ARTC

Melbourne–Brisbane Inland Rail Alignment Study

Working Paper No. 6 Design Standards

PB 100 YEARS

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Appendix A Standards

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
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
CBA	Cost-Benefit Analysis
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
EEC	Endangered Ecological Community
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
m	metres
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 (i.e. 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, [delete comma] 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
SEPP	State environmental planning policy
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
SRA	State Rail Authority
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

1. Introduction

1.1 Overview

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. This study, completed in June 2006, established the broad parameters for a potential future inland rail corridor between Melbourne and Brisbane.

1.2 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 the railway runs fairly close to the coast. For that reason, the existing Melbourne–Brisbane 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. The study undertook a high level analysis of various corridors and routes that had been proposed for an inland freight railway between Melbourne and Brisbane.

In its March 2008 announcement the Government stated that the Melbourne–Brisbane Inland Rail Alignment Study would 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.

1.3 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;
- 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;
- Stage 3 – Development of the preferred alignment.

A series of working papers is 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 Economic and Financial Analysis 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
	WP10	Development of Route	LTC
	WP11	Stage 2 Capital Works Costings	LTC
	WP12	Stage 2 Economic and Financial Analysis	FEC
Stage 3	WP9	Engineering Data Collection	LTC
	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	Economic and Financial Assessment	FEC
	WP19	Policy Issues, Options and Delivery Strategies	FEC

Note that the list of working papers has been revised since the completion of Stage 1 of the study. Some working papers have been re-titled and/or re-scheduled. In addition, the working papers listed as outputs of Stage 3 will appear as sections or appendices within an integrated final report of the study rather than being published as standalone documents.

1.4 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 Aurecon to support it in engineering and alignment development. Aurecon has in turn engaged Currie and Brown to assist in capital costing.

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

1.5 Stage 1 analysis

Stage 1 analysed numerous routes within the study area in order to determine the route to be analysed in Stage 2 (see Working Paper No. 5: Stage 1 Economic and Financial Analysis and the Identification of the Route for Further Analysis).

The route follows existing rail lines from Melbourne via Albury to Cootamundra, Parkes, Narromine, Dubbo, Werris Creek and Moree to North Star near Goondiwindi; with new construction from North Star to Brisbane via Toowoomba. North of Parkes the railway would require parts of the existing route to be upgraded, including minor deviations to improve its alignment.

The analysis retained a number of options for further analysis in Stage 2 of the study; including possible routes between Junee and Stockinbingal, Premer and Emerald Hill avoiding Werris Creek, North Star and Yelarbon near Inglewood, in the vicinity of Toowoomba and a more direct 'greenfield' route from Narromine to Narrabri.

The routes analysed in Working Paper No. 12 are shown in the figure below.

This paper discusses the design standards for Inland Rail and is independent of the proposed alignment location.

