbo and passes over what appears to be the crossing to the cattle market.

Increased environmental impacts, mainly relating to noise but which could also entail vibration, air quality and visual amenity impacts can be expected due to increased freight operations through the centre of Dubbo and within rural homesteads in the vicinity of the alignment. Further investigation will be required in stages 2 and 3; a by-pass of the centre of Dubbo may be needed.

The existing crossings of the railway to the west of Troy Junction include seven at-grade vehicular crossings mainly of significant road and highways, one ballasted under-bridge over a highway and the Macquarie River crossing. Consideration of heritage impacts should be given to any bridges or built railway infrastructure (e.g. stations) that may need upgrading or replacement. To the east of Troy Junction, there are an additional ten at-grade crossings of the alignment.

C03a — Dubbo (north-east)–Binnaway (existing — BAU)

Dubbo– to Merrygoen is 100 km of Class 2 track, which is steep and winding. There are some gradients as steep as 1 in 75, with long sections of 1 in 100 with many curves of 400 m radius and some as sharp as 320 m. There are many speed restrictions covering several kilometres of curved track, with six others due to bridge condition. In addition to the daily ore traffic, there is grain traffic a few times per week.

Merrygoen–Binnaway is 41 km of Class 2 track. The ruling gradient is 1 in 75, and there are curves as sharp as 400 m. There are six areas where speed is restricted, two of which may be due to bridge condition.

This section begins near Beni (479.782 km on the Troy to Merrygoen line) and ends at the start of the Binnaway deviation (several kilometres south of the junction with the line to Werris Creek at Binnaway station; (458.678 km on the Wallerwang–Gwabegar line).

The alignment passes close to Barbigal, through Ballimore and follows the Golden Highway before diverging to the north. It passes through a heavily wooded area between Goonoo and Cobbora State Forest. North of the forest the route passes close to Mendooran, crossing Castlereagh Highway before entering Merrygoen and crossing Merrygoen Junction at 82 km. The alignment leaves Merrygoen in a north-easterly direction following a similar route as the Castlereagh River.

The section runs through open undulating countryside with the track bed located either on low embankment or shallow cutting, with the alignment occasionally meandering to follow contours in low hill areas. Increased environmental impacts, mainly relating to noise but which could also entail vibration, air quality and visual amenity impacts can be expected due to increased freight operations through the centre of settlements and within rural homesteads in the vicinity of the alignment. Further investigation will be required in stages 2 and 3; a by-pass of the centre of significant settlements may be needed.

The existing crossings of the railway include about 33 at-grade vehicular crossings, some of significant roads and highways, and about 10 bridges or culverts over watercourses. Consideration of heritage impacts should be given to any bridges or built railway infrastructure (e.g. stations) that may need upgrading or replacement.

The section also passes through a heavily wooded area between Goonoo and Cobbora State Forest with a number of farm/forestry crossings evident.

C04a — Binnaway–Premer (existing — BAU)

To travel to Werris Creek from Dubbo, trains are required to reverse at Binnaway. From Binnaway Station to Premer is 67 km of Class 2 track with speed restrictions covering over 20 km of curved track, mainly on the section between Connemarra and Premer. In addition to the daily ore traffic, there is grain traffic a few times per week.

The section starts a few kilometres south of the junction with the line to Werris Creek at Binnaway Station (458.678 km on the Wallerwang–Gwabegar Line). The alignment follows the route of the Warrumbungles Way through open undulating countryside until Weetaliba. Climbing significantly to Coonemarra, it passes north-easterly between Round Mountain and Dean Mountain. The alignment falls continuously for 25 km to Premer, curving its way through heavily wooded low hills and on the edge of forest to the south-west of Premer. It ends (at 525.8 km) on a straight section of track 2.2 km before Premer Silo (528 km).

The track between Binnaway and Premer has long ruling gradients of 1 in 100. The section generally has the track bed located either on low embankment or shallow cutting.

Increased environmental impacts, mainly relating to noise but which could also entail vibration, air quality and visual amenity impacts can be expected due to increased freight operations through the centre of settlements and within rural homesteads in the vicinity of the alignment. Further investigation will be required in stages 2 and 3; a by-pass of the centre of significant settlements may be needed, some of which are covered by deviations proposed under previous study work.

The existing crossings of the railway include about 10 at-grade vehicular crossings, some of significant roads, and about 11 bridges or culverts over watercourses. Consideration of heritage impacts should be given to any bridges or built railway infrastructure (e.g. stations) that may need upgrading or replacement.

C05 — Premer (east)–Turilawa (west) (existing — BAU)

Premer (east)–Turilawa is 65 km of Class 2 railway, with undulating gradients of less than 1 in 100 and generally straight track with no sharp curves. Only freight trains use the section at present. The current line speed over much of the alignment is 100 km/h, with two local speed restrictions of 40 km/h that appear to be structure related.

The section begins where the line runs parallel to the Coonabarabran Road to the east of Premer (531.1 km). The alignment progresses from Premer towards the 'Gap' in the Dunover Mountain range and Werris Creek beyond. The section ends at the node located at Turilawa (west) (595.8 km).

From Premer, the section follows the Coonabarabran Road between Mount Tamarang to the south and densely wooded hills to the north. The alignment continues east passing to the south of Coolanbilla Mountain and Lake Goran and to the north of Coolah Tops national park. The route passes on flat country side to the north of Caroona crossing the Mooki River (584.1 km).

The section generally has the track bed located either on low embankment or shallow cutting with the alignment occasionally meandering to follow contours in low hill areas.

Increased environmental impacts, mainly relating to noise but which could also entail vibration, air quality and visual amenity impacts can be expected due to increased freight operations through the centre of settlements and within rural homesteads in the vicinity of the alignment. Further investigation will be required in stages 2 and 3; a by-pass of the centre of significant settlements may be needed.

The existing crossings of the railway include about 16 at-grade vehicular crossings, some of significant roads, and about six bridges or culverts over watercourses. Consideration of heritage impacts should be given to any bridges or built railway infrastructure (e.g. stations) that may need upgrading or replacement.

C06 — Turilawa (west)–Werris Creek (existing — BAU)

The section of Class 2 single track railway starts from the Turilawa (west) node (595.8 km) and runs on embankment on the side of the Gap Road to Werris Creek Yard through the 'Gap' in the Dunover Mountain range. The section connects with the line to Gunnedah at Gap Junction (599.971 km–Binnaway–Werris Creek chainage) and becomes a reversible line to Werris Creek passing through the station (605.151 km) and north junction to the end of line at Werris Creek Yard. There is a CountryLink passenger train crew depot at Werris Creek.

The alignment climbs from Turilawa (west) through open country side into the 'Gap' Dunover Mountain range. The track passes through the Gap on the south side on an elevated cut into the hill side. The alignment then continues to climb to Werris Creek through open country side on the east side of the Dunover range.

The vertical profile of the alignment climbs continuously from Turilawa to Werris creek at an average gradient of 1 in 100 but with a steep final section of curved alignment approaching Werris Creek compensated down to 1 in 69 and 1 in 79. Horizontal alignment is constrained by the requirement to tackle the terrain of the Gap and enter Werris Creek. However, the line speed remains at 115 km/h for much of the section with a restriction of 100 km/h over a 1 km section through the Gap. There is a 90 km/h restriction on the 500 m curve near Werris Creek.

The alignment generally crosses farmland and enters Werris Creek urban area. Increased environmental impacts, mainly relating to noise but which could also entail vibration, air quality and visual amenity impacts can be expected due to increased freight operations through settlements. Further investigation will be required in stages 2 and 3.

The existing crossings of the railway include about three at-grade vehicular crossings, one of a significant road, and a bridges or culvert over a watercourse.

C18 — Werris Creek–Turilawa (north) (existing — BAU)

Trains travelling towards Narrabri from Binnaway must reverse at Werris Creek. The line from Werris Creek to Narrabri serves the Gunnedah coal basin, and is 159 km of Class 1 railway, which is capable of handling 21 t axle load trains at 115 km/h and 23 t axle load trains at 80 km/h. Although coal traffic dominates the line, there is a mix of passenger, grain and other freight traffic every day. Werris Creek to Turilawa (north) is about 6 km long and passes through the Gap.

The section begins at the Werris Creek yard and passes through the station and a section of bi-directional track, through the junction with the Binnaway line (416.050 km) and crosses Gap Road on a five-span viaduct. It uses an embankment on the north side of Gap Road through the 'Gap' in the Dunover Mountain range. The alignment then curves north-west over Cana Road to the node at Turilawa (north) (419.713 km).

The alignment falls (initially at 1 in 74) from Werris Creek through open country-side on the east side of the Dunover range to the Gap Dunover Mountain range. The track passes through the Gap on the north side on an elevated cut into the hill side. It continues to fall from the Gap to Turilawa (north) through open country side. Speed is restricted initially to 90 km/h because of the 500 m radius curve leaving Werris Creek. Then it increases to 115km/h on the run to the Gap where a local speed of 100 km/h runs for approximately 1 km before increasing again to 115 km/h.

The alignment generally crosses farmland after leaving the Werris Creek urban area. Increased environmental impacts, mainly relating to noise but which could also entail vibration, air quality and visual amenity impacts can be expected due to increased freight operations through settlements. Further investigation will be required in stages 2 and 3.

The existing crossings of the railway include about three at-grade vehicular crossings, one of a significant road overbridge, a viaduct structure and a bridge or culvert over a watercourse. Consideration of heritage impacts should be given to any bridges or built railway infrastructure (e.g. stations) that may need upgrading or replacement.

C07 — Turilawa (north)–Emerald Hill (existing — BAU)

The line serves the Gunnedah coal basin, and is 77 km of Class 1 railway, currently capable of handling 21 t axle load trains at 115 km/h and 23 t axle load trains at 80 km/h. It is generally through open relatively flat countryside and graded flatter than 1 in 150, although the ruling gradient for the Werris Creek to Narrabri section is 1 in 75. It is gently curved, with only two curves less than 800 m radius each causing speed restrictions of less than 100 km/h. Although coal traffic dominates the line, there is a mix of passenger, grain and other freight traffic every day.

The section progresses in a north-easterly direction from the Turilawa (north) node point (419.713km) and crosses the Mooki River (432.14 km) following the Kamilaroi Highway around Black Mountain to the west of Breeza (433.937 km). The alignment crosses the highway to the south of Curlewis (457.94 km) and enters Gunnedah from the east in a shallow cutting. The local highway on the outskirts of the town crosses the railway on an overbridge, with the remaining level crossings towards the station (475.837 km). The route leaves Gunnedah over relatively flat countryside and progresses to Emerald Hill (499.127 km).

The alignment from Turilawa to Gunnedah runs with the track bed elevated slightly above the surrounding fields. The alignment connects to a number of freight yards (Gunnedah Yard (474.429 km) and Gunnedah Stockyard (476.841 km) within the town before leaving to the north-west over open countryside. On leaving Gunnedah, the alignment is on embankment and crossed at two locations by underpasses made by reinforced concrete bridge structures.

Increased environmental impacts, mainly relating to noise but which could also entail vibration, air quality and visual amenity impacts can be expected due to increased freight operations through the centre of settlements and within rural homesteads in the vicinity of the alignment. Further investigation will be required in stages 2 and 3; a by-pass of the centre of Gunnedah may be needed.

The existing crossings of the railway include about 18 at-grade vehicular crossings, some of significant roads, a highway bridge, two road underpasses and about three bridges or culverts over watercourses. Consideration of heritage impacts should be given to any bridges or built railway infrastructure (e.g. stations) that may need upgrading or replacement.

C08 — Emerald Hill-Baan Baa (existing — BAU)

The line serves the Gunnedah coal basin, and is 37 km of Class 1 railway, currently capable of handling 21 t axle load trains at 115 km/h and 23 t axle load trains at 80 km/h. It is generally graded flatter than 1 in 100 although the ruling gradient is 1 in 75 due to a 2 km length at this grade. It is gently curved, with only one length of 2.5 km having 440 m radius curves restricting trains to 80 km/h. Although coal traffic dominates the line, there is a mix of passenger, grain and other freight traffic every day.

The section proceeds north-west from Emerald Hill (499.127 km) over open relatively flat countryside crossing Cox's Creek (512.877 km) before entering Boggabri (515.174 km) from the south. Leaving Boggabri the alignment passes between hills before continuing to Baan Baa (530.703 km).

The track bed is generally elevated slightly above the surrounding fields. The alignment running in cut/fill as it negotiates its way through the short series of hills.

The alignment to the south of Boggabri is relatively flat and level with long lengths of straight connected by bends or curves with a minimum radii of 1000 m. North of Boggabri the alignment climbs for approximately 6 km to a high spot at chainage 522.7 km at an average gradient of 1 in 130 and then drops for 8 km into Baan Baa at an average gradient of 1 in 100.

Increased environmental impacts, primarily relating to noise but potentially also entailing vibration, air quality and visual amenity impacts, can be expected due to increased freight operations through the centre of settlements and within rural homesteads in the vicinity of the alignment. Further investigation will be required in stages 2 and 3; although a by-pass of Boggabri was not envisaged in the NSRCS study, further investigations may find it is required.

The existing crossings of the railway include about six at-grade vehicular crossings, some of significant roads, a road overbridge and about four bridges or culverts over watercourses. Consideration of heritage impacts should be given to any bridges or built railway infrastructure (e.g. stations) that may need upgrading or replacement.

C09 — Baan Baa–Narrabri (south) (existing — BAU)

The line serves the Gunnedah coal basin, and is 29 km of Class 1 railway, currently capable of handling 21 t axle load trains at 115 km/h and 23 t axle load trains at 80 km/h. It is generally graded flatter than 1 in 200 and generally straight track. Although coal traffic dominates the line, there is a mix of passenger, grain and other freight traffic every day.

The section proceeds north from Baan Baa (530.703 km) over open relatively flat countryside following the route of the Kamilaroi Highway to a point 1.7 km north of Turrawan (547.646 km). It then bears north-west, running along the north-eastern border of a national forest. The alignment follows closely the Kamilaroi Road heading towards Narrabri between the Namoi River and dense woodland. The section finishes at a point to the south of Narrabri (556.323 km).

The track bed is generally elevated slightly on low embankment above the surrounding fields or shallow cutting with the alignment meandering and climbing to follow contours in low hill areas.

Increased environmental impacts, primarily relating to noise but which could also entail vibration, air quality and visual amenity impacts can be expected due to increased freight operations within rural homesteads in the vicinity of the alignment. Further investigation will be required in stages 2 and 3; although it is noted the alignment passes generally through open countryside.

The existing crossings of the railway include about seven at-grade vehicular crossings and about two bridges or culverts over watercourses. Consideration of heritage impacts should be given to any bridges or built railway infrastructure (e.g. stations) that may need upgrading or replacement.

C10 — Narrabri (south)–Narrabri (north) (existing — BAU)

Section C10 is about 15 km of the existing railway through Narrabri. It has a range of gradients and curves down to 240 m radius.

The section begins as a Class 1 track to the south of Narrabri (556.323 km) and closely follows the Kamilaroi Road heading towards Narrabri until reaching Narrabri South Junction (564.795 km) where it changes to a Class 2 route to Moree.

From the South Junction the alignment by-passes the centre of Narrabri crossing the Narrabri Creek and local highways on a twelve span viaduct structure. The alignment curves north along the eastern outskirts of the town and crosses and follows the Old Newell Highway, passing under the Newell Highway before ending at the Narrabri (north) node (572.6 km). Radii as tight as 390 m exist along the town by-pass. The local line speed is limited to 80 km/h from the South Junction to Narrabri Station (569.240 km) with a limited local speed restriction of 30 km/h on the north side of the station imposed due to structure condition (569.960 km).

The existing railway forms a boundary between residential housing and countryside. Increased environmental impacts, mainly relating to noise but which could also entail vibration, air quality and visual amenity impacts can be expected due to increased freight operations through the outskirts of Narrabri. Further investigation will be required in stages 2 and 3. A by-pass of Narrabri has been considered and will be further developed and assessed at subsequent stages.

The existing crossings of the railway include about seven at-grade vehicular crossings a highway overbridge, the Narrabri River viaduct and about four bridges or culverts over watercourses. Consideration of heritage impacts should be given to any bridges or built railway infrastructure (e.g. stations) that may need upgrading or replacement.

C11 — Narrabri (north)–Moree (south) (existing — BAU)

Narrabri to Moree is 96 km of Class 2 line, allowing 19 t axle loads at 100 km/h, and 21 t axle loads at 60 km/h. This line is generally straight (with about five curves less than 800 m radius) and has a ruling gradient of 1 in 100. There is a daily passenger service, and daily grain, cotton and general freight services.

The section begins to the north of Narrabri (572.6 km) and generally follows the highway over relatively flat terrain to Moree, where it ends south of the town (656.24 km). The route passes through Edgeroi (593.661 km), Bellata (615.468 km) and Gurley (635.414 km) where loop lines exist.

The horizontal alignment has minor constraints with respect to avoiding areas of low hills north of Narrabri. The line speed of this section is generally 100 km/h. However, there are a number of isolated restrictions of:

- 75 km/h between 579.9 km and 580.4 km due to local curvature (400 m radius))
- 30 km/h between 603.8 km and 604 km due to what is believed to be structural reasons
- 80 km/h between 641 km and 641.5 km due to local curvature (600 m radius)
- 30/40/50 km/h between 646.2 km and 654 km due to what is believed to be structural reasons.

The alignment generally crosses farmland. Increased environmental impacts, primarily relating to noise but potentially also entailing vibration, air quality and visual amenity impacts, can be expected due to increased freight operations through settlements. Further investigation will be required in stages 2 and 3.

The existing crossings of the railway include about 23 at-grade vehicular crossings, a highway overbridge, and about 11 viaducts or culverts over watercourses. Consideration of heritage impacts should be given to any bridges or built railway infrastructure (e.g. stations) that may need upgrading or replacement.

C12 — Binnaway–Merebene (upgrade)

Binnaway is the junction for the disused line to Gwabegar. It begins at the junction with the line to Werris Creek at Binnaway station (458.678 km) and terminates at the end of the line at Gwabegar (603.609 km). There are 245 km of Class 5 branch line to Gwabegar that passes through Coonabarabran, the Warrumbungle Hills and Barradine. Climbing through the Warrumbungle Ranges, the first 86 km is a steep and winding railway with long gradients, including 4 km as steep as 1 in 55 and a 10 km section of 240 m radius curves. Ulamambri loading facility is located at 35.1 km

After Bugaldie, the final 54 km to Merebene has gentle gradients of less than 1 in 200 and only four curves less than 1000 m radius. Environmental impacts, mainly relating to noise but which could also entail vibration, air quality and visual amenity impacts, can be expected due to new freight operations through the centre of settlements and within rural homesteads in the vicinity of the alignment. Further investigation will be required in stages 2 and 3; a by-pass of the centre of significant settlements may be needed.

A large number of existing and disused crossings exist along the railway. These include at-grade vehicular crossings, some significant crossings of roads and watercourses. Consideration of heritage impacts should be given to any bridges or built railway infrastructure (e.g. stations) that may need upgrading or replacement.

C14 — Dubbo (north–Talbragar)–Curban — (upgrade)

From Dubbo–Gilgandra is 63 km of Class 3 line and from Gilgandra–Curban is about 23 km at Class 5. Running through open countryside with the track bed elevated slightly above the surrounding fields, the line has gradients generally less than 1 in 100, and gentle curves, with only a few sharper than 1000 m radius. There are no trains in the current timetable.

The section starts from where it crosses Dubbo St (469.87 km), through to McAnallys Road and progressing through Gilgandra and terminating at a point north of Borden Road crossing (553.84 km) to the west of the Castlereagh Highway south of Armatree.

Along the route are a number of loops connecting the single track ballasted formation to grain loading silos.

Environmental impacts, mainly relating to noise but which could also entail vibration, air quality and visual amenity impacts can be expected due to new freight operations through the centre of settlements and within rural homesteads in the vicinity of the alignment. Further investigation will be required in stages 2 and 3; a by-pass of the centre of significant settlements may be needed.

The existing crossings of the railway include about 25 at-grade vehicular crossings, some significant roads and highways, and about seven bridges or culverts over watercourses. Consideration of heritage impacts should be given to any bridges or built railway infrastructure (e.g. stations) that may need upgrading or replacement.

C15 — Curban–Coonamble — (upgrade)

Curban–Coonamble is about 57 km at Class 5. The line has gradients generally less than 1 in 100, and gentle curves, with only several sharper than 1000 m radius. There are no trains in the current timetable.

The section starts at a point north of a crossing of Borden Road (553.84 km) and ends a few kilometres south of the centre of Coonamble (616.133 km). Along the section, a number of loops connect the single track ballasted formation to what appears to be grain loading silos. It runs through open countryside with the track bed elevated slightly above the surrounding fields. Environmental impacts, mainly relating to noise but which could also entail vibration, air quality and visual amenity impacts can be expected due to new freight operations through the centre of settlements and within rural homesteads in the vicinity of the alignment. Further investigation will be required in stages 2 and 3; a by-pass of the centre of significant settlements may be needed.

The existing crossings of the railway include about 18 at-grade vehicular crossings of varying construction. Consideration of heritage impacts should be given to any bridges or built railway infrastructure (e.g. stations) that may need upgrading or replacement.

C13 — Kiandool–Narrabri (west) — (upgrade)

Section C13 is a short 4 km length of Class 3G flat and straight track.

The section starts at the Kiandool (573.01 km) and terminates at the Narrabri West node (569.65 km). The alignment is single track passing over Bohemia Creek and running through open countryside.

The vertical alignment climbs towards Narrabri at an average gradient of around 1 in 300 with the track bed elevated slightly above the surrounding fields.

The section crosses farmland. Increased environmental impacts, mainly relating to noise but which could also entail vibration, air quality and visual amenity impacts can be expected due to increased freight operations through settlements. Further investigation will be required in stages 2 and 3.

C16a — Premer–Premer (east) — (existing–BAU)

Section C16a is 5 km of Class 2 railway through Premer.

The single track section starts to the west of Premer (525.24 km) on straight track that borders dense woodland (to the north). The alignment curves to the north past Premer Silo (528 km) before passing to the east of the town and crossing two minor highways. After leaving the town, the alignment crosses a number of low level multi-span structures that allow floodwater to pass under the railway. Before reaching the Premer (east) node the alignment passes over a more conventional viaduct structure over a creek.

The alignment is constrained by the curves to the south of Premer required to negotiate the southern border of the forest and the southern entry into the town and also the change of direction for the alignment north of the town to run parallel to the Coonabarabran Road. The line speed entering the town being limited to 90 km/h and leaving the town restricted to 75 km/h with a local restriction over the structure passing over Cox's Creek.

Increased environmental impacts, mainly relating to noise but which could also entail vibration, air quality and visual amenity impacts can be expected due to increased freight operations through Premer. Further investigation will be required in stages 2 and 3 and a by-pass of Premer may be required.

The existing crossings of the railway include about three at-grade vehicular crossings of varying construction and four low-level viaduct structures across watercourses. Consideration of heritage impacts should be given to any bridges or built railway infrastructure (e.g. stations) that may need upgrading or replacement.

C17a — Moree (south)–Moree (north) — (upgrade)

The Section C17a is existing standard gauge track and is part of the Class 3W Moree–North Star Line. It is approximately 24 km long, and runs through the township or Moree, where a station and sidings exist. The alignment is generally straight and flat, although has some sharp curves near Camurra junction and turnout where four curves exist with radii down to 240 m and a 35 km/h speed restriction.

The section starts from a point on the south side of Moree (656.24 km) and follows the Newell Highway northwards over relatively flat terrain towards the town. The alignment then passes through the east side of the town and crosses the Mehi River in a north-easterly direction on a viaduct. The route continues on a north-easterly bearing and rejoins the Newell Highway 4.5 km from the town. The section continues adjacent to the highway crossing the Gwydir River and progressing through Camurra before turning off the line to Weemelah and curving through nearly 180° on to the line to North Star. This section then ends on straight track on the Moree to North Star line (684.83 km).

The line speed of the section approaching Moree is 100 km/h. However, this drops to around 80 km/h as the alignment passes through and leaves the town. There are further isolated restrictions of:

- 30 km/h at 668 km from what are believed to be structural reasons (Skinners Creek Crossing)
- 20k m/h at 672.4 km due to what is believed to be structural reasons.

The alignment is generally on low height embankments and viaducts across the river floodplain.

The alignment crosses a mixture of urban and farmland. Environmental impacts, mainly relating to noise but which could also entail vibration, air quality and visual amenity impacts can be expected due to new freight operations through Moree and within rural homesteads in the vicinity of the alignment. Further investigation will be required in stages 2 and 3; a by-pass of the centre of significant settlements may be needed.

The existing crossings of the railway include two major river crossings (Mehi River and Gwydir River), Skinners Creek crossing and a level crossing of the Gwydir Highway (in Moree). About 10 level crossings and nine bridges, viaducts or culverts for water crossings exist. Consideration of heritage impacts should be given to any bridges or built railway infrastructure (e.g. stations) that may need upgrading or replacement.

5.3.4 Railway operations–section journey times

The journey times of a reference train travelling on each section of the inland railway were estimated using benchmarking of two typical types of Class 1 railway;

- predominantly straight track
- track with significant curves.

The following table presents the estimates for existing sections of railway assumed to be upgraded to Class 1, and new sections of railway constructed to Class 1.

The journey time of a typical existing train running on Class 2 track is also identified where applicable.

Table 5-13 Benchmarking exercise (existing class 2 upgraded to class 1)

Route		Track class	Features	Gradients	Curves	km	Current class 2 timing	Bench-mark average speed	Est hrs:min
C01	Narromine –Dubbo (west)	2	Whylandra Creek and Delroy St bridges at 471 km	Several km at 1 in 70	A few very gentle	32	0:49	88 km/h	0:21
C02	Dubbo (west)–Dubbo (north-east)	2	Yard area			12	0:04	63 km/h	0:11
C03	Dubbo (north-east)–Binnaway	2	Plain Creek at 485km, Balimore Creek at 497 km, Baragonumble Creek at 509 km, 1 at 516 km, Talbragar River at 518 km, 1 at 524 km Merrygoen Creek at 553 km, 1 at 424 km (Merrygoen), 1 at 436 km, Ulindah (Binnia) Creek at 454 km,	12km of 1 in 100 at 537 km, 3 km of 1 in 70 at Merrygoen, otherwise gentle.	17+ areas of 410 m or sharper	130	3:19	63 km/h	2:03
C04 (part)	Binnaway–Conne-mara	2	1 bridge at 485 km	All gentler than 1 in 100	two less than 800 m	40	1:06	88km/h	0:27
C04 (part)	Conne-mara–Premer	2		Continuous fall at up to 1 in 100	Continuous curves, down to 280m	26	0:26	63 Km/h	0:24
C05 +C16	Premer (east)–Turilawa (east)	2	1+ Cox's Creek at 530 km. one at Tamarang.	All gentler than 1 in 100.	None	72	1:18	88km/h	0:49
C06	Turilawa (east–Werris Creek)	1			500m	6		88 km/h	0:04
C16/ C18	Werris Creek–Turilawa (north)	1			500m	6		88 km/h	0:04
C07	Turilawa (north)–Emerald Hill	1	Mooki River at 432 km. Gunnedah.	Most gentler than 1 in 150	Only two less than 800, + Gunnedah	77		88 km/h	0:55

C08	Emerald Hill –Baan Baa	1	one hill at 523km	Flat except for 2 km at 1 in 75.	Straight except for 2.5 km at 440 m	37		88 km/h	0:25
C09	Baan Baa–Narrabri (south)	1		Mostly gentler than 1 in 200	Straight	29		88 km/h	0:19
C10	Narrabri (south)–Narrabri (north)	1	Namoi River and Narrabri Creek and Narrabri	Various	Down to 240 m	15		63 km/h	0:14
C11	Narrabri (north)–Moree	2	Bridge at Narrabri, Bridge at 604 km	Mostly gentler than 1 in 200	Only five less than 800 m	109	Fastest 1:48	88km/h	1:14
C12 (part)	Binnaway–Bugaldie	5	Mountainous	11 km at 1 in 75, many gradients	Many curves down to 240 m	86		63 km/h or slower	1:21 or slower
C12 (part)	Bugaldie–Merebene	5		Mostly gentler than 1 in 200	Only four less than 1000 m	54		88 km/h	0:36
C13	Kiandool–Narrabri (west)	3G		Flat	Straight	4		88 km/h	0:02
C14	Dubbo (north)–Curban	3 and 5M	Coobaggie Creek at 496 km	Mostly gentler than 1 in 150	Only three less than 1100 m	88		88 km/h	1:00
C15	Curban–Coonamble	3 and 5M		Flat	Straight	57		88 km/h	0:38

Table 5-14 Benchmarking exercise (new track constructed to class 1)

Route	New alignment in NSRCS report	Description	Features	Gradients	Curves	km	Benchmark average speed	Journey time estimate
C50	301	Narromine–Curban (Armatree)	Greenfield	Flat	Straight	91	88 km/h	1:02
C51	302	Coonamble–Burren Junction	Greenfield, note does not join with Burren Junction to Moree section–further work required	Flat	Straight	115	88 km/h	1:18
C52+C17	303	Burren Junction–Moree (south)–	Greenfield: does not join with Coonamble	Flat	Straight	134	88 km/h	1:31

		Moree (North)	to Burren Junction section — further work required					
C53	304	Dubbo (west)–Dubbo (north–Talbragar)	Cross Macquarie River, by-pass Dubbo	3 km at 1 in 80	Some	9	63 km/h	0:08
C54	1401	Coonamble –Merebene (Gwabegar)	Greenfield	Flat	Few	74	88 km/h	0:50
C55	1402	Merebene (Gwabegar) –Kiandool (Narrabri)	Greenfield	Nothing steeper than 1 in 200	1	83	88 km/h	0:56
C56	308	Narrabri (west) – Narrabri (north)	Crosses rivers. By-pass Narrabri	2 km of 1 in 80	2	8	63 km/h	0:07
C57	305	Dubbo (west)–Dubbo (north-east)	Cross Macquarie River. By-pass Dubbo	3 km at 1 in 80	Some	10	63 km/h	0:09
C58	309	Narrabri (south)–Narrabri (north)	Crosses rivers, by-pass Narrabri	Flat	2	10	88 Km/h	0:06
C59	3408	Turilawa (west)–Turilawa (north) high speed	The Gap high speed cut off	Gentle	Continuous	4	88 Km/h	0:02
C60	3409	Turilawa (west)–Turilawa (north) low speed	The Gap slow speed cut-off	Gentle	Sharp	1	63 km/h	0:02
C61 (part)	501 (part)	Binnaway–Baan Baa (0 km–76 km)	Greenfield; winding and hilly away from Binnaway, seven tunnels.	All on gradients, 11 km at 1 in 136, 5 km at 1 in 66.	Continuous at 1000 m or gentler	76	63 km/h	1:12
C61 (part)	501 (part)	Binnaway–Baan Baa (76 km–145 km)	Greenfield. Binnaway node is at end of 3403	gentle, mostly gentler than 1 in 136. Nothing steeper than 1 in 90.	Straight	69	88 km/h	0:47
C62	601	Premer–Emerald Hill	Greenfield	Undulating short sharp grades up to 1 in 50	Few and gentle	73	88 km/h	0:49

				for 500m				
C03b	3301, 3302, 3303, 3304, 3401, 3402	Dubbo (north-east) to Binnaway. Barbigal deviation, Muronbung deviation, Boomley deviation, Merrygoen deviation, Toogarlan deviation, Piambra deviation	Taken all together; reduction in distance not included.	12km of 1 in 100 at 537 km, 3 km of 1 in 70 at Merrygoen, otherwise gentle.	Four of 420 m	130	88 km/h	1:28
C04b	3403 or 3404, 3405 and 3406	Binnaway to Premer. Binnaway deviations, Ulinda deviation, Oakey Creek to Premer deviation	Taken all together; reduction in distance not included.	Many around 1 in 130, with 8 km at 1 in 80.	Only two less than 800 m	70	88 km/h	0:47

5.3.5 Summary of characteristics for area routes

Journey times

The estimated journey times for a selection of routes across Area C (between Narromine and Moree (north)) have been calculated and are presented in the following table. A base case has been selected as the route along existing track from Narromine to Moree via Werris Creek; reversals are required at both Werris Creek and Binnaway if existing track is used throughout. Area routes have been selected to allow the area route journey time and costs to be estimated and compared. Sufficient combinations of sections have been presented to allow a preferred route to be selected and taken forward to more detailed development and assessment in Stage 2.

The journey times have been based on benchmarking of two typical sections of track for the reference train; namely generally straight track or track with a high proportion of significant curves and gradients. As described in other parts of this report, the times assume the train is continuously moving and is unhindered by other railway traffic; allowance has not been made for additional time which is required such as for crossing other trains, refuelling and crew changes. The estimates of time will also vary due to the level of accuracy of the benchmarking when applied to a range of route sections; the level of accuracy in predicting journey times is expected to improve with detailed modelling of the preferred route at later stages of this study.

There are a number of towns along the potential routes for the inland railway and new alignments have been considered to by-pass the towns of Narromine, Dubbo, Binnaway, Premer, Werris Creek, Narrabri and Moree. The journey times for by-passes are generally expected to be similar to (and slightly less than) times along existing track through the towns; the exception being for Werris Creek and Binnaway, where the by-pass removes the need for trains to reverse and results in large time savings. It is expected that the preferred route for the inland railway will include alignments that avoid significant settlements by an appropriate distance and further consideration will be made of environmental issues in stages 2 and 3 of the study.

Table 5-15 Journey time[13]

Area route	Description	Route length (km)	Journey time hr:min	
			Minimal upgrade to Class 2 track	Class 2 upgraded to class 1
CC01	Generally new route via Coonamble and Burren Junction	397	N/A	4:29
CC02	Generally new route via Dubbo, Coonamble and Burren Junction	435	5:24	4:56
CC03	Generally new route via Coonamble and Narrabri	430	N/A	4:49
CC04	Generally new route via Dubbo, Coonamble and Narrabri	468	6:18	5:16
CC11	Generally existing with Binnaway low speed, Werris Creek high speed, Moree and Narrabri by-passes	436	10:44	7:16
CC15	Generally existing with Narrabri and Moree by-pass and Binnaway to Baan Baa new route section	469	8:31	6:13
CC19	Generally existing with Premer to Emerald Hill new section and Binnaway low speed, Narrabri and Moree by-pass	488	9:18	6:19
CC21	Generally existing via Gwabegar with new section between Gwabegar and Narrabri and Narrabri and Moree by-passes	512	9:09	6:51
CC23	Existing alignment via Werris Creek (with Binnaway low speed by-passes assumed)	583	11:22	7:54
CC24	Existing alignment (with Turilawa low speed by-pass and Binnaway low speed by-pass assumed)	580	10:52	7:54
Base case	Existing alignment via Werris Creek (with reversals at Binnaway and Werris Creek assumed)	586	12:00	8:32
CC12 + deviations	Generally existing with Dubbo, Binnaway low speed, Werris Creek high speed, Moree and Narrabri by-passes, and C03b and C04b deviations.	496	N/A	6:25
CC16 + deviations	Generally existing with Dubbo, Moree and Narrabri by-passes and Binnaway to Baan Baa new route section plus C03b deviations	457	N/A	5:26
CC20 +deviations	Generally existing with Premer to Emerald Hill new section and Dubbo, Binnaway low speed, Moree and Narrabri by-passes, plus C03b and C04b deviations	472	N/A	5:28

[13] For conciseness routes which have similar times have not been reported in this table. Refer to complete table in Volume 2

5.3.6 Summary of issues for Area C

The key issues identified during Stage 1 that have a bearing on the selection of a preferred route are:

- the options for routes across Area C generally comprise new alignments across relatively flat terrain on the western side of Area C or generally use of existing or upgraded track across more undulating to hilly terrain across the eastern half of Area C.
- the journey time for new routes across the western side of Area C are estimated to be in the order of 270 to 320 minutes (4:30 to 5:20), excluding additional time required for train-crossing manoeuvres, refuelling and crew change.
- the journey time for the existing route from Narromine via Werris Creek to Moree (north) is estimated to be in the order of 720 minutes (12hours) using existing track. If existing infrastructure is upgraded to a Class 1 standard and reversals are removed from Werris Creek and Binnaway, this time estimate is reduced to about 444 minutes (7:24). Further improvements to the existing railway by construction of a range of short sections of new track (deviations) between Dubbo and Premer and/or new sections of track across country between Binnaway and Baan Baa or Premer and Emerald Hill result in the time estimate to be reduced to between 326 and 385 minutes (5:26 to 6:25).
- the western routes cross large lengths of flood-prone land, areas of black soil and deep soft soils. Both these issues will influence design solutions and construction costs. An alignment generally from Narromine to Coonamble to Narrabri and Moree appear to minimise the impacts of flooding and ground conditions.
- the existing railway between Werris Creek and Narrabri is used for coal traffic on a daily basis. Whilst track improvement works are ongoing on this section, any further upgrades on this and other existing track (such as for passing loops, track improvements and bridge upgrades) would need to be planned around existing and future traffic.
- there are many areas of national estate and other areas of environmentally sensitivity across Area C that will require further consideration and management at subsequent stages of the project. The new route between Coonamble and Narrabri passes close to area of national estate and crosses two short lengths of state forest.
- the existing railways pass through and close to many towns and significant settlements. Some by-passes of major towns have been considered. Environmental impacts, mainly relating to noise but which could also entail vibration, air quality and visual amenity impacts can be expected due to new freight operations through the centre of settlements and within rural homesteads in the vicinity of the alignment. Further investigation will be required in stages 2 and 3; a by-pass of the centre of significant settlements may be needed. New alignments will be developed to avoid significant impacts on settlements.

5.3.7 Comparative routes

Two routes have been chosen to demonstrate the differing engineering features of this area, shown in Figure 5-19:

- via Werris Creek and Narrabri (using the existing railway), and

- via Narromine, Coonamble, Merebene and Narrabri (new section of railway between Coonamble and Narrabri)

Profiles have been developed to demonstrate the differing terrain these routes traverse; these are provided in Figure 5-20.

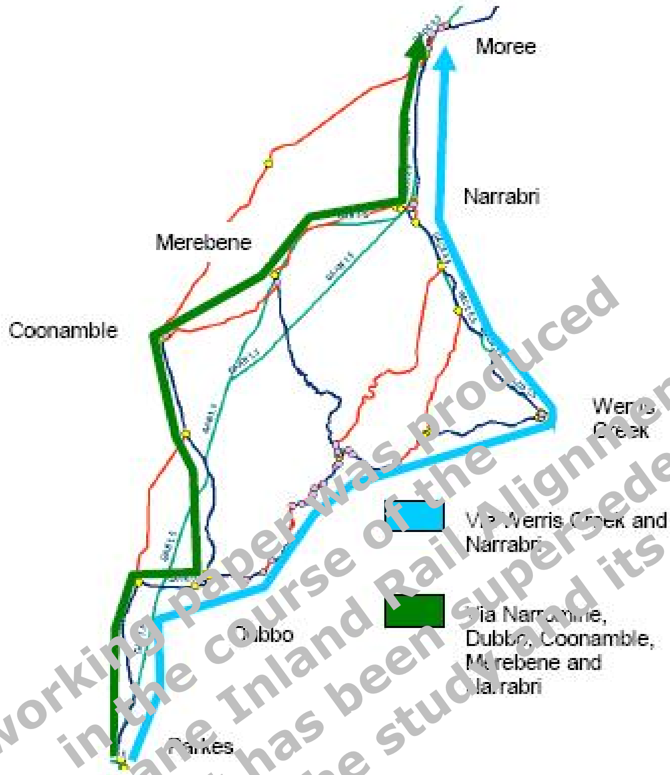


Figure 5-19 Parkes to Moree plan

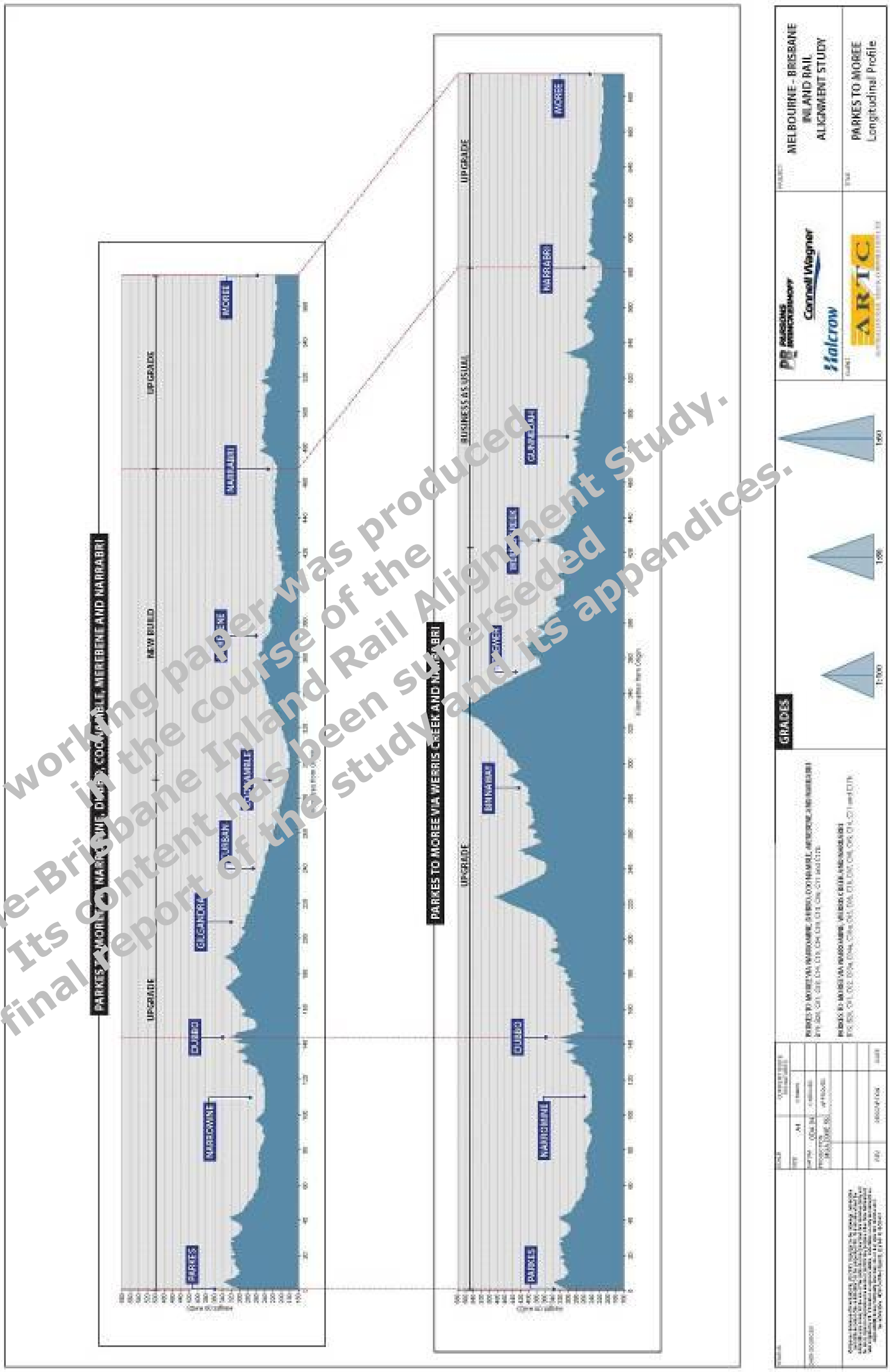


Figure 5-20 Illustrative profiles, Parkes to Moree

5.4 Area D route options — Moree to Brisbane

5.4.1 General description of Area D

Area D route options extend from Moree North (Cumurra) in NSW via either Warwick or Toowoomba to the existing intermodal freight facility at Acacia Ridge in Brisbane's southern outskirts. Refer to Figure 5-21. A total of 34 route sections have currently been identified, which combined make up 36 area route options that vary between approximately 480 km to 600 km in track length.

Route options pass through mainly undulating farmland in the north-west of NSW and southern Queensland before travelling east, where they encounter the Great Dividing Range (peak height 560 m RL) before descending to the Brisbane Valley (Acacia Ridge) (at RL of 66 m).

Distinct range crossings at Warwick, Clifton and Toowoomba were investigated to traverse the range and in all cases steep gradients (1 in 60), and extensive tunnelling and possibly large viaducts will be required. Routes crossing the range also encounter highly sensitive environmental areas, including national parks and world heritage listed areas, which significantly constrain the rail alignments.

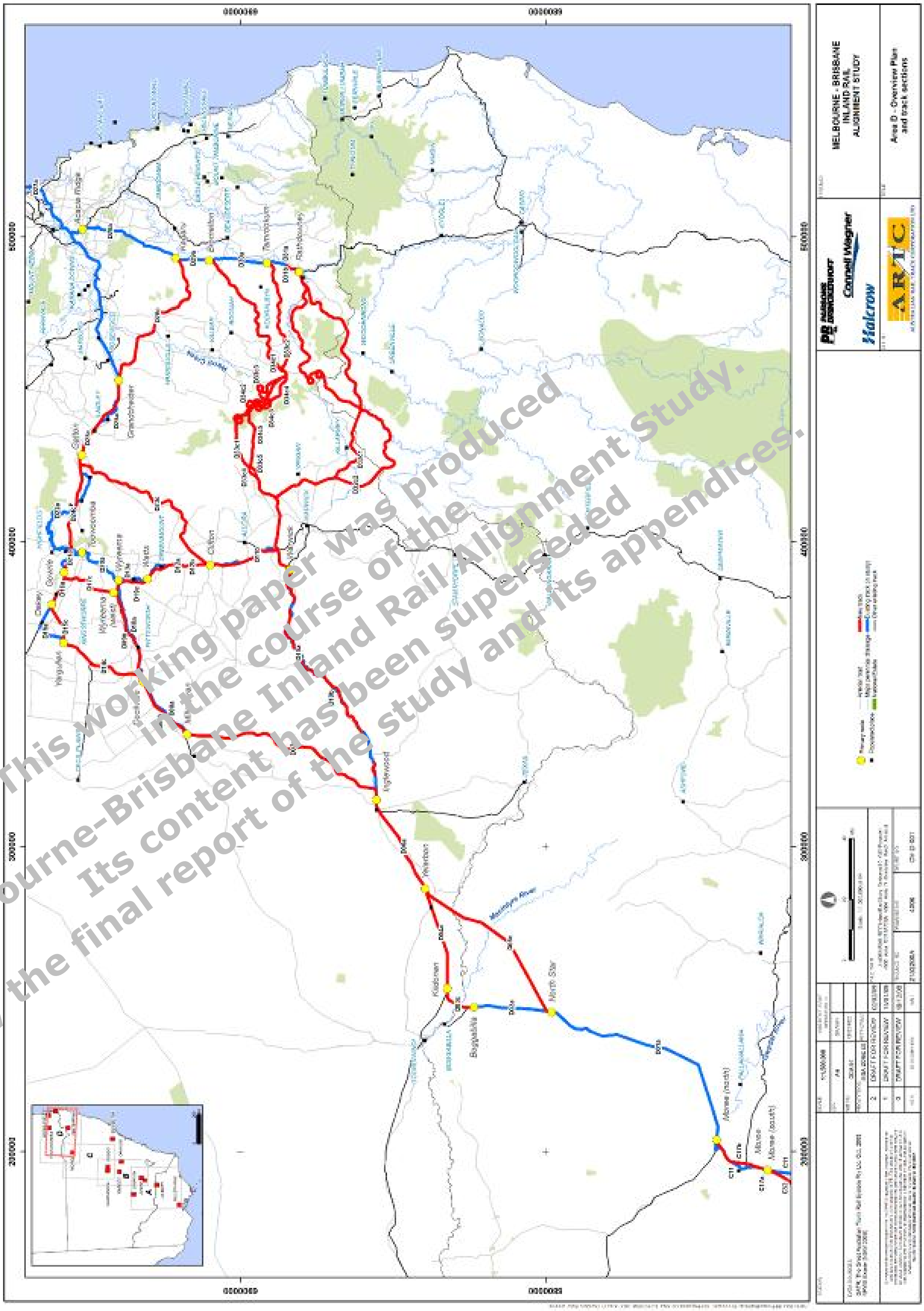


Figure 5-21 Area D overview plan

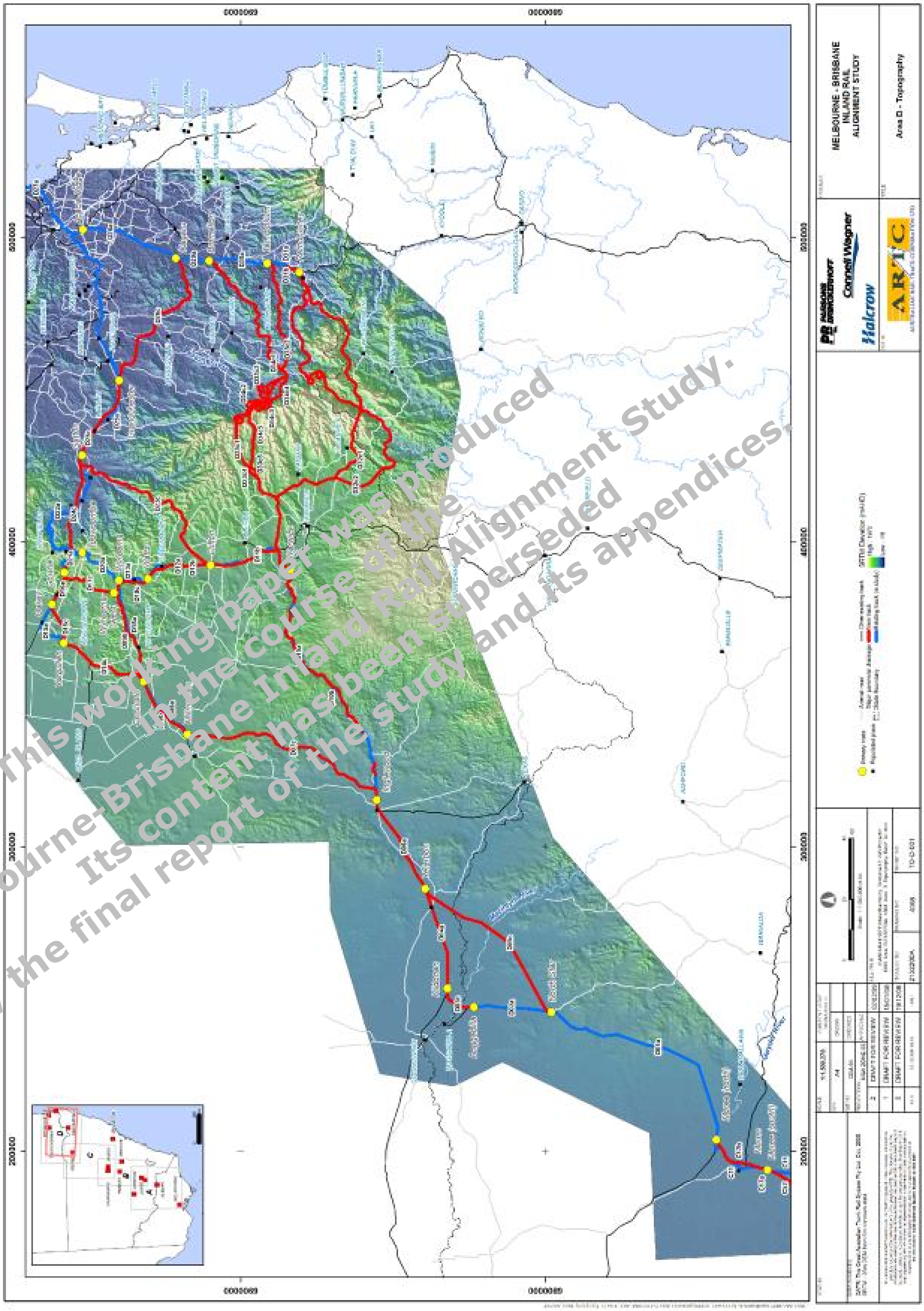


Figure 5-22 Area D topography

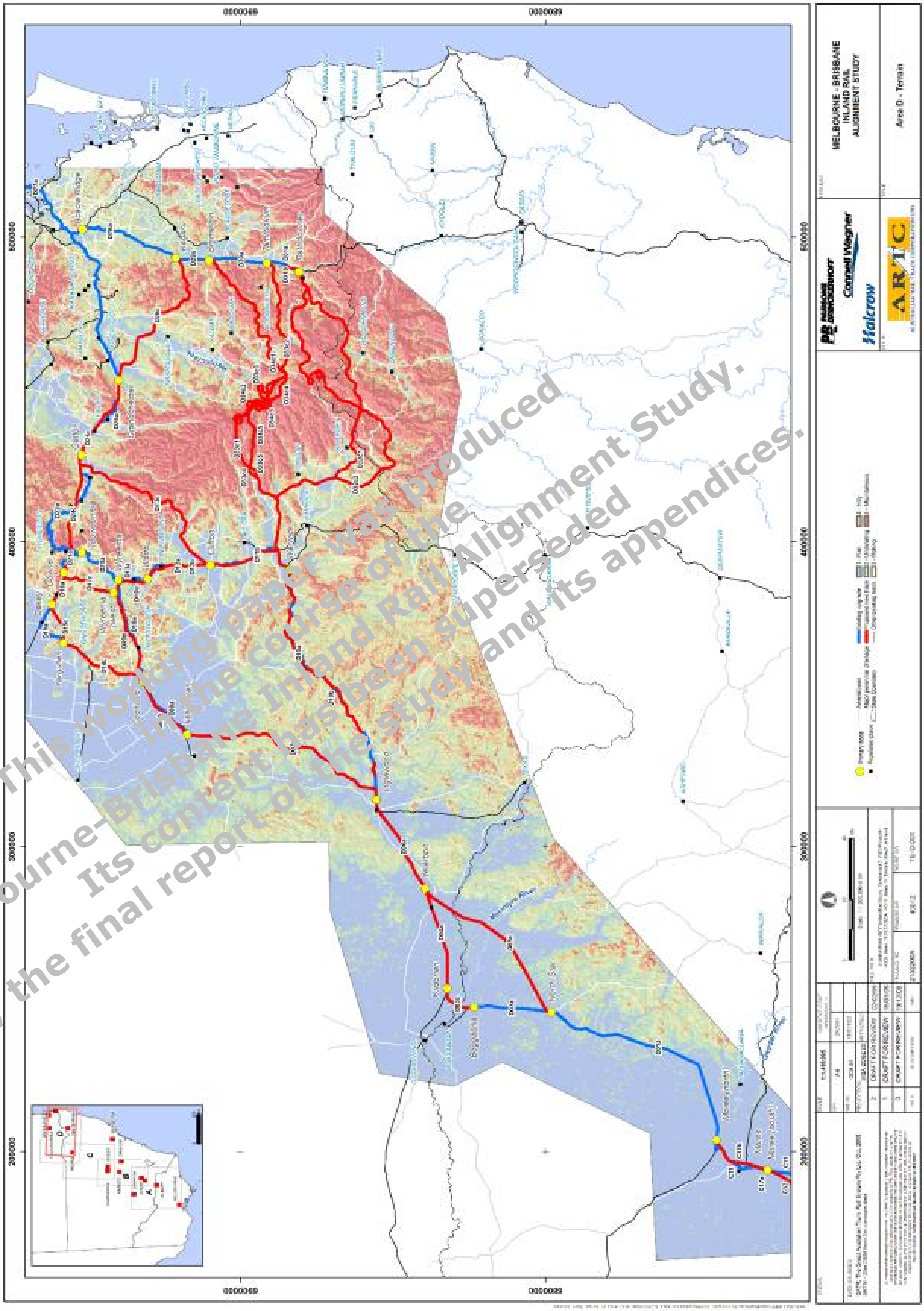


Figure 5-23 Area D terrain

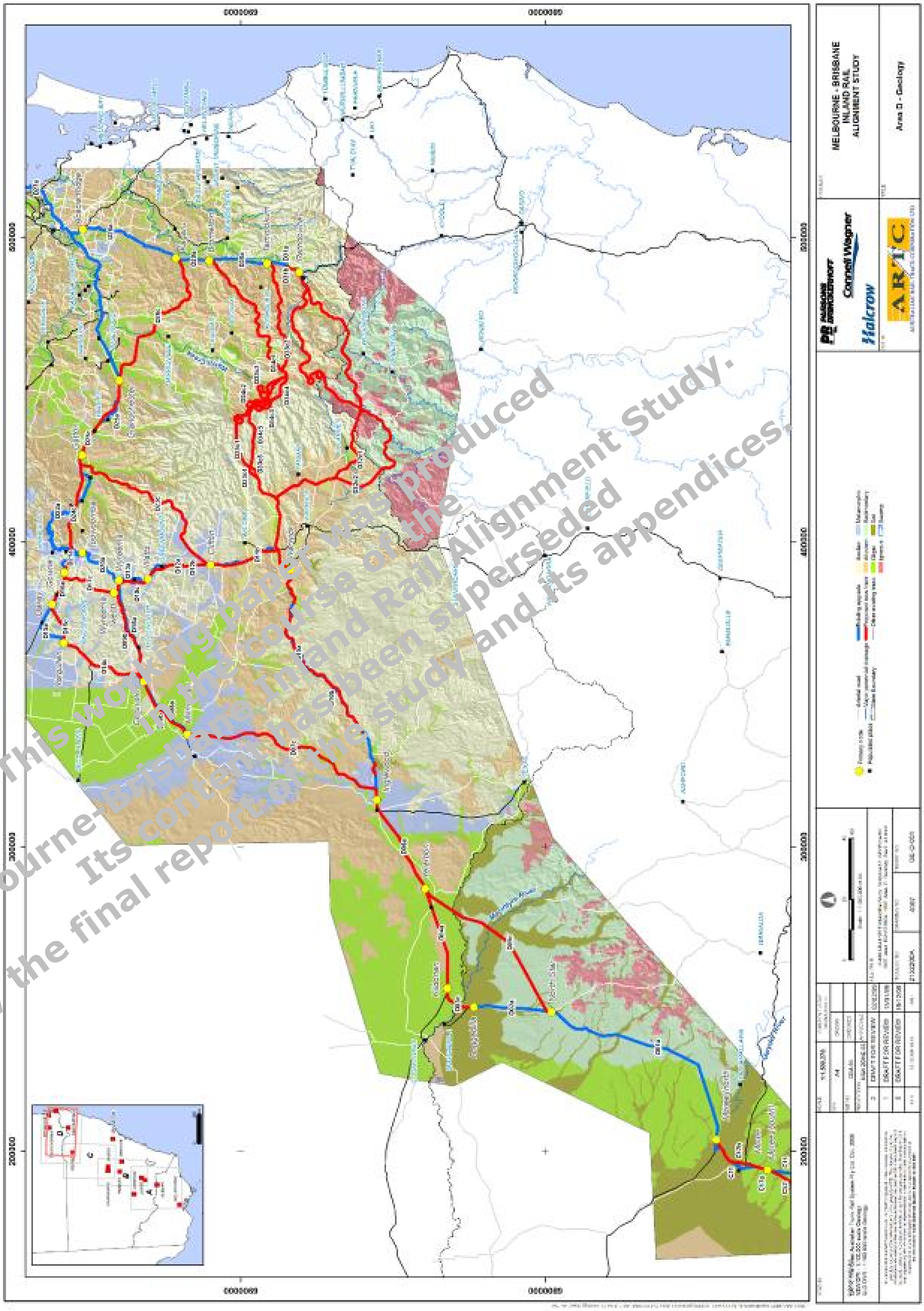


Figure 5-24 Area D geology

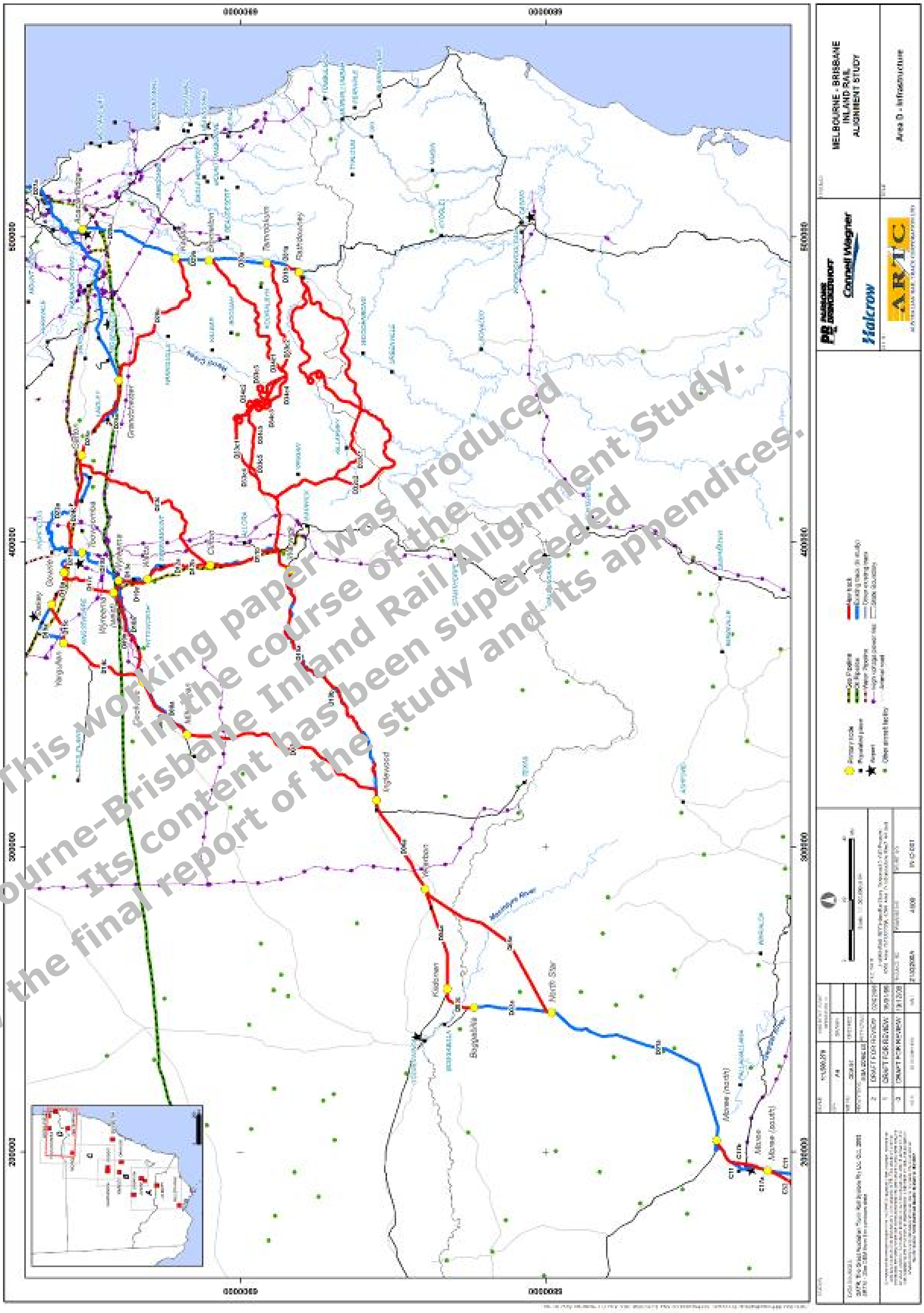


Figure 5-25 Area D infrastructure

5.4.2 Definition of section and area routes

There are approximately 36 potential routes from Moree North to Acacia Ridge that are a combination of separate route sections.

There is a possible further route east of Ipswich from Darra to Clapham and Yeerongpilly linking back Acacia Ridge, which will be assessed in Stage 2.

Table 5-16 lists these routes and sections.

Table 5-16 Area D routes

Area route	Description	Length (km)	Route sections
DD01	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Millmerran, Cecilvale, Yargullen, Oakey, Gowrie, Gatton, Grandchester, Kagaru	531	D01+D02+D03+D04+D06+D07+ D08+D14+D15+D16+D24+D25+D26+D28
DD02	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Millmerran, Cecilvale, Yargullen, Oakey, Gowrie, Gatton, Grandchester, Kagaru	519	D01+D05+D06+D07+ D08+D14+D15+D16+D24+D25+D26+D28
DD03	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Millmerran, Cecilvale, Wyreema West, Gowrie, Gatton, Grandchester, Kagaru	522	D01+D02+D03+D04+D06+D07+ D08+D09+D17+D24+D25+D26+D28
DD04	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Millmerran, Cecilvale, Wyreema West, Gowrie, Gatton, Grandchester, Kagaru	510	D01+D05+D06+D07 +D08+D09+D17+D24+D25+D26+D28
DD05	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Millmerran, Cecilvale, Wyreema, Gowrie, Gowrie, Gatton, Grandchester, Kagaru	536	D01+D02+D03+D04+D06+D07+ D08+D18+D20+D21+D24+D25+D26+D28
DD06	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Millmerran, Cecilvale, Wyreema, Gowrie, Gowrie, Gatton, Grandchester, Kagaru	525	D01+D05+D06+D07+D08+ D18+D20+D21+D24+D25+D26+D28
DD07	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Clifton, Watts, Wyreema West, Gowrie, Gatton, Grandchester, Kagaru	555	D01+D02+D03+D04+D06+D10+D11 +D12+D19+D17+D24+D25+D26+D28
DD08	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Clifton, Watts, Wyreema West, Gowrie, Gatton, Grandchester, Kagaru	544	D01+D05+D06+D10+D11+D12+ D19+D17+D24+D25+D26+D28
DD09	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Clifton, Watts, Wyreema, Gowrie, Gowrie, Gatton, Grandchester, Kagaru	564	D01+D02+D03+D04+D06+D10+D11+ D12+D13+D20+D21+D24+D25+D26+D28
DD10	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Clifton, Watts, Wyreema, Gowrie, Gowrie, Gatton,	552	D01+D05+D06+D10+D11+D12+D13+ D20+D21+D24+D25+D

Area route	Description	Length (km)	Route sections
	Grandchester, Kagaru		26+D28
DD11	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Clifton, Gatton, Grandchester, Kagaru	526	D01+D02+D03+D04+D06+D10+ D11+D23+D25+D26+D28
DD12	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Clifton, Gatton, Grandchester, Kagaru	514	D01+D05+D06+D10+D11+ D23+D25+D26+D28
DD13	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan Yelarbon, Inglewood, Warwick, Rathdowney, Tamrookum, Bromelton, Kagaru	521	D01+D02+D03+D04+D06+D10+ D32C1+D31+D30+D29+D28
DD14	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Rathdowney, Tamrookum, Bromelton, Kagaru	509	D01+D05+D06+D10+D32C1+ D31+D30+D29+D28
DD15	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick Rathdowney, Tamrookum, Bromelton, Kagaru	563	D01+D02+D03+D04+D06+D10+ D32C2+D31+D30+D29+D28
DD16	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Rathdowney, Tamrookum, Bromelton, Kagaru	551	D01+D05+D06+D10+D32C2+ D31+D30+D29+D28
DD17, DD19. DD21, DD23, DD25	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton, Kagaru		D01+D02+D03+D04+D06+D10+ D33C1+D30+D29+D28
DD18, DD20, DD22, DD24, DD26	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton, Kagaru		D01+D05+D06+D10+ D33C1+D30+D29+D28
DD27, DD29, DD31. DD33, DD35	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Bromelton, Kagaru		D01+D02+D03+D04+D06+ D10+D34C1+D29+D28
DD28, DD30, DD32, DD34, DD36	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Bromelton, Kagaru		D01+D05+D06+D10+D34C1+D29+D28

Table 5-17 shows a number of route sections that are common to all combinations of routes.

Table 5-17 Area D common sections

Section	From	To	Line
D01	Moree North	North Star	Moree to North Star
D06	Yelarbon	Inglewood	Warwick to Dirranbandi
D28	Kagaru	Acacia Ridge	Coastal Route

5.4.3 Review of sections

There are multiple route options between the following distinct nodal locations. These include:

- North Star–Yelarbon
- Inglewood–Gowrie and down the Toowoomba Range
- Inglewood–Warwick to Interstate Coastal Standard Gauge (via Rathdowney, Tamrookum, Bromelton, or Clifton/Gatton/Kagaru).

North Star to Yelarbon

An abandoned corridor and track exist from North Star–Boggabilla–Kildonan on the Queensland narrow gauge network. Options for this section include:

- build a greenfield alignment from North Star–Yelarbon (D05)
- upgrade the disused line from North Star–Boggabilla (D02), build greenfield from
- Boggabilla–Kildonan (D03), and build new standard gauge or dual gauge for the existing QR sections from Kildonan–Yelarbon (D04).

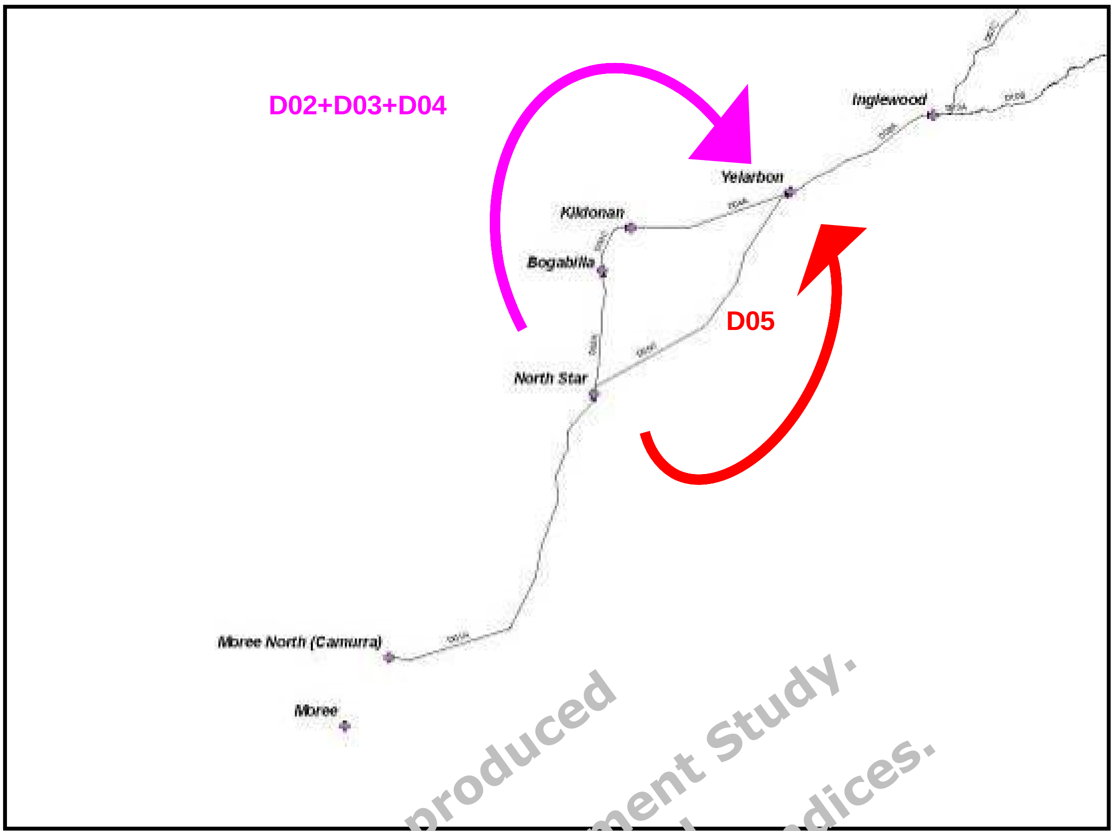


Figure 5-26 North Star to Yelarbon

Inglewood to Gowrie (Toowoomba Range) or Warwick (to interstate coastal gauge)

At Inglewood two distinct route options evolve:

- North to Millmerran (D07), which supports either the Toowoomba or Gowrie to Gatton range crossing or
- East to Warwick and then to the coastal interstate route option.

The Inglewood–Millmerran route traverses the Toowoomba range via Gowrie–Gatton (D24), Gatton–Grandchester (D25) and then Grandchester–Kagaru[14] (D26). In between there are multiple options to get from Inglewood–Gowrie.

[14] "Grandchester–Kagaru" has been used in this study. Officially Queensland Transport calls this segment the Southern Freight Rail Corridor and the end towns are Rosewood and Kagaru.

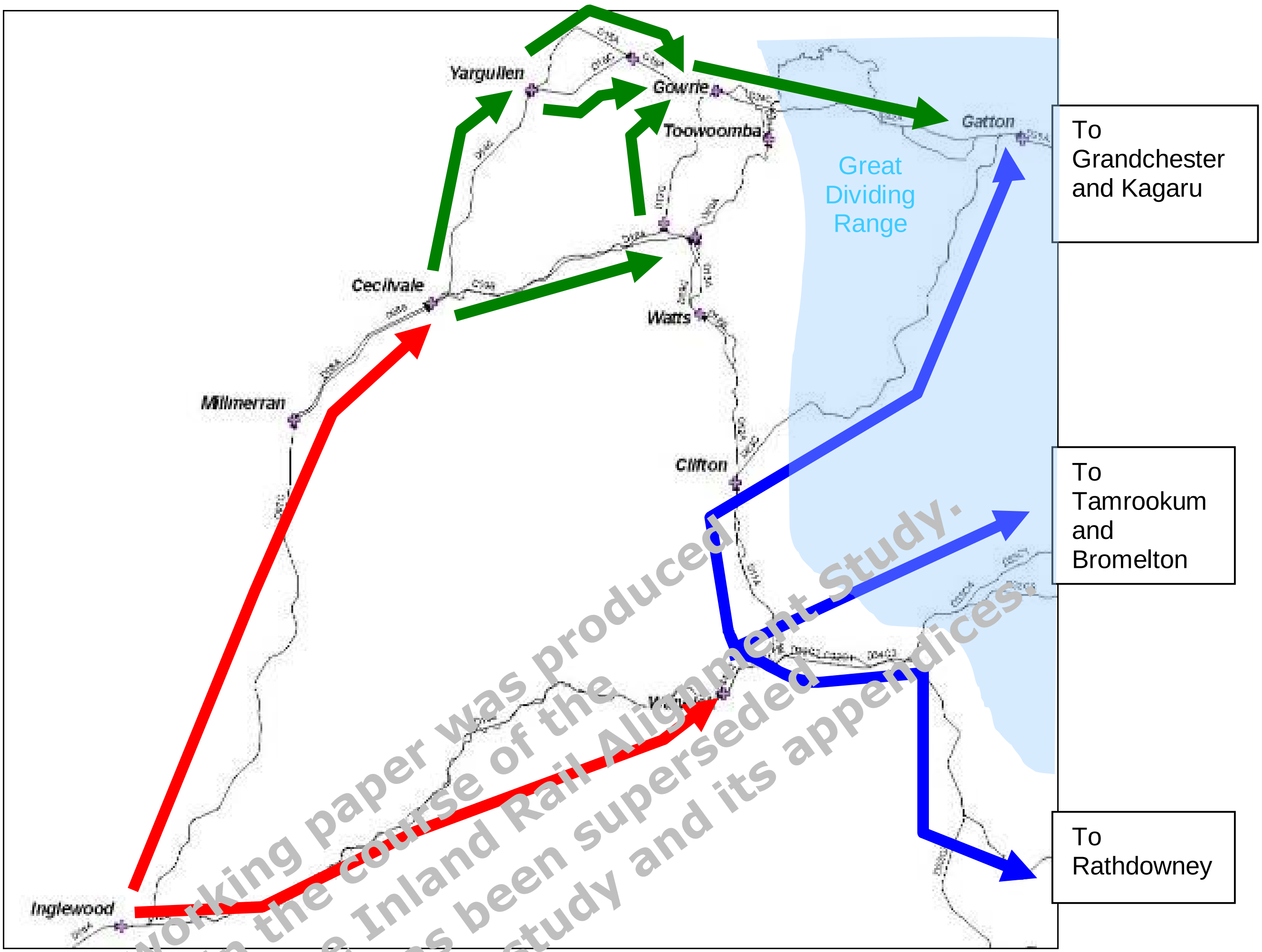


Figure 5-27 Inglewood to Brisbane via Toowoomba or Warwick

The Inglewood–Warwick (D10) route would use a Warwick to coast option (Warwick–Bromelton/Tamrookum/Rathdowney–D32, D33, and D34) or the Clifton–Gatton (D23) option north of Warwick heading directly to Gatton then onto Grandchester (D25) and Grandchester–Kagaru (D26).

These range crossings are a combination of the following route sections:

- Gowrie–Gatton (D24), Gatton to Grandchester (D25), Grandchester–Kagaru (D25), Kagaru–Acacia Ridge (D28).
- Clifton–Gatton (D23), Gatton–Grandchester (D25), Grandchester–Kagaru (D25), Kagaru–Acacia Ridge (D28).
- Warwick–Bromelton/Tamrookum/Rathdowney (D32, D33, D34), then the coastal route to Acacia Ridge, Rathdowney–Tamrookum (D31), Tamrookum–Bromelton (D30),
- Bromelton–Kagaru (D29). Within each of these route sections (D32, D33, D34) there are multiple alignment options for the different vertical grading criteria (1 in 100, 1 in 80, 1 in 60).

Cecilvale details

Multiple route options are available from Cecilvale with all options eventually connecting to the Gowrie–Gatton–Grandchester–Kagaru range crossing. Available options include:

- using existing corridor between Cecilvale and Wyreema west (D09) and build a greenfield alignment Wyreema west to Gowrie (D17)
- using both the existing section between Cecilvale and Wyreema (D18), as well as the Wyreema–Toowoomba (D20) section
- building new alignments heading north towards Yargullen (D14) then onto Oakey (D15) on the Dalby–Toowoomba line), thence from Oakey into Gowrie (D16). This option includes greenfield and the reuse of mothballed lines (Oakey–Cecil Plains line) and has the advantage of avoiding the poor terrain and constraints between Cecilvale and Wyreema.

All options would need to use the Inglewood to Millmerran (D07) and the Millmerran–Cecilvale (D08) sections.

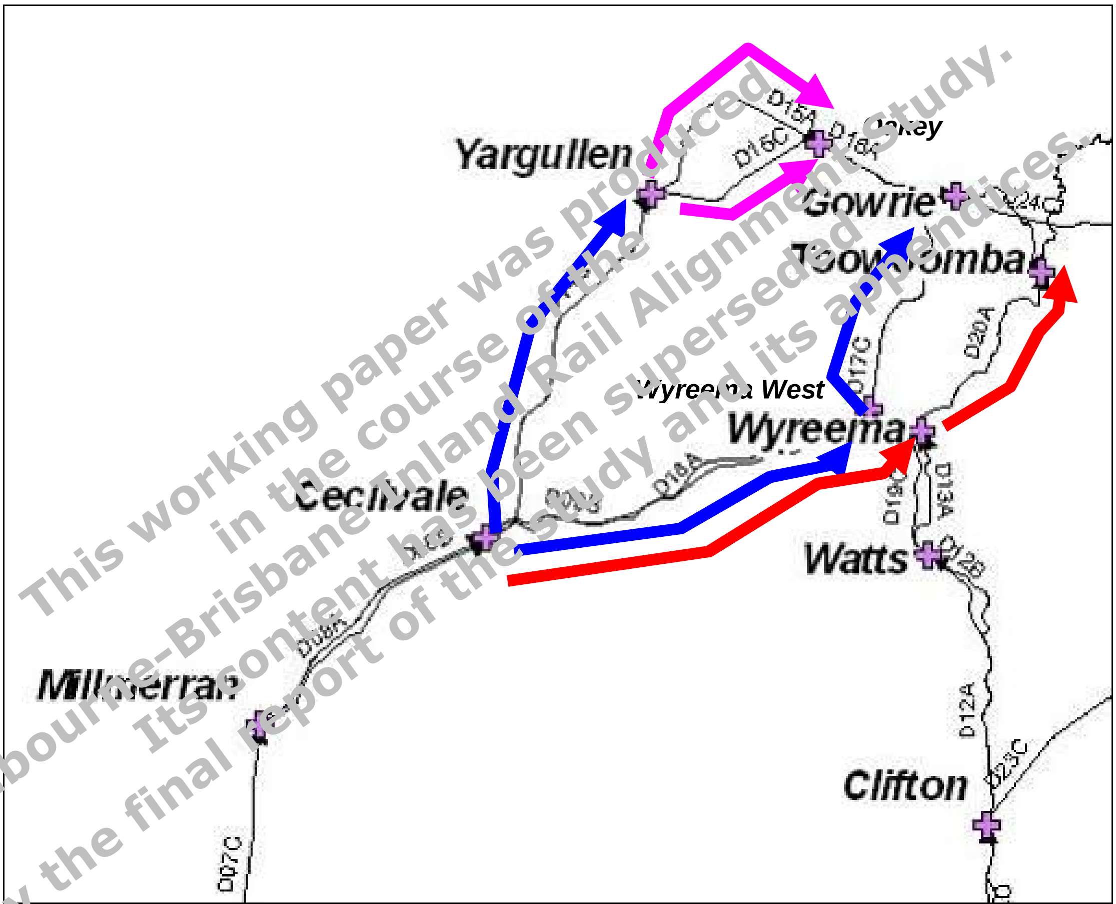


Figure 5-28 Cecilvale

Warwick details[15]

From Warwick the options either go north to Clifton (D23) or continue east along one of the three potential range crossings to the existing standard gauge costal route as follows:

- Warwick to Rathdowney (D32) — two options exist:

1. D32c1 via Killarney and Woodenbong, 24.4 km tunnel, 30.92 km viaduct.

[15] Another option of Warwick, Clifton and Gatton has 12 km of tunnels and 11.5 km of viaducts. Alignments for range crossings at Warwick were based on 20 m topographical contours for the purpose of comparative analysis with Toowoomba crossing. Subsequently 5 m contours were procured, which indicate alignments are not optimised for engineering. Nevertheless errors in overall tunnel and viaduct lengths between 5 and 20 m contours are not considered significant in rugged terrain and for the purposes of comparative analysis. No further development work is envisaged.

2. D32c2 via Koreelah includes spiral, 14.6 km tunnel and a 29.9 km viaduct.

- Warwick to Tamrookum (D33) —five options exist,
  1. D33c1–1 in 80 grade, approx 11.23 km of tunnel and 28.1 km viaduct.
  2. D33c2–1 in 100 grade with spiral, 19.55 km of tunnel and 26.6 km viaduct.
  3. D33c3–1 in 100 grade, spiral, 18.1 km of tunnel and 27.9 km of viaduct.
  4. D33c4–1 in 100 grade, spiral, 15.1 km of tunnel and 24.9 km of viaduct.
  5. D33c5–1 in 60 grade, 12.5 km of tunnel and 14 km of viaduct, 2 R550m curves.
- Warwick to Bromelton (D34) — five options exist:
  1. D34c1–1 in 80 grade, approx 13.0 km of tunnel and 24.5 km viaduct.
  2. D34c2–1 in 100 grade with spiral, 23.4 km of tunnel and 25 km viaduct.
  3. D34c3–1 in 100 grade, spiral, 22.9 km of tunnel and 26 km of viaduct.
  4. D34c4–1 in 100 grade, spiral, 19.3 km of tunnel and 23.4 km of viaduct.
  5. D34c5–1 in 60 grade, 15.9 km of tunnel and 17.3 km of viaduct, two 550 m radius curves.

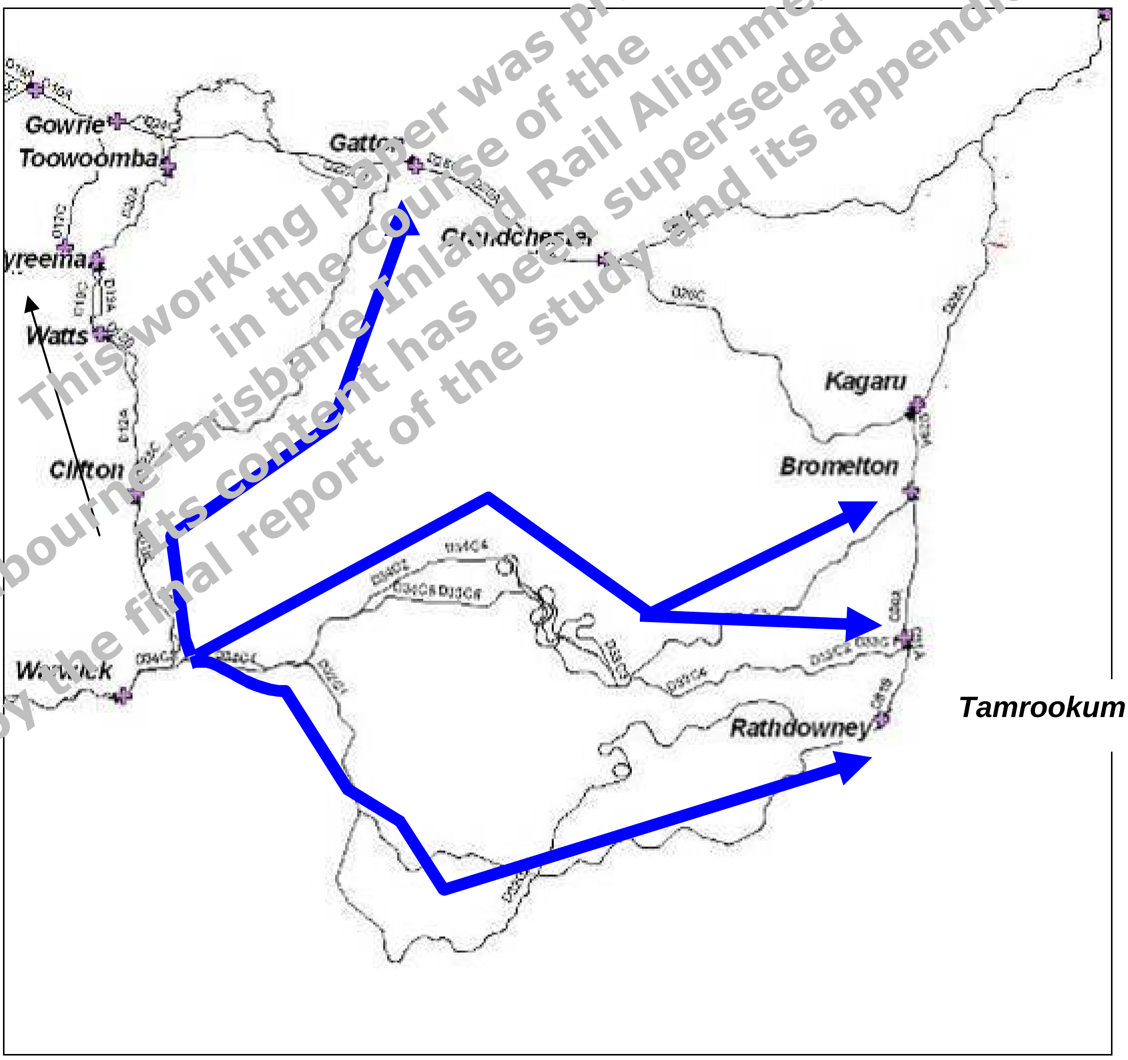


Figure 5-29 Warwick details

Clifton details

At Clifton the route section can either:

- use the Greenfield Clifton–Gatton (D23) range crossing,
- head north to Watts (D12), to eventually use the Gowrie–Gatton (D24) range crossing via two options from Watts–Gowrie
- this route has approximately 11.7 km of viaducts.

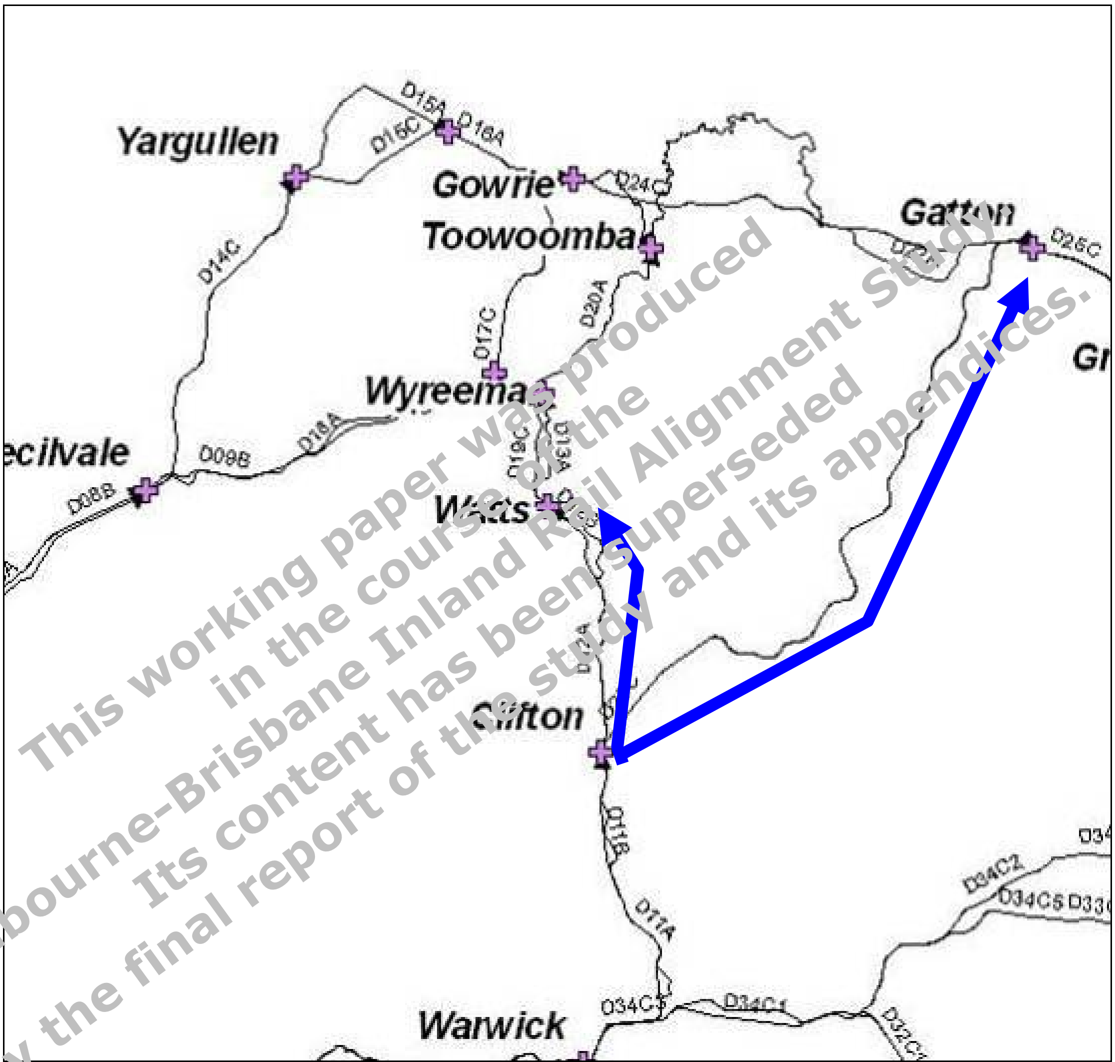


Figure 5-30 Clifton details

At Watts, the option is to either:

- head towards Toowoomba/Gowrie via Wyreema using the existing QR corridor and sections Watts–Wyreema (D13) and Wyreema–Toowoomba (D20) going through major towns and urban areas, OR
- build greenfield alignments that by-pass Wyreema and Toowoomba to their west to Gowrie, via Watts to Wyreema West (D19) and Wyreema West–Gowrie (D17).

Both these options will require the use of the Gowrie–Gatton (D24) and Gatton–Grandchester (D25) and Grandchester–Kagaru (D25) range crossing.

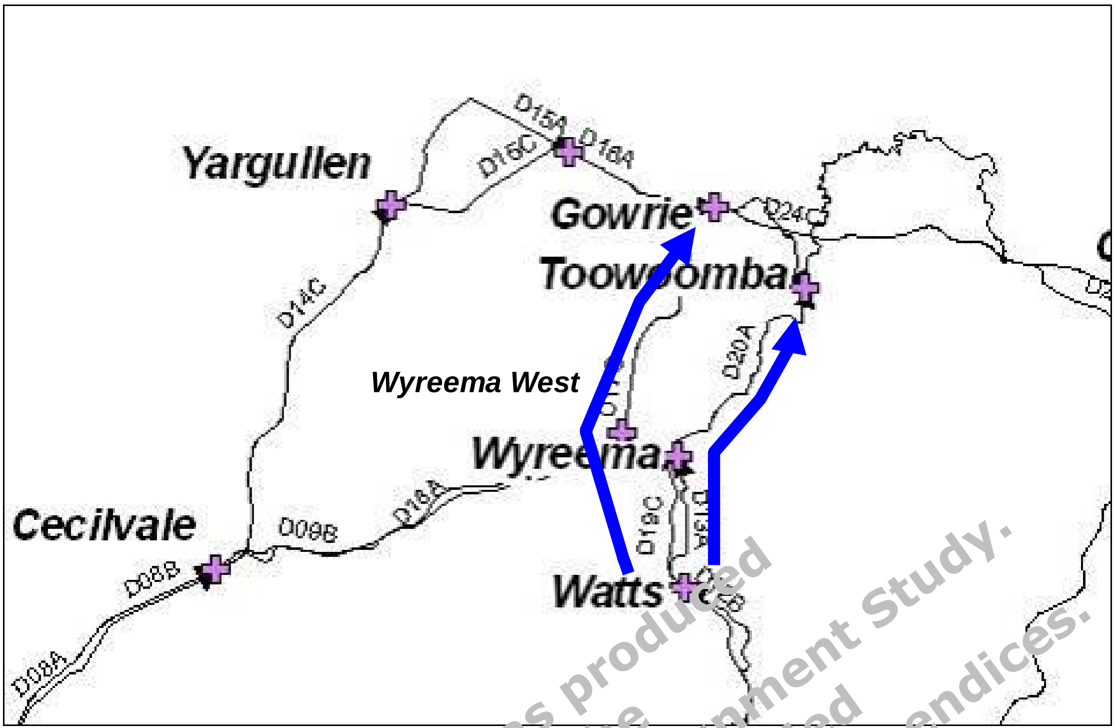


Figure 5-31 Watts details

Notes of routes

- All Toowoomba Range route options from Gowrie–Gatton (D24) have assumed the Southern Freight Rail Line (Rosewood/Grandchester–Kagaru (D25)), will be used to access Acacia Ridge to avoid directing any traffic via Ipswich and the existing QR metropolitan network.
- Acacia Ridge has been assumed to be the northern most node and end point for this study.
- Any option into Toowoomba and therefore from Wyreema is not advised due to the impact freight would have on existing services, urban areas, and infrastructure restraints, such as standard/narrow gauge issues through Toowoomba, OHW heights and bridge clearances. Gowrie, to the north-west of Toowoomba, is considered the main launch point for any range crossing.
- A route from Warwick to Clifton then up through Watts to Gowrie, for an eventual range crossing if possible, but would be the longest route and most indirect way to traverse the total route.

5.4.4 Standard, narrow and dual gauging

The two sections of track in NSW, Moree North to North Star (D01) and North Star to Boggabilla (D02) are existing standard gauge routes. There are numerous other route sections where the route traverses existing QR narrow gauge track on the South-western line (Toowoomba to Dirranbandi) and Western line (Toowoomba to Charleville).

The majority of the existing QR track form west of Warwick/Toowoomba is in a substandard state for freight operations proposed and without current asset data it is likely that significant upgrade of existing infrastructure and widening of formation for standard gauge track will be required. Track structure is generally rated for 15.75 TAL with max 50 kg/m rail, timber sleepers interspersed with steel and formation typically crushed rock and sand ballast.

Gauge clearances may also limit maximum heights and widths to between 2.65 m and 2.9 m. Curves and grades on these tracks are frequently under a radius of 1000 m and are much steeper than 1 in 100 respectively, and significant curve and grade easing would be required to meet operational design parameters proposed.

Heritage and substandard load rated bridges (often old timber) exist on most existing QR lines investigated in the scope of this study. Structural analysis of under-bridges may provide opportunities to strengthen some bridges but it has generally been assumed that replacement of most bridges will be necessary. Many road overbridges may also need to be replaced due to the height restrictions of double stacked containers, as existing QR lines have container height restrictions between 2.65 m and 2.95 m.

The existing standard gauge coastal route that includes sections Rathdowney–Tamrookum (D31), Tamrookum–Bromelton (D30), Bromelton–Kagaru (D29) and Kagaru–Acacia Ridge (D28) is generally Class 1 track and maximum container height of 3.01 m.

Track structure is 53 kg/m rail with 60 kg/m rail on curves and timber and concrete sleepers.

The maximum allowable axle loading (tal) with speeds that depend on axle loads as below:

- 23 tal — 80 km/h max allowable speed
- 21.5 tal — 100 km/h max allowable speed
- 19.5 tal — 115 km/h max allowable speed
- XPT — 130 km/h max allowable speed.

Small amounts upgrading of track structure may be required to replace timber sleepers with concrete and upgrade 53 kg/m rail with 60 kg/m. Curve and grade easing may also be required, due to the minimum radius being 240 m and steepest grade 1 in 50.

Note, however, the ARTC is using concrete to replace the sleepers on the entire north coast line.

The intent is also to use corridors of disused lines: North Star–Boggabilla (D02) and Yargullen–Oakey (D15). It has been assumed that any disused track 'upgrading' would be a similar scope of work to greenfield construction (i.e. no reuse of derelict line infrastructure, pending infrastructure assessment/inspection).

Existing QR tracks pose the challenge of being narrow gauge. Options for treatment of this include:

- dual gauging of these QR lines
- construct brand-new standard gauge track (in the existing QR corridors or greenfield)
- construct a mix of dual gauge and standard gauge track with deviations and realignment to improve existing curve and grade constraints.

There are advantages and disadvantages in all these options that should be considered.

Table 5-18 Standard verses dual gauge

Greenfield standard gauge		Dual gauging	
Advantages	**Disadvantages**	**Advantages**	**Disadvantages**
Greenfield style freedom in construction and design. No need to replace existing, run independently of each other. Not inheriting the existing problems of the existing narrow gauge railway (tight curves and steep grades).	May have to build in excess crossings to provide suitable alignment (flyovers or diamonds into existing QR tracks, snaking across major roads and rivers). Need to duplicate existing level crossings and bridges. Potential spatial and clearance problems associated with two tracks in the corridor. Potential for excessive earthworks needed to 'duplicate' tracks.	QR network use and possible business pick up. Potential sharing of maintenance costs between ARTC and QR. Reuse of existing embankments and cuttings, lowering required earthworks, and possibly some infrastructure such as bridges and rail.	Extra cost associated with dual gauging (signalling, dual gauge turnouts, extra rail and associated track components, dual gauge sleepers). Dual gauging of many infrequently used turnouts (sidings and loops) and complexity of dual gauging. Network operations impacts during construction to existing narrow gauge traffic. Kinematic envelop problems associated with dual gauging. Signalling system interfaces between QR system and IRAS system. Tend to inherit the existing problems of the existing narrow gauge railway particularly tight curves and steep grades, which may be unacceptable for freight operations.

5.4.5 Terrain and hydrology

Western Plains

Western Plains terrain types occur to the west of the Darling Downs and they comprise the flood plains of the major rivers interspersed with higher ground. In these terrain types, the major rivers fan out into broad flood plains that are crisscrossed by a number of anabranches, remnant oxbows and ephemeral channels. Some of the features have been obscured by agricultural practices. The terrain is predominantly flat and some of the rivers diverge into separate systems as they flow westwards. All but the largest watercourses are ephemeral and flow only occurs after significant rain.

The major river crossings typically comprise extended embankments with culverts or bridges placed at strategic intervals. The larger catchments respond to prolonged periods of widespread rain which can lead to extended periods of inundation.

Darling Downs

Darling Downs terrain types occur in the general area between Yelarbon and Toowoomba. While the terrain in these areas has greater relief than the Western Plain terrain type, the rivers still follow highly braided flow paths through wide, extensive valleys. The emergence of ridges and hills provides clear routes along which the railway can run to minimise major creek crossings.

The larger catchments respond to prolonged periods of rain which can lead to extended periods of inundation.

Mountain and Escarpment

Mountain and Escarpment terrain types occur as the railway descends from Toowoomba or crosses mountain ranges, such as the Great Dividing Range. This terrain type is typified by steep slopes that are incised by many deep gullies. The dimensions of the waterway crossings will be determined more by the local morphology than the size of the watercourse and it would not be uncommon to have major structures spanning a valley with only a small creek below.

Eastern Valleys

Eastern Valleys terrain types typically occur to the east of the Great Dividing Range and around Toowoomba. They comprise the valley floors of the major river systems which are characterised by agricultural land use. River channels are well defined, and commonly meander through the valley floor. In most cases the transport corridors run parallel to the waterways, and the meanders in the creeks and rivers often crisscross the straighter rail alignment, resulting in several chains of crossings.

Eastern Hills

Eastern Hills terrain types generally occur to the east of the Great Dividing Range where the railway crosses from one major valley to another. The alternative routes of the railway in these areas become quite sinuous as they wind up and down the valleys.

Rivers and creeks in these terrain types are typically well defined, relatively steep and constrained within well delineated valleys. These valleys do not permit the wider meanders of the Eastern Valleys, though the irregularities of the material in the valley floor promote sinuous channels. Occasionally, the sinuosity of the creeks and rivers requires a chain of crossings as the waterways wind under the straighter alignment of the railway.

Watercourses are more permanent than the Mountain and Escarpment terrain types. The presence of permanent vegetation in the waterways limits bank erosion.

Urban

Urban terrain types are typically defined by the density of surrounding urban development rather than landform though, generally urban development avoids steep terrain. Local morphologies vary, but the waterways in this terrain type are characterised as being modified and constrained within artificially reduced flood plains.

The principal concern relating to the design of new crossings in this terrain type is to mitigate adverse impacts on the built environment. This will commonly require an increase in the crossing width and possibly height with the purpose of causing no increase in flood levels upstream of the crossing.

Coastal

Coastal terrain types are encountered on the approaches to the Port of Brisbane. Much of the route up the Lytton Peninsula skirts reclaimed land, with industrial development on the west and mangroves on the east.

The vertical alignment is generally constrained by maximum sea levels and areas exposed to waves may need to be raised sufficiently as protection against wave set up.

Drainage in these areas is difficult, principally because of the flat hydraulic gradients and the tendency of channels to become silted and colonised with mangroves.

5.4.6 Tunnels and major viaducts

There are tunnels and major viaducts required on all the range crossing route sections, as below:

- Warwick–Rathdowney
- Warwick–Tamrookum
- Warwick–Bromelton
- Clifton–Gatton
- Gowrie–Gatton
- Gatton–Grandchester
- Grandchester –Kagaru

All these sections are in mountainous and rugged terrain, and tunnels are required, along with viaducts over valleys that can have depths around 55 m. High level route options have been developed for comparison in Stage 1; these are conceptual only with many assumptions made to arrive at these proposed tunnel and viaduct lengths. Significant further design work would be required on these segments to further refine these options to confirm their feasibility. It is also highly probably that these lengths can be further reduced via more refinement and engineering.

5.4.7 Railway operations

Operations overview

From Moree the 131 km line to Boggabilla is Class 5 and has no timetabled service. It is mainly flat, with a ruling gradient of 1 in 100, and generally straight.

In Queensland, the 76 km of track from the point where the Goondiwindi line turns away from the border to Inglewood is narrow gauge and largely flat and gently graded. There is little traffic on the south-western system to Toowoomba, with weekly general freight and livestock trains, plus weekly cotton and grain trains in season.

Between Inglewood and Acacia Ridge via Warwick, Toowoomba and Ipswich there is approximately 285 km of extremely steep and winding narrow gauge railway. Use of this existing formation is not possible for the size and speed of train being considered by the study.

The inland railway may use parts of the western system, from Chinchilla to the Port of Brisbane, notably via Oakey, Gowrie, Toowoomba, Gatton or Grandchester. This is one of QR's busy coal systems.

Table 5-19 Benchmarking exercise, existing infrastructure upgraded to class 1

Code	Route	Track class (existing)	Features	Gradient	Curves	km	Average speed	Est hrs:min
D01A	Camurra–North Star	3W	Standard gauge	1:100	>1000 m	78.323	B1 88 km/h	0:53
D02A	North Star–Boggabilla	Derelict (was 3W)	Derelict standard gauge	1:100	>1000 m	25.677	B1 88 km/h	0:17
D03C	Boggabilla–Kildonan	New	Greenfield	1:264	>1000 m	12.561	B1 88Km/h	0:08
D04A	Kildonan–Yelarbon	Narrow 15.75 tal	Flat and straight	1:220	>1000 m	33.87	B1 88km/h	0:23
D05C	North Star–Yelarbon	New	Greenfield	1:99	>1000 m	60.38	B1 88Km/h	0:40
D06A	Yelarbon–Inglewood	Narrow 15.75 tal	Flat and straight	1:96	>1000 m	33.372	B1 88km/h	0:22
D07C	Inglewood–Millmerran	New	Greenfield	1:100	>1000 m	73.638	B2 63 km/h	1:10
D08A	Millmerran–Cecilvale	Narrow 15.75tal	Flat and straight	1:100	>1000 m	23.283	B1 88 km/h	0:15
D08B	Millmerran–Cecilvale	New	In existing corridor	1:100	>1000 m	23.296	B1 88 km/h	0:15
D09B	Cecilvale–Wyreema West	New	In existing corridor	1:100	>800 m	33.014	B2 km/h	0:31
D10A	Inglewood–Warwick	Narrow 15.75 tal	Windy and hilly	1:50	200 m min	95.304	Actual 37 km/h	Actual 3:13
D10B	Inglewood–Warwick	New	In existing corridor, with deviations	1:100	>800 m	91.746	B2 63 km/h	1:27 or slower
D11A	Warwick–Clifton	Narrow 15.75 tal	Flat and straight	1:60	200 m min	33.568	Actual 45 km/h	Actual 0:55
D11B	Warwick–Clifton	Narrow 15.75 tal	In existing corridor, with deviations	1:100	>800 m	31.909	B2 km/h	0:30
D12A	Clifton–Watts	Narrow 15.75 tal	Hilly and curvy	1:64	250 m min	23.999	B2 km/h	0:22
D12B	Clifton–Watts	Narrow 15.75 tal	In existing corridor, with deviations	1:100	>800 m	22.815	B2 63 km/h	0:21
D13A	Watts–Wyreema	Narrow 15.75 tal	Hilly and curvy	1:64	250 m min	11.241	B2 km/h	0:10
D14C	Cecilvale–Yargullen	New	Greenfield	1:100	>800 m	31.249	B1 88 km/h	0:21
D15A	Yargullen–Oakey	New and derelict (was 15.75 tal)	New (greenfield) section and reuse derelict line corridor	1:100	>800 m	18.441	B1 88 km/h	0:12
D15C	Yargullen–Oakey	New	Greenfield with some reuse of derelict line corridor	1:100	>800 m	14.339	B1 88 km/h	0:09
D16A	Oakey–Gowrie	Narrow 15.75 tal	Hilly and curvy	1:100	400 m min	11.587	B1 88 km/h	0:08
D17C	Wyreema – Gowrie	New	Greenfield	1:100	>800 m	18.993	B2 km/h	0:18
D18A	Cecilvale–Wyreema	Narrow 15.75 tal	Hilly and curvy	1:50	160 m min	36.605	B2 km/h	0:35

D19C	Watts–Wyreema West	New	Greenfield	1:00	>800 m	14.079	B2 63 km/h	0:13
D20A	Wyreema–Toowoomba	Narrow 15.75 tal	Hilly and curvy	1:50	300 m min	18.446	B2 km/h	0:17
D21A[16]	Gowrie–Toowoomba	Narrow 15.75 tal	Hilly and curvy	1:88	350 m min	11.425	B2 63 km/h	0:41
D23C	Clifton–Gatton	New	Greenfield	1:80	>800 m	67.255	Mixture	0:48
D24C	Gowrie–Gatton	New	Greenfield	1:60	>800 m	40.385	B2 km/h	0:38
D25A	Gatton–Grandchester	Narrow 15.75tal	Hilly and curvy	1:50	110 m min	33.185	B2 63 km/h	0:31
D25C	Gatton–Grandchester	New	Greenfield	1:80	>800 m	28.724	B2 63 km/h	0:27
D26C	Grandchester–Kagaru	New	Greenfield	1:80	>800 m	55.161	B2 km/h	0:52
D28A	Kagaru–Acacia Ridge	Class 1	Existing standard gauge	1:50	500 m min	33.[illegible]12	B2 63 km/h	0:32
D29A	Bromelton–Kagaru	Class 1	Existing standard gauge	1:50	600 m min	11.422	B1 88 km/h	Actual 0:07
D30A	Tamrookum–Bromelton	Class 1	Existing standard gauge	1:55	500 m min	19.[illegible]33	B1 88 km/h	0:13
D31A	Rathdowney–Tamrookum	Class 1	Existing standard gauge	1:55	200 m min	11.728	B2 km/h	0:11
D31B	Rathdowney–Tamrookum	Class 1	Upgrades and deviations	1:80	>800 m	11.471	B1 88 km/h	0:07
D32C1	Warwick–Rathdowney	New	Greenfield	1:80	>800 m	134.13	mixture	1:51
D32C2	Warwick–Rathdowney	New	Greenfield	1:100	>800 m	167.747	mixture	2:18
D33C1	Warwick–Tamrookum	New	Greenfield	1:80	>800 m	126.297	mixture	1:42
D33C2	Warwick–Tamrookum	New	Greenfield	1:100	>800 m	145.139	mixture	1:53
D33C3	Warwick–Tamrookum	New	Greenfield	1:100	>800 m	144.592	mixture	1:57
D33C4	Warwick–Tamrookum	New	Greenfield	1:100	>800 m	134.338	mixture	1:43
D33C5	Warwick–Tamrookum	New	Greenfield	1:60	550 m min	123.249	B2 63 km/h	1:57 & slower
D34C1	Warwick–Bromelton	New	Greenfield	1:80	>800 m	136.772	mixture	1:51
D34C2	Warwick–Bromelton	New	Greenfield	1:100	>800 m	155.583	mixture	2:02
D34C3	Warwick–Bromelton	New	Greenfield	1:100	>800 m	155.006	mixture	2:15
D34C4	Warwick–Bromelton	New	Greenfield	1:100	>800 m	144.812	mixture	1:58
D34C5	Warwick–Bromelton	New	Greenfield	1:60	550 m min	133.279	mixture	1:59 & slower

[16] Reversal required at Toowoomba.

Area D summary table

Table 5-20 Area D summary

Area route	Description	Length (km)	Route sections
DD01	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Millmerran, Cecilvale, Yargullen, Oakey, Gowrie, Gatton, Grandchester, Kagaru	499	6:12
DD02	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Millmerran, Cecilvale, Yargullen, Oakey, Gowrie, Gatton, Grandchester, Kagaru	487	6:04
DD03	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Millmerran, Cecilvale, Wyreema West, Gowrie, Gatton, Grandchester, Kagaru	494	6:23
DD04	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Millmerran, Cecilvale, Wyreema West, Gowrie, Gatton, Grandchester, Kagaru	483	6:15
DD05	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Millmerran, Cecilvale, Wyreema, Gowrie, Gowrie, Gatton, Grandchester, Kagaru	508	6:37
DD06	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Millmerran, Cecilvale, Wyreema, Gowrie, Gowrie, Gatton, Grandchester, Kagaru	496	6:29
DD07	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Clifton, Watts, Wyreema West, Gowrie, Gatton, Grandchester, Kagaru	525	6:58
DD08	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Clifton, Watts, Wyreema West, Gowrie, Gatton, Grandchester, Kagaru	513	6:50
DD09	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Clifton, Watts, Wyreema, Gowrie, Gowrie, Gatton, Grandchester, Kagaru	532	7:05
DD10	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Clifton, Watts, Wyreema, Gowrie, Gowrie, Gatton, Grandchester, Kagaru	520	6:57
DD11	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Clifton, Gatton, Grandchester, Kagaru	495	6:16
DD12	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Clifton, Gatton, Grandchester, Kagaru	483	6:08
DD13	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan Yelarbon, Inglewood, Warwick, Rathdowney, Tamrookum, Bromelton, Kagaru	488	5:58
DD14	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Rathdowney, Tamrookum, Bromelton, Kagaru	477	5:50
DD15	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Rathdowney, Tamrookum, Bromelton, Kagaru	530	6:25
DD16	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Rathdowney, Tamrookum, Bromelton, Kagaru	519	6:17
DD17	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton, Kagaru	468	5:38
DD18	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton, Kagaru	457	5:30

DD19	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton, Kagaru	487	5:49
DD20	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton, Kagaru	476	5:41
DD21	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton, Kagaru	487	5:53
DD22	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton, Kagaru	475	5:45
DD23	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton, Kagaru	476	5:39
DD24	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton, Kagaru	465	5:31
DD25	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton, Kagaru	465	5:53
DD26	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton, Kagaru	454	5:45
DD27	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Bromelton, Kagaru	459	5:34
DD28	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Bromelton, Kagaru	448	5:26
DD29	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Bromelton, Kagaru	478	5:58
DD30	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Bromelton, Kagaru	466	5:50
DD31	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Bromelton, Kagaru	467	5:41
DD32	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Bromelton, Kagaru	456	5:33
DD33	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Bromelton, Kagaru	467	5:41
DD34	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Bromelton, Kagaru	456	5:33
DD35	Moree North (Camurra) to Acacia Ridge via North Star, Boggabilla, Kildonan, Yelarbon, Inglewood, Warwick, Bromelton, Kagaru	456	5:42
DD36	Moree North (Camurra) to Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Bromelton, Kagaru	444	5:34

5.4.8 Comparative routes

Two routes have been chosen to demonstrate the differing engineering features of this area, shown in Figure 5-32:

- via Warwick, and
- via Toowoomba
- Both routes cross the Great Dividing Range and require tunnels and/or viaducts.

Profiles have been developed to demonstrate the differing terrain these routes traverse. These are provided in Figure 5-33.

.

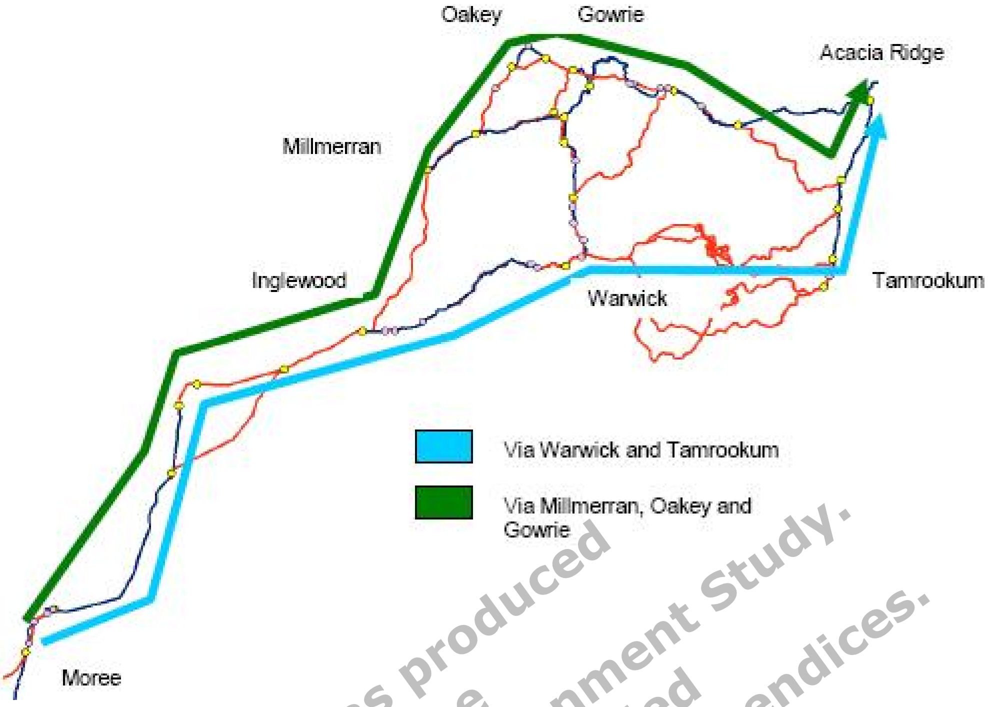


Figure 5-32 Moree to Brisbane plan

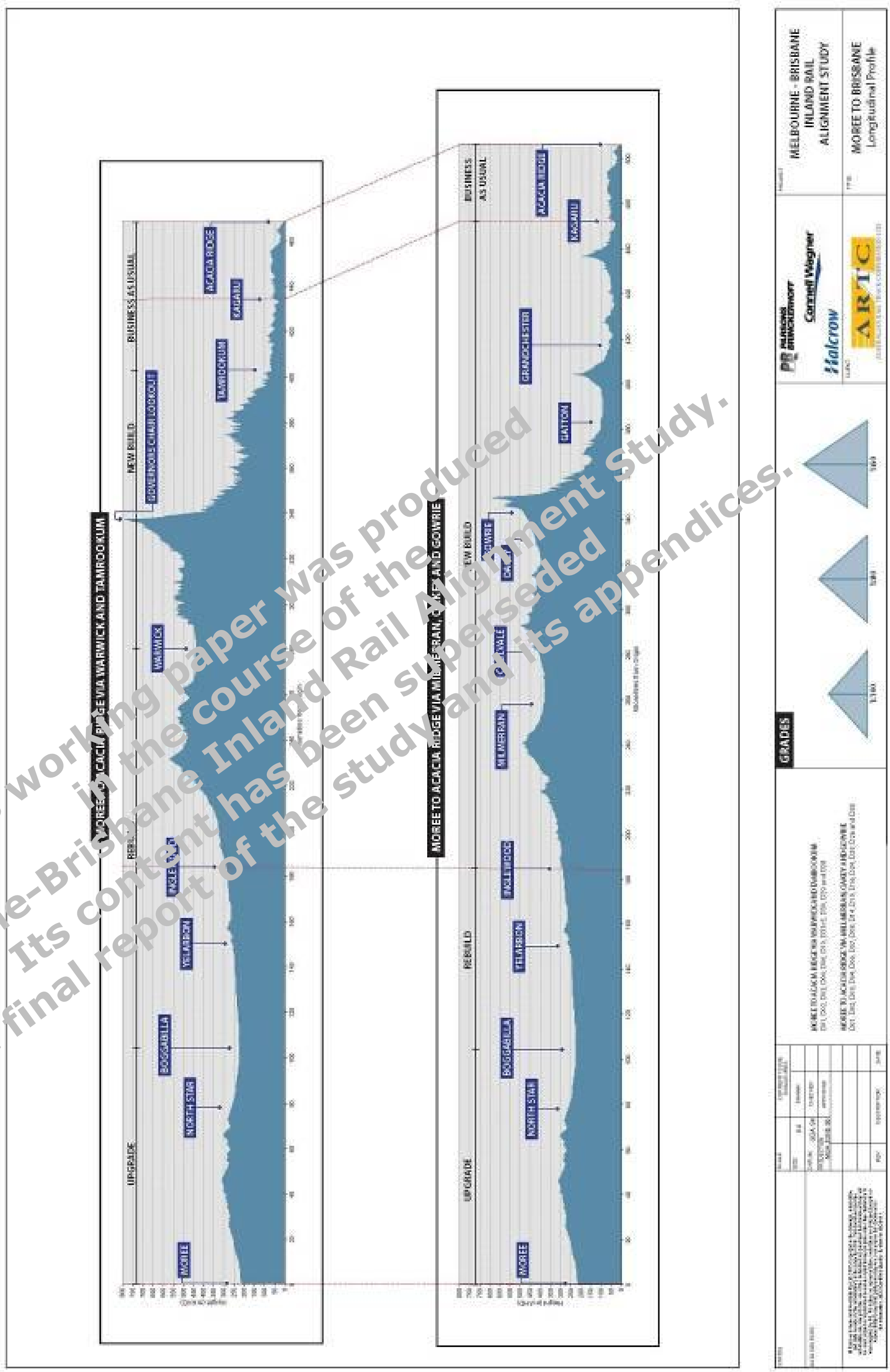


Figure 5-33 Illustrative profiles, Moree to Brisbane

Appendix A

Glossary

ABS	Australian Bureau of Statistics
AC traction	Alternating Current traction motors; used in newer diesel-electric locomotives
ACCC	Australian Competition and Consumer Commission
alignment	The exact positioning of track; may be compared with 'route', which gives only a very general indication of the location of a railway
ARA	Australasian Railway Association
area route	For the purposes of the study, a route over an entire area, i.e. areas A, B, C or D
ARTC	Australian Rail Track Corporation
articulated wagons	Wagons comprising two or more units, with adjacent ends of individual units being supported on a common bogie and permanently coupled
AS 4292	Australian Standard for Railway Safety in six parts 1995-97
ATC	Australian Transport Council
ATEC	Australian Transport and Energy Corridor Ltd
ATMS	Advanced Train Management System; communication-based safeworking system currently being developed by ARTC
ATSB	Australian Transport Safety Bureau
axle load	The load transmitted to the track by two wheels of one axle of a bogie
backhaul	Returning wagons to a point where they can be used for their next assignment; freight moving in the opposite direction to the main flow
BAH	Booz Allen Hamilton (now Booz & Co)
bank engine	locomotive used to assist a train on part of its journey, typically to climb a steep grade; such grades are termed 'banks' in railway parlance
BAU	Business As Usual
BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
BITRE	Bureau of Infrastructure, Transport and Regional Economics (formerly BTRE and BTE)
bogie	two axles and a sub-frame under each end of a wagon
BOOT	Build, Own, Operate, Transfer
break of gauge	Where a line of one track gauge meets a line of a different track gauge.
broad gauge	Railway track gauge of 1600 mm; used in Victoria except on interstate main lines and some other lines
BTE	Bureau of Transport Economics; now the BITRE
BTRE	Bureau of Transport and Regional Economics; now the BITRE
cant	Difference in the height of two rails comprising the railway track; cant may also be described as superelevation. It allows a train to travel through a curve at a speed higher than otherwise. Camber on the curve of a road has a similar function.
capex	capital expenditure
CCM	Capital cost model
coastal route	The existing rail route from Melbourne to Brisbane via Sydney
corridor	A strip of land with a width measured in kilometres that is suitable for a railway. Study of a corridor leads to the identification of route options.
CountryLink	CountryLink is part of the Rail Corporation of New South Wales (RailCorp). It operates passenger trains from Sydney to Melbourne, Sydney to Brisbane and to NSW regional centres.
CPI	Consumer Price Index
CSO	Community Service Obligation

DBFM	Design, Build, Finance, Maintain
DC	Direct Current; form of electric traction
DIRN	Defined Interstate Rail Network
distributed locomotives	The practice of providing additional locomotive power within or at the rear of a train as well as in front.
DITRDLG	Australian Government Department of Infrastructure, Transport, Regional Development and Local Government
DMU	Diesel multiple-unit passenger train
DORC	Depreciated Optimised Replacement Cost
double stacking	Placement of one intermodal freight container on top of another in a specially designed well-wagon
EBITDA	Earnings before Interest, Tax, Depreciation and Amortisation
EIA	United States Energy Information Administration
EIRR	Economic Internal Rate of Return
energy efficiency	Ratio of the transport task to the energy input; a measure of energy efficiency is tonne/km per MegaJoule (MJ)
energy intensity	Ratio of energy input to transport task; the inverse of energy efficiency; a measure of energy intensity is MJ/net tonne/km
FEC	Financial and Economic Consultant for the Melbourne-Brisbane Inland Rail Alignment Study, i.e. PricewaterhouseCoopers with ACIL Tasman and SAHA
five-pack wagon	Five wagons operated as one, either through being permanently coupled or the use of articulation
fuel consumption	Measured in litres per gross tonne kilometre (litres/gtk) or sometimes litres per 1,000 gross tonne kilometre (litres/1,000 gtk); sometimes net tonnes are used instead of gross tonnes
GATR	Great Australian Trunk Rail System
GDP	Gross Domestic Product
GIS	Geographic Information System
gross	Total mass of a wagon and its payload
GST	Goods and Services Tax
gtk	Gross tonne kilometres; a standard measure of track usage; the gross weight of a train multiplied by kilometres travelled.
hr	hour
IA	Infrastructure Australia
IEA	International Energy Agency
IGA	Intergovernmental Agreement (1997) between the Commonwealth, NSW, Victoria, Queensland, Western Australia and South Australia which led to the establishment of ARTC
IPART	NSW Independent Pricing and Regulatory Tribunal
IRR	Internal Rate of Return
kg	kilogram(s)
kg/m	kilograms per metre
km	kilometre(s)
km/h	kilometres per hour
kW	kilowatt, a unit of power
L	Litre(s)
L/gtk*1000	Fuel consumption expressed in litres per gross tonne kilometre x 1000
land-bridging	Replacement of sea transport with land transport between two sea ports, e.g. between Brisbane and Melbourne.
LEP	Local Environmental Plan

Line sector	In the context of the study, a length of line connecting two nodal points.
loading gauge	the maximum permissible height and width dimensions for a rail vehicle and its load; see structure gauge
LTC	Lead Technical Consultant for the Melbourne-Brisbane Inland Rail Alignment Study, i.e. Parsons Brinckerhoff with Connell Wagner and Halcrow
mass	The mass of an object is measured in kilograms; mass and weight are used interchangeably in the study
M-B	Melbourne-Brisbane
MIMS	Maintenance Integrated Management System
MJ	MegaJoule: a unit of both energy and work
mm	millimetre(s)
MPM	Major Periodic Maintenance; planned maintenance on infrastructure assets at intervals of more than once a year.
mt	million tonnes
mt pa	million tonnes per annum
narrow gauge	Railway track gauge of 1067 mm; used in Queensland except on the interstate line from Sydney to Brisbane
NCOP	National Code of Practice
node	In the context of the study, a point at which alternative routes diverge.
NPV	Net Present Value
NPVI	Ratio of Net Present Value to Investment Costs (ie capital costs)
NSRCS	North-South Rail Corridor Study completed in 2006
NSW	New South Wales
ntk	net tonne kilometres; the payload of a train multiplied by kilometres travelled
opex	operating expenses
payload	Weight of products and containers carried on wagons
PB	Parsons Brinckerhoff, Lead Technical Consultant
PwC	PricewaterhouseCoopers, Financial and Economic Consultant
Qld	Queensland
QR	Queensland Rail, a corporation owned by the Queensland Government
RailCorp	RailCorp (Rail Corporation of NSW); owns rail track in the Greater Sydney region, operates passenger trains in that region and (under the name CountryLink) to Melbourne and Brisbane and regional NSW.
RAMS	Rail Access Management System; manages and records access to ARTC track; RAMS is licensed to other track owners.
RCRM	Routine Corrective and Reactive Maintenance; comprises maintenance, inspections and unplanned minor maintenance that is carried out annually or at more frequent cycles
Reference train	A notional train specification used in developing the Inland Rail Alignment
RIC	Rail Infrastructure Corporation, NSW, owner of NSW rail network other than metropolitan sections owned by RailCorp. Interstate track and certain other sections are leased to ARTC.
RL	Stands for reduced level in surveying terminology; elevation relative to a specific datum point
RoA	Return on Assets
route	In the context of the study, primary description of the path which a railway will follow.
RTA	Roads and Traffic Authority - various states
SA	South Australia

safeworking	Signalling system and associated rules that keep trains a safe distance apart
SKM	Sinclair Knight Merz
SNP	Short North Project; capacity increases for freight currently being planned for the railway between Strathfield and Broadmeadow; 'short north' refers to the railway between Sydney and Newcastle.
SPV	Special Purpose Vehicle established for the development and/or the operation of a project.
SSFL	Southern Sydney Freight Line; independent track for use by freight trains between Macarthur and Chullora, currently under construction
standard gauge	Railway track gauge of 1435 mm; used on the ARTC network and for the NSW railway system
structure gauge	Specification for the position of structures such as overhead bridges, tunnels, platform, etc, relative to a railway track, to allow adequate clearance for the passage of trains.
superfreighter	Term used to describe high-priority intermodal freight trains
tal	tonnes axle load
tare	Weight of an empty wagon
TCI	Track Condition Index; TCI is an indicator of the condition of track by compilation of a number of measures of its geometry
TEU	Twenty-foot Equivalent Unit, the standard unit measure of shipping container size
t pa	tonnes per annum
train kilometre	A standard measure of track usage; number of trains multiplied by the total kilometres travelled
TSR	Temporary Speed Restriction
TTM	Train Transit Manager
Vic	Victoria
VicTrack	VicTrack, owner of Victoria's rail network; interstate track and certain other lines are leased to ARTC
VOC	Vehicle Operating Cost
WA	Western Australia
well-wagon	A wagon where the central loading deck is lower than the bogies at either end to allow higher loads to be carried within the loading gauge
WP	Working Paper
WTT	Working Timetable

Appendix B

Methodology details

Methodology details

Information presented below is intended to provide greater detail regarding the LTC's approach to Stage 1 for Working Paper 2 by outlining:

- the technical expertise applied
- the data prepared and used by the team
- the assumed infrastructure elements and their application.

Process

Quantitative outputs generated by the LTC team for Stage 1 Working Papers 2, 3 and 4 were contributed to by the following experts:

- cost planners — capital costs (capex)
- train modeller — travel time
- train operations — operating costs (opex)
- track maintenance — maintenance
- environmental scientists — alignment impacts.

These outputs were based on alternative route study section alignments generated from sources discussed in Section 2 and nominal designs prepared by the LTC's engineering team.

Teams dedicated to a single study area reviewed the route study sections and became familiar with the territory within their study area. These teams were supported by Technical Leaders who provided consistency of approach and assumptions for engineering issues common across the study. Technical Leaders were appointed to the following engineering specialities:

- track
- hydrology
- geotechnics
- structures.

The LTC team used geographical information systems (GIS) as an analysis tool and information hub. Figure B1 outlines the means of interaction across the team, GIS and the application of existing and new data.

Quantitative outputs were prepared to **a degree of accuracy appropriate for the comparison of alternative route study sections**. In particular, it was agreed that capex would be based on high level quantities that differentiated the characteristics of each alternative. To achieve this, assumed or 'sample' designs for a range of infrastructure elements were prepared for the cost planners to estimate unit rates for this study. Also in parallel, application rules for each of the 'samples' (based on the information available in GIS) were prepared by the engineering team to allow GIS to quantify infrastructure elements for each route study section. These quantities were then forwarded to the cost planner for determination of the capex for each route study section. Details of these infrastructure elements, their 'sample' design and application rules are discussed in more detail below.

It was envisaged that the cost and train performance data would be combined for the economic and financial consultant's evaluation and to identify the preferred route.

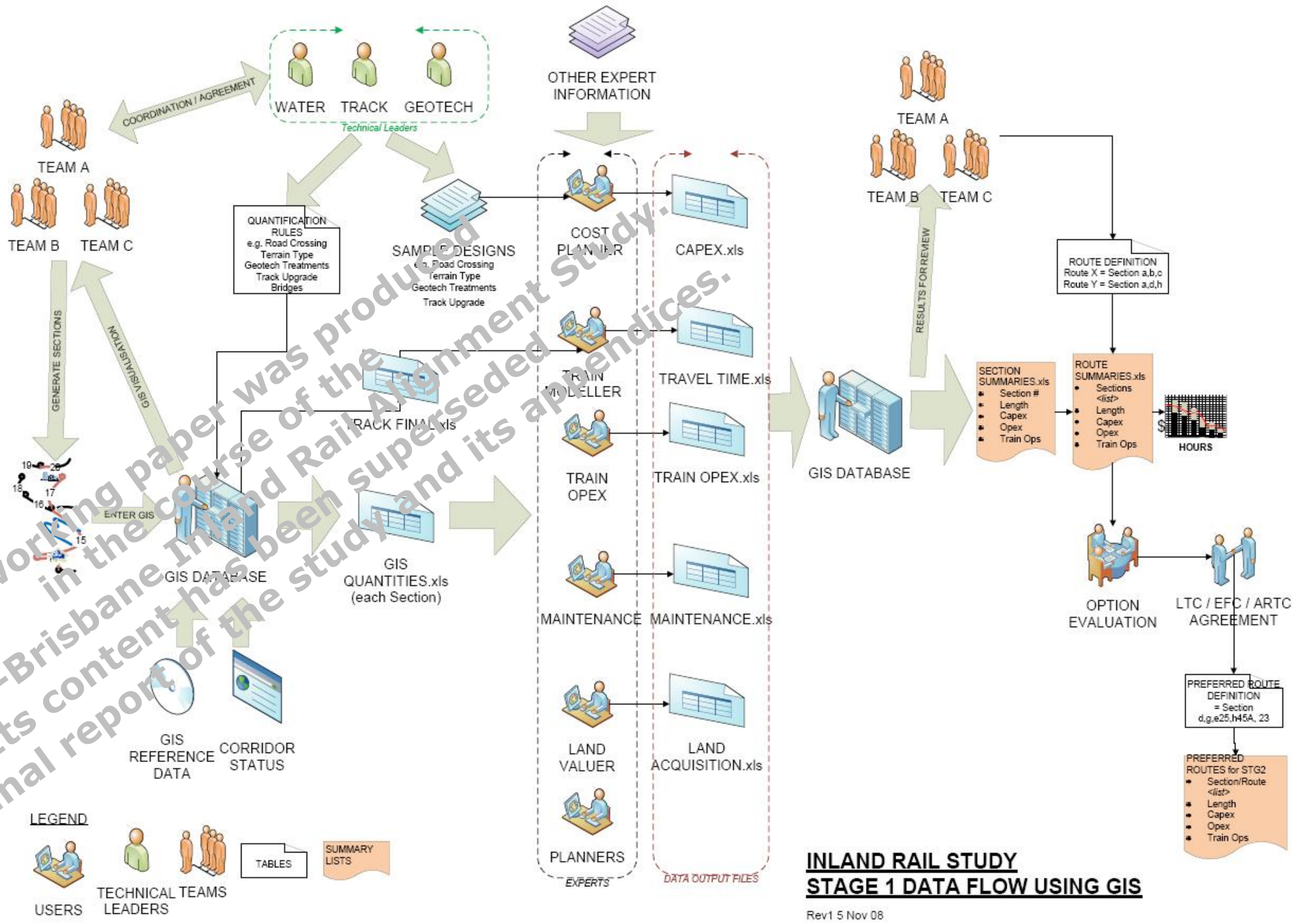


Figure B1 –Inland Rail Study: Stage 1 data flow using GIS

Infrastructure elements

A more detailed description of the assumptions, allowances and application of infrastructure elements for an inland rail follows.

Track and associated works

For the purposes of this study, track is considered to include rail, sleepers and ballast. Track issues relevant to this study needed to include the status of existing track, configuration of the final track and track works required to provide the final track configuration.

The status of existing track was derived from several below-rail track asset owners. Each existing track was classified and mapped in GIS as either: Class 1XC; Class 1C; Class 2; Class 3; Class 4; abandoned; broad gauge (Victoria); narrow gauge (Queensland).

Table B–1 outlines the track configuration assumed for a new railway. Table B–2 outlines the works assumed to be necessary for new or upgraded track and associated support infrastructure, to achieve the final track configuration.

GIS was used to quantify the extent of track and works required for each route study section. The track team prepared details of each final track configuration and a brief scope of works for the cost planners to estimate unit rates for the work.

Axle load limitations and speed restrictions on existing track were not considered in Stage1.

Table B1 Track configuration

Issue	Assumed configuration
Track gauge	Standard (Upgrade existing narrow gauge to dual gauge)
Track capacity and class	Existing track and bridges 21.5 t axle load min. at 115 km/h, i.e. no upgrade for Classes 2, 1C, 1XC New track (greenfields or upgraded) Class 1C 25 t axle load min. at 115 km/h, i.e. upgrade Classes 3, 4 and 5 to Class 1C. New bridges (greenfields or upgraded) 32.5 T min. at 115 km/h
Structure outline	New track 7.1 m high x 5 m wide (double stack profile)

▪

Table B2: Track works and support infrastructure

Type of works	Applied To	Activities	Bridges	Road crossings
New track construction	Greenfields (outside existing rail corridors)	— Greenfields earthworks — New single track	New	New
Track upgrade	Existing Classes 3, 4, 5 and abandoned, and broad gauge	— Remove existing track — Formation rejuvenation — New track	Replace all existing	Replace all existing
	Existing narrow gauge	— Remove existing track — Formation rejuvenation — New dual gauge track	Replace all existing	Replace all existing

Refer to sections below for further discussion regarding viaducts, tunnels, water and road crossings.

New turnouts would be required for loops on new track, and for replacement of existing turnouts on track to be upgraded. Information regarding existing turnouts was not readily available. The quantity and cost of new turnouts were derived by GIS.

Terrain and earthworks

The type of terrain, or variability of slope and elevation, has a significant effect on track alignment and earthworks that support a track alignment. Thus flat country with little variation will present less demand for significant cut and fill earthworks. Alternatively, very hilly country will require significant cut and fill quantities as the alignment searches for the best route as it reconciles maximum track grade criteria with the steeper terrain. In other words, the degree of cut and fill volume is affected by the local variability of the terrain.

Given the number of the alternative route study sections and poor quality of contour information it was not feasible to generate actual estimates of earthworks quantities using three-dimensional design tools. However, using elevation data (with an equivalent accuracy of 5 m contours) it was possible to categorise terrain into five types that included: flat; rolling undulating; hilly; and mountainous

This was done by identifying the terrain category for each 25 m x 25 m square across the whole study area. A standard deviation for elevation values for each square was calculated in GIS by sampling all other squares in the 250 m x 250 m surrounding area.

Standard deviation is a measure of variability and therefore in this application, represents the local variability of terrain. As a result, terrain was categorised in bands of standard deviation of elevation data. These resulting terrain categories were mapped in GIS. A comparison of mapped terrain categories and the density of overlaid plan contours indicated a consistency and therefore general validity of the terrain categorisation process.

Figure B–2 is an example of a region of the sample design showing categorised terrain and the sample alignment (note that this sample area is outside the study area).

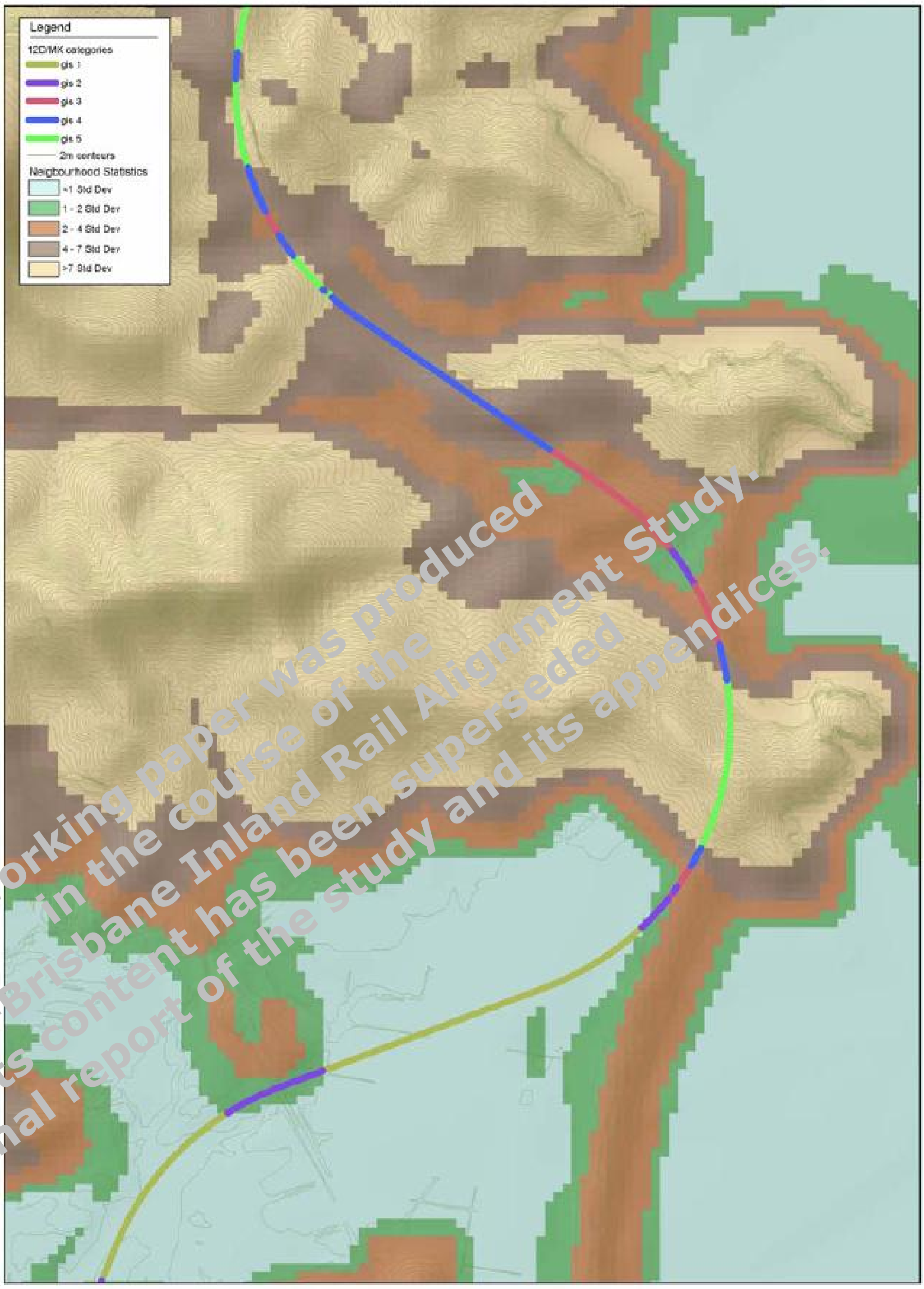


Figure B2–Sample design for terrain categories

Earthworks unit cost rates per kilometre were prepared by the cost planners for each of the five terrain categories based on sample designs prepared by the engineering team. Sample alignments were designed through a range of typical terrains and were documented in a traditional concept design format that included details that effect cost and quantities.

GIS was used to quantify the extent of each terrain category encountered by each route study section. The cost planners then applied these quantities against the earthworks unit rates to determine a total cost for earthworks for each route study section.

Earthworks costs were required only for new alignments outside existing railway corridors and did not include sections that would be treated with tunnels, viaducts or floodplain embankments.

Water crossings

Water crossings were assumed to consist of either:

- single watercourses
- floodplains
- minor random flow paths.

Infrastructure elements applied for each type of water crossing included:

- bridges (five types of different lengths) for major watercourses
- single culverts for minor watercourses
- culverts with raised embankments for floodplains (100 m of waterway per km of floodplain)
- number of culverts per km for minor random flow paths.

The application and quantity of various infrastructure elements for watercourses was calculated by GIS based on the upstream watercourse length that was provided in the GIS reference geo-database information. Sample designs for infrastructure elements were prepared by the engineering team and forwarded to the Cost Planner for estimation of unit rates.

Road crossings

A new freight railway will impinge significantly on road crossings whether they are on existing or new track. There are a range of road crossings types that require a variety of solutions depending on road traffic volumes and surrounding environment. The treatment of a road crossing was determined for cost purposes by the track team, which is practised in the principles of level-crossing assessment. A high-level regime of typical road crossing treatments was prepared for the range of existing road types that are mapped in GIS. Table B–3 provides a summary of the road crossing treatments and their application to GIS road types.

As noted in Table B–3, this study has assumed that level crossings will continue to be a valid solution at the intersection of a new railway and less significant road types. It must be emphasised that the above treatments have been prepared for cost and comparative purposes only and that the actual application of road-crossing treatments would be subject to an extensive risk assessment.

The modern desire to improve safety at level crossings is likely to result in the closure of some roads. An allowance has been made for this by reducing level crossing costs 10%.

The Stage 1 assessment has made the broad assumption that the existing level crossings on existing track will require an upgrade only if the track is to be upgraded. This has been necessary due to limited availability of information regarding existing level crossings.

No allowance has been made, at this time, for additional crossings that may be required for miscellaneous situations, such as crossings for stock routes or for severed property access.

Table B3: Road crossing categories and road types

Road crossing category	Road crossing description	GIS road type application
Grade separation — major	Four lane road overbridge with approach ramps	Freeway
Grade separation — minor	Two lane road overbridge with approach ramps	Highway Arterial
Grade separation — pedestrian	not used	not used
1A	Give way Signs	Track; 2-wheel drive Track; 4-wheel drive
1B	Give way signs + approach warning signs	not used
2	Stop signs	Urban service lane
3A	Flashing lights + bells	Local
3B	Flashing lights + bells + boom barriers	Sub-arterial Collector road Dedicated bus way
3C	Special warning lights	Private or restricted
4	Level crossing gates	not used
5A	Manual control	not used
5B	Special control	Access way
P1	Signs only	not used
P2	Signs + pedestrian maze	Paths
P3	Signs + lights + alarms	Paths
P4	Signs + lights + alarms + boom barriers or Swing Gates	not used
P5	Special control	not used

The track team prepared sample designs for level crossing and the structures team prepared grade separations. The sample designs were forwarded to the cost planner to estimate unit costs. GIS was used to identify road crossing categories at the intersection of the proposed track alignment and existing roads. GIS then quantified these road crossings for each route study section, which were then forwarded to the cost planner.

Other structures

Tunnels

There are several instances in which tunnelled alignments were considered in this study. It must be emphasised that details of tunnels, and their subsequent cost, ranges significantly depending on the ground conditions, tunnel length, fire and life safety principles and grade applied. Tunnel costings were derived from estimations prepared in the Liverpool Range Study (2006). A brief comparison of tunnel requirements with this Inland Rail Study confirmed that the Liverpool Range Study tunnel was suitable for Stage 1 comparative purposes, subject to a few minor adjustments.

The configuration of new tunnels for an inland rail was assumed to be:

- 68m^2 cross-section, horseshoe shape, which catered for single track, a double stacking structure gauge and a walkway
- a ballasted track system
- longitudinal ventilation provided by a system of jet fans (resulting in a purge time in the order of 30 minutes)
- a bolted and shotcrete-lined structure that is effectively free draining, based on basalt/volcanic type rock ground conditions
- emergency egress was assumed to self-rescue by the crew supported by ventilation control of potentially hazardous smoke (i.e. isolated escape passage for fire and life safety purposes have not been allowed for at this time).

Potential tunnels identified in the study ranged between 150 m to over 10 km. As mentioned above, tunnel length affects tunnel configuration and cost. Longer tunnels can often result in additional infrastructure to satisfy ventilation, fire and life safety and construction efficiency requirements with the provision of elements such as vertical shafts and fan stations. On the other hand, shorter tunnels can have a higher cost per metre due to the establishment costs. It is understood that a single rate per metre was applied by the cost planner that would generally account for long and short tunnels.

Further development of tunnel solutions will require a preliminary fire and life safety assessment for the project.

Tunnels were mapped in GIS and their length was quantified for the cost planner. The quantities for earthworks and geotechnical treatments were accordingly deducted.

Viaducts

Viaducts have been identified as potential solutions for alignments in hilly terrain, which are in addition to bridges required for water and road crossings. Typically, these structures are much longer and have a higher cost rate per metre. A ‘sample’ design was prepared based on a viaduct that was 200 m long and 60 m high and built using balanced cantilever techniques.

Tunnels were mapped in GIS and their length was quantified for the cost planner. The quantities for earthworks and geotechnical treatments were accordingly deducted.

Platforms and turnouts

Quantities were not developed for:

- modifications to platform structures that might be affected by the revised structure gauge
- for freight
- new turnouts for new or upgraded track
- modification to bridges to accommodate double stacking where the track would not be upgraded (e.g. over bridges on the main south, south of Albury).

Geotechnics

The underlying geology of the study route sections is likely to have significant influence on the cost of the project (e.g. due to earthworks, stabilisation and various ground treatments), and is related to the terrain categories (as previously discussed). The geological influences assessment completed for Stage 1 comparative purposes was generally based on geological maps at 1:250,000 scale. A common range of simplified but study-specific geological units were developed and matched to the lithology provided on individual geological maps. Geological map lithology was available and translated into geological units in GIS. The study-specific geological units were:

- hard rock
- soft rock
- soil–swamp
- soil–Aeolian
- soil–soil
- soil–gilgaid/black.

Geotechnical treatments were developed for a matrix of geological units and terrain categories. Treatments were selected based on average cut or fill heights within the terrain category, and the engineering judgement of the geotechnical team. In each case the treatment was defined in four steps that, where required, included:

- site preparation (FSP)
- fill batter and compaction (FB)
- excavation conditions (EC)
- excavation batter (EB.)
-

Details of geotechnical treatment were forwarded to the cost planner for development of unit rates. GIS was used to quantify the extent of geotechnical treatments for each section.

Track curves

The extent of track curves was required for train operation energy and fuel consumption calculations. Each route study section alignment was mapped with sufficient information to identify the size and number of track curves. GIS was then used to categorise and quantify track curves into the following groups:

- <300 m radius
- 300–500 m radius
- 500–800 m radius
- 800 m–1,000 m radius.

Noise impact

It is likely that a new freight line, even if running in existing rail corridors, will have unacceptable impacts on some existing dwellings. Accordingly, noise mitigation measures and possible dwelling acquisition would be required.

An allowance for mitigation of noise in urban areas, where the track was being upgraded, was made based on an assumed 4 m-high, double noise wall system. GIS quantities were calculated using reference geo-database information for the cost planner.

Noise mitigations for residence outside urban areas could not be appropriately quantified at this time and are not included in quantities in Stage 1 estimates.

Appendix C

Rail operational details

Railway operations

Introduction

Optimising the operational aspects of the inland railway involves the interaction between demand; locomotive power, train mass, axle loads, length and maximum speed; and track ruling gradient and curves.

Demand on this route is not expected to outstrip the possible supply of available paths on a single line, so maximising payload in order to minimise the number of trains required is not considered a determining feature of the train design. For the infrastructure, the capacity to carry enough trains will be considered in later stages of the project. In Stage 1, it has been assumed that a single track railway with passing loops will be able to carry all likely tonnages.

Reference train

To provide a base from which to inform infrastructure design, a reference train was considered, to help clarify the likely characteristics of the railway operations.

The *ARTC Train Operating Conditions Manual, 2004* (the *TOC Manual*) details the process for calculating the effect of different locomotives, rollingstock and loads on speed and trailing load, and the restrictions imposed by infrastructure. It was used to estimate the likely make-up of the train, along with technical data relating to the performance of 3,220 kW AC locomotives and typical wagons.

Length

The ARTC's 2008–2024 Interstate and Hunter Valley Rail Infrastructure Strategy submission to Infrastructure Australia states that ARTC would like to see the East–West corridor enhanced so that 1,800 m-long trains can operate between Adelaide and Melbourne. It is therefore reasonable to plan for the inland railway to cater for 1,800 m-long trains to operate over its full length, bringing the network benefits of linking Melbourne and Brisbane to the existing 1,800 m-long train system.

Containers

Because the inland railway is being designed mainly to carry intermodal shipping container traffic, the reference case train is a container wagon train. Some bulk products are carried in containers on this corridor, notably grain and ores, but this study is using the through intermodal traffic between Melbourne and Brisbane as the determining traffic for infrastructure design purposes.

Container loads are measured in Twenty Foot Equivalent Units (TEU), the standard modular length of typical containers. The most common container is 40 foot, or two TEU. They are usually loaded by customers based on individual orders, rather than shippers concerned with maximising loads, and this often leads to a relatively low weight per TEU, often 9 to 10 t per TEU. Although international container traffic is often loaded to 12 or 13 t per TEU, the traffic on the inland railway is expected to be mainly domestic freight. An average of 10 t per TEU has been used for this study.

Locomotives

Locomotives are the major capital expense for a train operator, and because their maintenance costs are a significant operating expense, train operators will wish to maximise the efficient operation of their locomotives.

This study has assumed that the latest AC traction diesel locomotives will be used on the line. This is based on the current trend towards these locomotives on interstate intermodal traffic, and the likelihood future developments in locomotive design will be towards greater fuel efficiency and technology that will better match power output to train and route characteristics, rather than more powerful locomotives.

It is assumed that for these very long distance, single track routes train operators will tend to use a minimum of two locomotives (double heading), as ‘insurance’ against technical defects that might stop a single-headed train, delaying traffic and possibly blocking the line while assistance is arranged.

The reference case traction power available is similar to the latest GT46C ACe locomotive. A train would have a minimum of two 3,220 kW AC drive locomotives weighing 134 t, with an axle load of 22.3 t that is capable of operating at 80 km/h on a nominal 21 t axle load lines. These locomotives have a maximum speed of over 115 km/h, and can deliver 500 kN at 20 km/h. These locomotives are restricted to 115 km/h on Class 1 lines, and 80 km/h on Class 2 lines.

These locomotives can be electronically ‘de-rated’, so that power output and fuel consumption can be matched to the demands of a particular train load and route. This supports the assumption that train operators will prefer to provide three locomotives, even if the power is not fully used, because it will be possible to ‘turn down’ surplus power rather than waste fuel by providing excess power. In the previous generation of locomotives, the engines were either turned on or off whilst in motion, or could be more finely adjusted for power output only while stationary.

These locomotives would not require any maintenance en route. Minor maintenance may take place at terminals, although this is not considered by this study.

Wagons

The reference train is an entirely container wagon train.

A typical wagon is 25.75 m long and weighs 22 t. It can carry four TEU with a payload of up to 70 t and thus 92 t gross with the ability to run at 115 km/h with an axle load of 23 t. Currently these wagons are restricted by the track class, and can only run at 115 km/h on Class 1 track with an axle load of 19 t, 100 km/h at 21 t axle load, and 80 km/h at 23 t axle load.

A train capable of carrying the maximum number of TEU within 1,800 m (minus two locomotive lengths) would therefore be 68 wagons with a carrying capacity of 272 TEU, averaging 2,720 t payload (at 10 t per TEU) and 4,215 t gross.

The TOC manual suggests that a single stack train fully loaded with average weight containers is too heavy for two 3,220 kW AC locomotives to meet the superfreighter (A2) train timings between Junee and Sydney, a hilly section of the existing coastal route, which would limit loads to 3,640 t gross. Three locomotives would be able to haul this load, as they would have the capacity for 5,460 t gross at these speeds.

Double stacking

The 2008–24 Interstate and Hunter Valley Rail infrastructure Strategy also suggests that double stacking between Melbourne and Sydney, and Parkes and Sydney, is a desirable goal within the 15-year period covered by the strategy. This suggests that double stack operation on the inland railway will bring some network benefits by the time it is built. Our base case assumes that double stacking is catered for between Parkes and Brisbane from the opening of the inland railway, and that trains are loaded as if double stacked over the full length of the line.

The benefits of double stacking have been considered by ARTC as being a cost saving of 1.5–4% of train operating cost.

Double stacking is currently achieved on the East West corridor using five unit (five-pack) bogie well wagons, typically 105 m in length and weighing 100 t tare weight. They are capable of carrying 20 TEU weighing up to 320 t and thus 420 t gross. Currently these wagons are restricted by track class, and can only run on Class 1 track at 115 km/h with an axle load of 19 t, 100 km/h at 21 t axle load, and 80 km/h at 23 t axle load.

One of the challenges of double stacking is that restrictions on how the different sizes and weights of containers are safely loaded typically result in only 40% of the length of a typical train actually being loaded double stacked. If a train consisted of 40% double-stack capable bogie well wagons, the train might comprise:

- three locomotives; 66 m in length total.
- 60% flat wagons; 38 flat wagons, 978.5 m total length, carrying 152 TEU.
- 40% double-stack well wagons, seven five-pack bogie well wagons, 735 m total length, carrying 140 TEU double stacked.

The total carrying capacity of this train would be 292 TEU, thus averaging a payload of 2,920 t and a trailing load of 4,456 t gross. Three locomotives would be able to haul this load, as they would have the capacity for 5,460 t gross at current superfreighter speeds on the hilly Junee–Sydney section.

Although this is based on an average load 10 t per TEU, not the maximum, it is based on a fully loaded train. Studies have shown that intermodal trains on the existing coastal corridor are not always fully loaded.

Given the development of locomotives whose fuel consumption can be matched to required power, and the desire to provide a reliable service, it is expected that train operators will use three locomotives per train for both single and double stack services.

Train axle loads

A typical wagon capable of carrying 4 TEU weighs 22 t tare, and within an axle load of 21 t could carry 15.5 t per TEU. Although this exceeds typical current domestic load densities, the cost of transport generally can be expected to rise, driving increased efficiencies in the supply chain, such as higher loading densities. This figure could become a constraint on loading even average loads in the future; 23 t axle loads would enable the same wagon to carry 17.5 t per TEU, whilst 25 t axle loads would enable the wagon to carry 19.5 t per TEU. The latter would suggest a near doubling of current loading density, to levels above that found in international shipping containers, and is considered less likely to occur. Current track standards restrict train speeds as axle loads increase, typically 100 km/h with 23 t axle loads and 80 km/h with 25 t axle loads.

An axle load of 23 t would allow existing typical single stack wagons to be loaded to their maximum 70 t payload, achieving an average of 17.5 t per TEU. This would mean a train 1,800 m long of three locomotives could haul 67 wagons with a maximum total payload of 4690 t and a maximum trailing load of 6164 t gross. This exceeds the typical loads allowed for superfreighters at 115 km/h on the hilly Junee to Sydney section of the existing coastal route, but would efficiently use the estimated 6,300 t haulage capacity that three 3,220 kW AC locomotives would have if operating at 100 km/h. This suggests that a typical single stack train could take full advantage of a 23 t axle load.

Double stacking requires the use of well wagons, where the bottom container is lowered into a well between the bogies. Because this creates more unproductive train length than on flat wagons there is pressure to use space saving articulated wagons, which share bogies between wagons, on double stack train services. This reduction in the number of axles per TEU carried means that double stack trains then have more axle load constraints than single stack ones.

The maximum load that the example 40% double stacked train with 292 TEU could carry, if limited only by an axle load of 23 t, would be a payload of 5,110 t and 6,624 t gross, assuming that vehicle tare weights can remain the same and that the increased axle load can be passed on to payload weight capacity gain. This load would require the use of four locomotives. With the present average weight of 10 t per TEU and bogie wagons, loading would in fact be limited by height and centre of gravity issues before axle load. However, higher axle loads should increase the percentage of a double stack capable train that is actually double stacked compared with current practice, because there can be greater use of articulated wagon sets, increasing the length of the train that can be loaded, and there will be greater flexibility over the weight distribution of the containers on each wagon.

If wagons with the same tare weights as existing ones but capable of carrying loads to take advantage of 25 t axle loads were developed, the potential double stack train would carry a payload of 5,764 t and weigh 7,300 t gross. This exceeds the ability of the current maximum of five locomotives allowed to haul trains, and so would require distributed locomotives. It seems unlikely that containers will load to the average of 19.75 t suggested by this maximum in the current market.

This suggests that a 23 t axle load is much more likely to be fully used by a typical double stack train than 25 t.

The low average weight per TEU of typical containers means that train operators are unlikely to be able to maximise the benefits available if axle loads were increased from 21 t to 23 t in the current market, but future increases in load densities will mean that 21 t axle loads become a constraint. For double stack trains, increasing axle loads from 21 t to 23 t will bring capacity benefits to operators, even at current loading densities, through greater use of articulated wagons with flexibility over double stacking.

The initial economic forecast indicates that the demand for intermodal container traffic between Melbourne and Brisbane is around 8 mt pa, of which 4.9 mt pa is from Melbourne to Brisbane. This level of traffic can be carried by six trains a day each way at 2 t axle load, and thus axle loads are not seen as a significant capacity constraint at an economic level.

The ability to convey 23 t axle load trains at a maximum speed of 115 km/h is operationally desirable, and should be considered during the infrastructure study.

Future axle load developments

The above analysis suggests that demand for 23 tal double stack trains travelling at 115km/h can be used at the moment, and that demand for 25 tal trains will exist if container load densities increase considerably. Infrastructure assets, particularly those that govern axle loads, have a very long lifespan and it may be economic to plan for traffic growth that is not currently foreseen.

The heaviest axle loads are the 30 tal used by loaded coal trains in the Hunter Valley, which are restricted to 60 km/h at these loadings. ARTC is considering the adoption of Association of American Railroads (AAR) infrastructure standards in the Hunter Valley, which cater for rollingstock with 32.5 tal. If combined with the use of AAR loading gauge, Australian train operators could purchase off-the-shelf American rollingstock. The size of the American market leads some train operators to believe this will reduce the cost of rollingstock in the Australian market. Train operators wish to see the adoption of AAR standards by ARTC, arguing that savings in rollingstock costs will outweigh the increased infrastructure costs, because the biggest ARTC clearance and axle load standards are now quite close to AAR ones.

Reference train

The reference train is hauled by three 3,220 kW AC drive locomotives. It is 1,800 m long, 40% double stacked and capable of 115 km/h on 21 t axle load track. It is assumed to be carrying 292 TEU weighing 2,920 t and have a trailing load of 4456 t gross. It is capable of meeting the fastest freight train timings over routes with gradients as steep as 1 in 40.

Future growth is expected to see a demand for wagons capable of running at 115 km/h with 23 t axle loads and this should be planned for.

Banking locomotives

Where the ruling gradients of a route are concentrated in one particular location, train operators may choose to use the optimum number of locomotives on a train for the majority of the journey, and attach extra ones only where the gradient requires it. Use of 'banking locomotives' is undesirable because it requires the trains to stop to attach and to detach them, and because banking locomotives spend a larger percentage of the day unproductive than train locomotives do. However, where the route is long, this method of working may be economic compared with having an overpowered train. It is currently used between Melbourne and Adelaide by trains to Perth, because of the steep gradients leaving Adelaide and the relatively gentle grades on the remainder of the route to Perth.

If the inland railway is built with a ruling gradient of 1 in 80 and for single stack trains, train operators may choose to use only two 3,220 kW locomotives and banking locomotives between, say Cootamundra and Melbourne. However, if there are also steep gradients out of Brisbane into the Toowoomba Ranges, it would seem more likely that train operators would use three locomotives for the entire journey, rather than employ banking locomotives at both ends of the route.

Ruling gradient

The steepest gradient that is long enough to limit the haulage capacity of the locomotives is the ruling gradient for a route. The inland railway is planned to carry intermodal traffic from Melbourne to Brisbane and so this is considered a single route. The previous study used a ruling gradient of 1 in 80 in planning new alignments. At present, there is a 20 km section of the Main South line in Victoria approaching Heathcote Junction, between Melbourne and Seymour, where gradients are around 1 in 50. This is the steepest prolonged section of standard gauge railway on the far western corridor that is common to all route options.

The Wagga Wagga to Junee section, which has 1 in 40 gradients, is also likely to be on the inland railway route.

The ARTC TOC manual, Section 1, Route Standards lists many route sections in the NSW portion of the far western corridor with gradients of 1 in 75, suggesting this would be the ruling gradient for trains even if engineering solutions are used to reduce the steepest gradients.

In Victoria, the ARTC Network Interface Co-ordination plan, Appendix XIII, Grades curve and gradient diagrams indicates many gradients steeper than 1 in 80 between Melbourne and Albury. In particular, the line rises for 20 km southbound with many gradients of 1 in 50 between Heathcote Junction and Seymour. At Glenrowan and Chiltern there are 3 km and 4 km sections of 1 in 75 rising in both directions.

The line over the Toowoomba ranges in Queensland provides steeper gradients on sharper curves for longer distances and is currently narrow gauge. The engineering solution required to provide a practical route is likely to require significant new alignments, and so these gradients are not assumed to be the ruling gradients for the study. In particular, the Queensland Government is looking to improve the Toowoomba range crossing and previous studies have identified routes with maximum gradients of 1 in 60 between Gowrie and Grandchester. There may also be alternatives via Warwick providing 1 in 80 and 1 in 100 ruling gradients.

The study will need to assess the impact on capacity and operating cost of using 1 in 50 as the ruling gradient, versus the capital cost of using an easier gradient. The chosen reference train is capable of maintaining timings over a route with gradients of 1 in 50.

Curvature

Curvature in the track increases the rolling resistance of the train, requiring more power to maintain speed than straight track. In addition, the wear forces on the wheels and rails increase as speeds increase, so curves are subject to speed restrictions. Cant, applied to reduce wheel/rail forces on curves, may also limit the maximum speed through curves. In general, curves with a radius of sharper than 800 m have an effect on line speed and rolling resistance.

Journey time

Average train speed

The previous NSRCS identified transit time between Melbourne and Brisbane (specifically 27 hours) as a significant factor in moving market share from road to rail transport. As a starting point, this study considered whether this desired transit time can be met using the existing rail corridor from Melbourne to Brisbane via Albury, Cootamundra, Parkes, Narromine, Binnaway, Werris Creek and Moree to North Star. A new railway will be required from North Star due to the use of narrow gauge in Queensland and the very steep and winding route of the existing line out of the Toowoomba ranges. If a single type of train were capable of making such a journey, travel time might be around 38½ hours, as estimated in the following table.

Table 1 Estimated journey time over current track

	km	Time h: m	Average speed
Current journey time South Dynon to Moree, by a train capable of 115 km/h but also axle load suitable for Class 2 track:	1399	25:05	56
Current journey time Moree to North Star, by a train with axle load suitable for Class 5 track:	93	1:57	48
50 km missing link from North Star to Goondiwindi. New railway at, say, 88 km/h:	50	0:34	88
Current journey time Goondiwindi to Roma Street by an 80 km/h narrow gauge freight train:	455	10:58	43
Totals	1997	38:34	52

Apart from the missing section of route and break of gauge between NSW and Queensland there would also be many constraints on a north–south service introduced by the configuration of track and signalling, which is based on the historic infrastructure and orientation of traffic flowing from inland to seaports rather than the north–south traffic proposed on the inland railway. In particular, the proposed route requires two reversals, at Binnaway and Werris Creek, and has 23 safe working stops, where trains must stop to obtain authority to proceed. Removing these constraints by building short cut-off lines deviations and installing modern signalling could save journey time:

Table 2 Estimated journey time with safe working time and reversals removed

	km	Time h: m	Average speed
Current journey time South Dynon to Moree, by a train capable of 115 km/h but also axle load suitable for Class 2 track:	1399	21:05	66
Current journey time Moree to North Star, by a train with axle load suitable for Class 5 track:	93	1:57	48
50 km missing link from North Star to Goondiwindi. New railway at, say, 88 km/h:	50	0:34	88
Current journey time Goondiwindi to Roma Street by an 80 km/h narrow gauge freight train:	455	10:58	43
Totals	1997	34:34	58

Journey time benchmarking exercise

A benchmarking exercise was carried out to establish the potential journey time improvements that might arise from upgrading the whole existing route to Class 1.

Sections of the existing Class 1 coastal route were studied to gain an understanding of the likely average speed of an intermodal train capable of a maximum speed of 115 km/h over different types of terrain, defined by curves and gradients. The sections chosen represented the most uniform characteristics of gradients and curves over long lengths, to clearly identify the effect those characteristics have on journey time. The timetable was also studied, to see what average speeds are currently being used on those sections for intermodal superfreighter trains. In this way, an understanding of the effect of terrain on the average speed of trains over railway that is all Class 1 and nominally capable of 115 km/h was gained. Three distinct route sections were identified.

The 366 km from Seymour to Junee. Although there are sections of up to 4 km at gradients of 1 in 50 and 1 in 60, and 2 km of curves down to 530 m radius outside Junee, it is generally defined as flat and straight. It has a 115 km/h maximum speed, but sectional run times and timetables show intermodal trains currently average 88 km/h.

The 207 km from Cootamundra to Goulburn is both hilly and curved. There are many gradients over 10 km long at up to 1 in 70, whilst there are sections of 1 in 50 and even 1 in 40. There are several kilometres of 400 m radius curves, several sections with curves sharper than 400 m radius and 5 km of 300 m radius curves. It has a 115 km/h maximum speed, but the non-stop intermodal train covers this section at an average 63 km/h.

The 262 km from Maitland to Wauchope has gentle gradients, but is almost continuously curved. Although there are several kilometres with gradients of 1 in 80, most of the sections are flatter than 1 in 200. Most curves are between 500 m and 300 m radius. It has a 115 km/h maximum speed, but the superfreighter timing, once stops are removed, averages 63 km/h.

It was not possible to identify a significant length of hilly railway without curves.

Two benchmarking speeds were thus chosen to represent likely average speeds if any part of the existing route was upgraded to Class 1 standard.

Relatively straight and flat sections were deemed capable of an average 88 km/h.

Sections that are hilly or curved or both were deemed capable of an average of 63 km/h.

The existing far western inland route curve and gradient diagrams were then studied to allocate existing routes to benchmarking types, and thus create notional running times if a superfreighter train could run over those routes and they had a speed profile similar to the existing coastal route.

Table 3 summarises the results of the journey time benchmarking exercise.

Table 3 Estimated journey time following benchmarking exercise

Actual and estimated journey time if all existing track is upgraded as per benchmarking exercise against existing 115 km/h Coastal route:	km	Time h: m	Average speed
South Dynon to Cootamundra, actual:	528	6:50	77
Cootamundra to North Star:	970	12:45	76
38 km missing link from North Star to Kurumbul. New Railway at, say, 88km/h:	38	0:25	88
Kildonan to Inglewood:	67	0:45	88
Inglewood to Kagaru via Toowoomba. New railway, possibly slower than 63 km/h:	335	5:19	63
Kagaru to Acacia Ridge, actual:	36	0:34	63
Totals	1974	26:38	74

The two existing sections of coastal route listed in the table above have maximum line speeds of 110 km/h and 115 km/h for superfreighter trains, whilst the average timetabled speed attained is 77 km/h and 81 km/h. This suggests that a maximum line speed of 115 km/h is necessary to achieve a timetable average of 80 km/h.

The benchmarking and journey time estimate used very large sections and does not therefore cover all local conditions, but rather provides a general assessment. In particular, the demanding terrain in the Toowoomba ranges is likely to result in average speeds lower than 63 km/h.

The purpose is to estimate whether the existing corridor has the potential to meet the demand for a journey time of 27 hours Melbourne–Brisbane. Although the exercise indicates potential for a non-stop 26½ hour journey, other time factors must be included.

Other journey time factors

Crossing time at passing loops

The majority of the inland railway will be single line, and passing loops for trains going in opposite directions will be required. Another comparison was made with the existing coastal corridor, the 777 km of single line between Maitland, at the extremities of the Sydney system, and Acacia Ridge, the Brisbane Intermodal terminal.

It was assumed that the inland railway intermodal Melbourne–Brisbane trains will have priority over all other traffic, and will only be stopped to cross other similar trains. This benchmarking exercise measured the time spent stationary by the four high priority Sydney–Brisbane intermodal trains when they cross each other. The timetable of these long intermodal trains on a Wednesday was analysed, and the number of minutes spent stationary in passing loops waiting to cross other superfreighter services was extracted.

Timetabled stops that were solely for safe working procedures (token exchanges) were excluded from the analysis. This reflects the expectation that safe working stops will not be required on the inland railway.

Table 4 Delays incurred by superfreighters crossing each other on the single line coastal route

Superfreighter train number	Crossing delay encountered
3BM2	Nil — does not cross another superfreighter.
3MB4	5 minutes
3MB7	5 minutes
3BM7	5 minutes
3BA6	28 minutes
3AB6	34 minutes
3BM4	1 hour 15 mins — crosses two superfreighters.
3MB2	2 hours 3 minutes
Four trains per day making eight crossing moves.	Average stationary crossing time 34 minutes.

When comparing the timings of crossing moves with non-stop timings, the time difference due to slowing to a stop and accelerating back-up to line speed must be added to the time spent standing. The TOC manual suggests three minutes should be added to sectional running times to account for this.

A graph of potential crossing movements on an inland railway carrying six trains per day suggests that each train might face between eight and 12 crosses on the single lines between Cootamundra and the Acacia Ridge, depending on the timetable used. An average of ten was used.

If the fastest existing train services have an average of 34 minutes standing and three minutes speed penalty when crossing one other superfreighter and an average of 10 crosses will be encountered on the inland railway, an average time penalty of six hours and 10 minutes is estimated.

This suggests that six hours and 10 minutes must be added to the high-level Melbourne–Brisbane journey time estimate to allow for crossing movements.

The accuracy of this estimate is low, since the type, timetable and frequency of traffic that the inland railway will carry is not known, nor is the location of passing loops. However, it is important that the journey time includes an allowance for crossing moves, as these are incurred in all scenarios.

Train crew depots

Train crew will need relief at least every 12 hours. Train operators have shown a strong desire to operate non-stop, as this maximises the utility of the rollingstock and crew, and on some east–west corridor operations the crew travel off-duty on the train. A crew living on board is unlikely to occur on the inland railway due to the unpopularity of shifts away from home, higher density of population, density of traffic and proximity to existing depots on the far western corridor. A train crew changeover can be achieved in a minimum of 10 minutes. As the timetabled journey time is over 24 hours, at least two crew changeovers will be needed. Train operators are likely to programme crew changeovers at less than 12-hourly intervals to ensure reliability of shift length when trains run late.

Given the need to refuel the locomotives en route, Parkes will probably be one of the train crew depots, with another depot likely further north.

It is likely that crew changeovers will be combined with crossing movements, for which an average of 37 minutes has been estimated. Therefore it is not necessary to add further time to allow for crew changeovers.

Refuelling

The reference locomotives have fuel tanks giving a range of approximately 1,300 km. This means that they will need to refuel en route. The existing locomotive depot at Goobang Junction (Parkes) is close to the halfway point and is the junction with the east–west corridor, where some train remarshalling and crew changeovers can be expected. However, refuelling locomotives in the existing depot will require detaching them, shunting, reattaching and then brake tests, which can typically delay trains by up to four hours.

Refuelling could take place in about 45 minutes, but would require the construction of a loop line with refuelling pad that allows at least one train to stand, with locomotives attached, clear of other traffic. This infrastructure would avoid the need for the shunting and subsequent brake testing that will be required if the existing depot was used. The cost of providing loops and equipment that allow a train to be refuelled in 45 minutes will be much less than the route enhancements necessary to produce a similar journey time if four hour refuelling stops are allowed for. New refuelling facilities will be the most efficient way of minimising journey time, and should be provided.

An alternative would be to use in-line refuelling, as is used on some of the east–west corridor services. In this operation a fuel bowser is hauled behind the locomotives, and refuelling takes place whilst the train is moving. A time penalty for refuelling is avoided and intermediate facilities are not required, but the bowser reduces the freight carrying capacity of the train.

In this study, it is assumed that refuelling will take about 45 minutes, at facilities that allow train locomotives to stay attached to the train and do not block main lines while refuelling is taking place. The journey time estimate should be increased by a further 45 minutes, in addition to crossing move allowances.

Minimum journey time

Minimum journey times could be achieved by trains given top priority. This could be achieved by adding to the 26 hour 30 minute non-stop journey time an allowance for ten crossing moves taking the minimum of eight minutes per cross, 20 minutes for two crew changeovers and assuming refuelling of trains on the move via in-line bowsers carried on the trains. Minimum journey time could be 28 hours and 10 minutes. This estimate would only apply to those trains able to take advantage of optimised passing loop locations and timetables, and therefore is only achievable in a very limited number of timetable and infrastructure scenarios.

Benchmarking exercise conclusion

The benchmarking exercise generated a potential journey time estimate via an upgraded existing corridor of 33 hours 25 minutes, made up as follows:

Table 5 Overall journey time benchmark

Factor	Time estimate h:m
Non-stop journey time	26:30
Crossing other high priority trains	6:10
Train crew changeovers	Included in crossing time.
Refuelling	0:45
Total	33:25

This high level journey time is based on speeds and delay factors for a service of four high priority superfreighter trains per day, which reflects both the estimated service on the inland railway and the current service on the coastal route.

The accuracy of the journey time estimation is considered to be + or–3½ hours for the Melbourne to Brisbane journey, based on a margin of error of 10 minutes per 100 km section.

Further work is testing the accuracy of the journey time estimate for a sample of the route, using RailSys computer simulation modelling. The test results will be added to this working paper.

Existing traffic

Train count by corridor segment

Trains published in the current ARTC Working Timetable are identified in the following table. However not all freight train paths are published in the Working Timetable. Trains for seasonal traffic, such as grain, are managed by the Train Control Offices on an 'as required' basis.

The summary is for south to north movements and similar movements can be assumed for the opposing direction.

Table 6 Existing traffic: Melbourne-Cootamundra (Standard Gauge)

Frequency	Train type	From and to	Comments
Two daily	CountryLink XPT Passenger	Melbourne–Coota–to Sydney	
Four daily	1500 m intermodal	Melbourne–Coota–(Sydney/Brisbane)	
One daily	1200 m general/steel	(Perth)-Melbourne–Coota–(Port Kembla)	May have some wagons with 25 t axle load
1–3 days/week	General freight	Melbourne–Cootamundra	
1–3 days/week	Grain	Melbourne–Coota-(Moree)	
One (days unclear)	Uncle Bens Grain	Melbourne–Wodonga	
Once a week	Manildra Group Grain	(Narrandera)–Junee–Coota–(Bomaderry)	
Once a week	CountryLink Xplorer DMU Passenger	(Griffith)–Junee–Coota–(Sydney)	
Once per week	General freight and oil tank cars	Bomen–Coota–(Sydney)	Bomen is just north of Wagga Wagga

Seasonal	Grain	Throughout corridor	Probably no more than one a day
Three daily	VLP loco-hauled passenger	Melbourne–Albury	After completion of standardisation currently under way.

Table 7 Existing Traffic: Cootamundra-Parkes (Goobang Junction)

Frequency	Train type	From and to	Comments
One daily	1800 metre intermodal	(Sydney)–**Coota–Parkes**–(Perth)	
One daily	1200 m general/steel	(Newcastle)–**Coota–Parkes**–(Whyalla)	May have some wagons with 25 t axle load
One twice a week	Ore in containers	(Port Kembla)–**Coota–Parkes**–(Goonumbla)	
1–3 days/week	Grain	(Melbourne)–**Coota–Parkes**– (Moree)	
Seasonal	Export grain	Port Kembla–**Coota–Stockinbingal**–Temora	Occasional; serving major grain terminal at Temora.
Seasonal	Grain	Throughout corridor	Probably no more than one a day

Table 8 Existing Traffic: Parkes (Goobang Junction) to Narromine

Frequency	Train Type	From and to	Comments
One twice per week	Ore in containers	(Port Kembla)–**Parkes–Goonumbla**	Goonumbla is just north of Parkes
One as required	Ore in containers	**Goobang Junction–Narromine**–(Cobar)	This traffic may be attached to/detached from Newcastle ore train at Narromine; needs to reverse at Narromine.
1–3 days/week	Grain	(Melbourne)–**Parkes–Narromine**–(Moree)	
Seasonal	Grain	Throughout corridor	Probably no more than one per day

Table 9 Existing Traffic: Narromine-Dubbo-Merrygoen-Werris Creek

Frequency	Train type	From and to	Comments
1–daily	Ore in containers	(Cobar)–**Narromine–Merrygoen**–(Newcastle)	Requires to reverse at Merrygoen — may detach Parkes portion at Narromine
1–3 days/week	Grain	(Melbourne)–**Narromine–Werris Creek**–(Moree)	Requires to reverse at Binnaway and Werris Creek
As required	Cotton in containers	(Warren)–**Narromine–Dubbo**–(Sydney)	Not in WTT but traffic believed to still exist — attached to Dubbo to Sydney daily container train
Seasonal	Grain	Throughout corridor	Probably no more than one a day

Table 10 Existing Traffic: Werris Creek–Narrabri–Moree

Frequency	Train type	From and to	Comments
1–daily	CountryLink Xplorer DMU Passenger	(Sydney)–Werris Creek–Moree	140km/h running
2–daily	General freight and cotton	(Sydney)–Werris Creek–Narrabri or Moree	
1–3 days/week	Grain (El Zorro)	(Melbourne)–Werris Creek–Moree	Requires to reverse at Werris Creek
1–daily	Grain for Gunnedah flour mill	Gunnedah–Moree	
1–2 days a week	Flour	(Bomaderry)–Werris Creek–Gunnedah	25 tonne axle load when loaded southbound
Up to 5 paths daily	Coal–25 t axle load when loaded southbound	(Newcastle)–Werris Creek–Gunnedah or Boggabri	Loops now being extended by ARTC to allow these to operate 72 wagon consists–7200 t gross
Seasonal	Grain	Throughout corridor	Probably no more than one a day

Table 11 Chinchilla–Oakey–Toowoomba: maximum number of paths

Frequency	Train type	From and to	Comments
188 a week	Coal	Chinchilla–**Oakey–Toowoomba**–Grandchester–Port of Brisbane	Maximum number of paths that are made available. Some of these are east of Grandchester.
8 a week	General freight	Chinchilla–**Oakey–Toowoomba**–Grandchester–Port of Brisbane	
8 a week	Intermodal including fuel	Chinchilla–**Oakey–Toowoomba**–Grandchester–Port of Brisbane	
8 a week	Grain	Chinchilla–**Oakey–Toowoomba**–Grandchester–Port of Brisbane	
2 a week	Cotton	Chinchilla–**Oakey–Toowoomba**–Grandchester–Port of Brisbane	Seasonal
1 a week	Molasses	Chinchilla–**Oakey–Toowoomba**–Grandchester–Port of Brisbane	
3 a week	Livestock	Chinchilla–**Oakey–Toowoomba**–Grandchester–Port of Brisbane	

Table 12 Kildonan–Inglewood: maximum number of paths

Frequency	Train type	From and to	Comments
1a week	Cotton	Goondiwindi–**Kildonan–Toowoomba**–Grandchester–Port of Brisbane	Seasonal
1 a week	Molasses	Goondiwindi–**Kildonan–Toowoomba**–Grandchester–Port of Brisbane	
1 a week	Livestock	Goondiwindi–**Kildonan–Toowoomba**–Grandchester–Port of Brisbane	

Table 13 Toowoomba-Grandchester: maximum number of paths

Frequency	Train type	From and to	Comments
188 a week	Coal	Chinchilla–**Toowoomba–Grandchester**–Port of Brisbane	Maximum number of paths that are made available
Eight a week	General freight	**Toowoomba–Grandchester**–Port of Brisbane	
Eight a week	Intermodal including fuel	**Toowoomba–Grandchester**–Port of Brisbane	
Eight a week	Grain	**Toowoomba–Grandchester**–Port of Brisbane	
Three a week	Cotton	**Toowoomba–Grandchester**–Port of Brisbane	Seasonal
Two a week	Molasses	**Toowoomba–Grandchester**–Port of Brisbane	
Four a week	Livestock	**Toowoomba–Grandchester**–Port of Brisbane	

Future Traffic

The future traffic estimates for the Melbourne–Brisbane corridor are dealt with in depth by the FEC elsewhere in the study, but it is expected that the initial estimates of 8 mt pa of intermodal container traffic could be handled by six trains per day each way.

Passing loops

On a single track railway, trains must pass trains going the other way ('cross') at passing loops. The passing loop length limits the length of (at least one of) the trains. The number and spacing of the passing loops limits the capacity and timetable flexibility of the railway. The need to stop and wait to cross increases the overall journey time and also fuel consumption.

Later stages of the project will identify the number and location of loops, but as a starting point the maximum distance between loops is expected to be roughly 80 km, representing approximately one hour travelling time within sections at 80 km/h and thus a one hour following train headway. For trains going in opposite directions, there would be a two hour gap between services if loops were one hour apart.

The timetables desired by train operators should be used to assist in planning the location of loops. If the timetable is made up of regular interval departures from both ends throughout the day, passing loops need to be at regular intervals along the inland railway. If trains are flighted, and generally leave close together at the same times from both ends, loop capacity must be concentrated towards the centre of the railway, where the two flights will meet. Comparison with the existing operation is not easy, as this does not meet customers' desires for an evening departure on day A and an early morning arrival on day C, which is expected to drive demand on the inland railway. Later stages of the study will assess the likely operating regime and its impact on loop location.

The length of passing loops is to be identified, but as a starting point the east-west corridor standard of 1,800 m-long trains has been chosen as indicative of the potential demand by train operators for loop capacity. Study of the reference train suggests that 1,800 m trains would be optimum for single stack trains with maximum loads at 23 t axle loads and three locomotives, and for heavily loaded double stack trains with four locomotives, suggesting that this length is likely to be used if axle loads of 23 t are allowed and average container load densities increase above current levels. Loops should be at least 200 m longer than the trains, so that the rear of a train that is stopping in the loop clears the main line points quicker than if the loop is only a little longer than the train.

Maintenance machine sidings

On-track machines used in track maintenance are typically prepared and moved close to the site where they will be used well before work begins, because they require maintenance and are relatively slow moving when travelling to site. It is therefore desirable to have sidings where they can be stored, clear of trains, at intervals along the line. Although existing routes have such sidings at intervals as close as 30 or 40 km, this is as a result of historic siding provision rather than strategic planning.

Later stages of the project will identify the number and location of loops, but if the maximum distance between loops is expected to be 80 km (representing one hour section lengths) it is reasonable to plan for each loop to have a 200 m engineers' siding associated with it, unless there is an existing engineers' siding within 80 km.

Track Reliability

WOLO speed restrictions

The danger of track buckling due to heat is mitigated by the introduction of temporary speed restrictions during the hottest part of the day on certain types of track, to reduce the likelihood of forces causing the track to move under the combined stresses of heat expansion and train movements. These are known by the codename WOLO. Track with concrete sleepers can be exempted from these speed restrictions because of its strength. For track without concrete sleepers, the maximum speed of loaded freight trains is limited to 80 km/h, generally between noon and 20.00 on days where the air temperature is forecast to exceed 35°C.

Note the coastal route is being refurbished with concrete sleepers for the whole Melbourne–Brisbane route.

Capacity

Capacity is not to be analysed as part of working paper 2.

The reference train provides a starting point for the analysis of capacity, as it has an average payload of 292 TEU and 2,920 t payload.

From a costing point of view, the study has assumed that passing loops will be required at intervals around 80 km, and this suggests an operational capacity of one hour following train headway. For trains going in opposite directions, there would be a two-hour gap between services if loops were one hour apart.

From this basis, later stages of the study will consider the likely operational strategies that will best meet the FEC-generated demand for services.

Train control

In Stage 1 of the study, the detail of the signalling system is not being investigated, other than assuming that the control system will not require trains to stop for safe working duties. Currently the lines from South Dynon–Cootamundra, Parkes–Dubbo, and the routes in Queensland, have signalling systems that allow trains to run non-stop from one section to another. Other lines in the corridor have signalling systems where the train crew must exchange tokens or other physical authority to proceed before moving from one section to another. This adds journey time and fuel penalties to operations, particularly where trains cross on single lines just to exchange tokens. The minimum time penalty for stopping, exchanging tokens and then accelerating back to line speed is likely to be eight minutes, but it can be much longer where crew have to access token machines locked away at unmanned locations. Encountering eight of these locations on one trip would add a minimum of an hour to transit time. Crossing delays are discussed in the journey time benchmarking exercise. ARTC's strategies include introduction of an Advanced Train Management System (ATMS), which will not require trains to stop before receiving authority to proceed, and so there will be time and fuel cost savings for train operators once it is installed.

Demand for train paths on the inland railway is not expected to be high enough to cause any difficulty in designing the signalling system to cope with the number of train movements required, regardless of whether ATMS or another modern signalling system is used.