Melbourne-Brisbane Inland Rail Alignment Study

Existing railways and corridors studied in stage 2

Overview plan

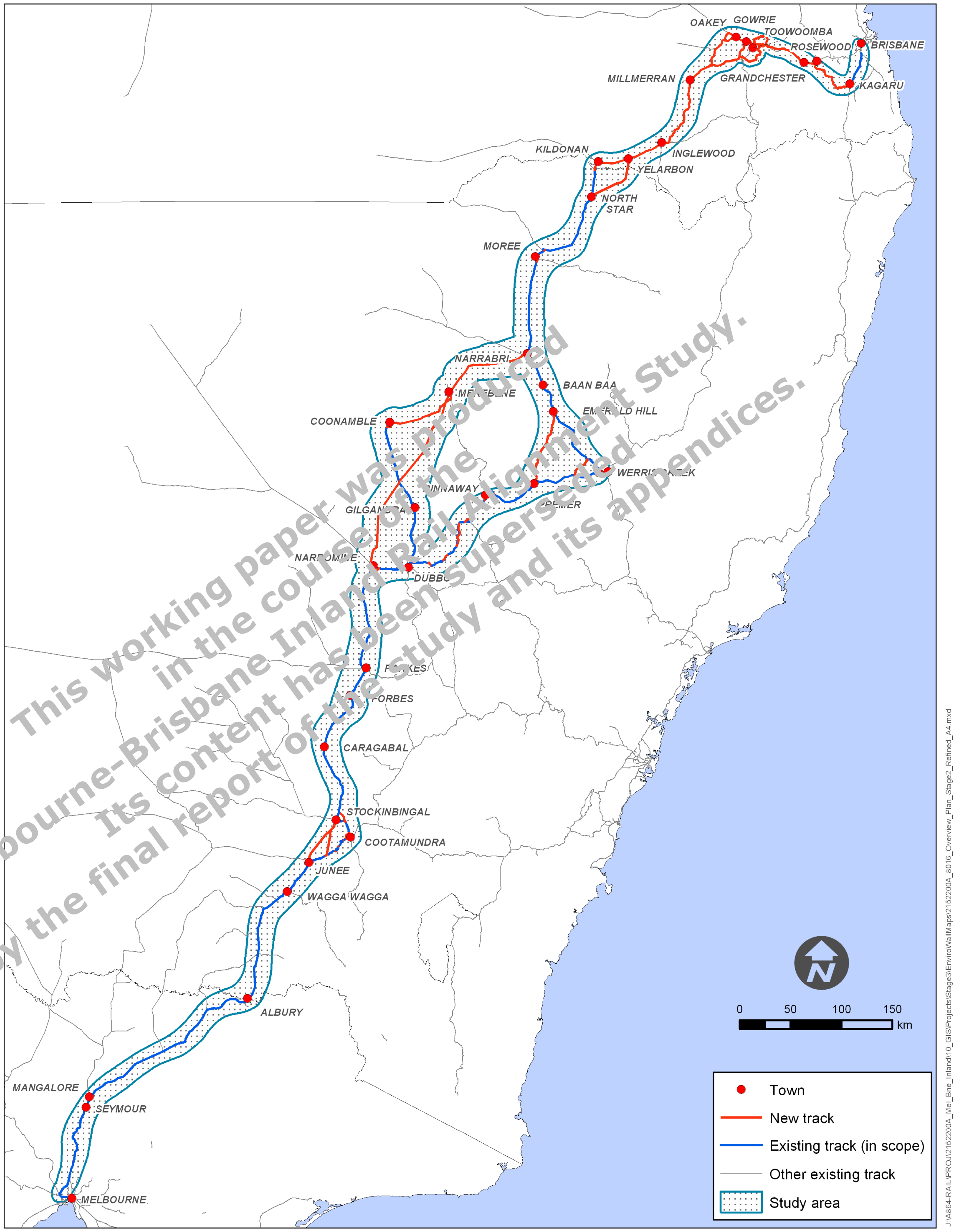

Figure 1-1 Melbourne–Brisbane inland rail corridor (Stage 2)

1.6 Working Paper No.6 objectives

The objective of Working Paper No. 6 is to outline the engineering standards to be adopted for the study, and to record the engineering assumptions adopted for this stage of the analysis. In some cases, as identified in this working paper, certain criteria cannot be established at this stage and will require further investigation during Stage 3.

The level of detail for the developed design in Stage 3 will depend on the potential cost and impact that each item will have on the feasibility of the project. For example, significantly more detail will be developed for tunnels than for level crossings as tunnels represent a significant cost, planning and operation constraint on the preferred alignment.

2. Methodology

2.1 Background

Inland Rail is a ‘clean sheet’ concept. As no inland route currently exists between Melbourne and Brisbane, there is an opportunity to develop new standards for both rollingstock and below-rail infrastructure. These new standards are considered in terms of both the capital cost and operational benefits.

Building Inland Rail to a higher standard would allow increased speeds and/or axle load but require additional capital expenditure. Building to a lower standard would allow reduced capital costs at the expense of operational restrictions.

Stage 1 of this study analysed many alternative routes with different combinations of existing, new and upgraded track. Much of the existing infrastructure in the corridor is already of Class 1 standard or being upgraded to Class 1C (as defined in Table 4-2 Track standards). The route identified for further analysis uses a considerable amount of that track in order to achieve capital cost savings. Upgrading the entire route to a higher standard would be difficult because of the existing operations, and expensive because of the considerable distance involved. Therefore operating the entire inland railway to a higher standard is not considered to be a viable option. Existing standards are adopted when using the existing track.

The new sections of track could be constructed to a higher standard, a lower standard or to existing Class 1 standards. Because Class 1 standards have been developed and refined over years of operating freight railways in Australia, constructing to a lower standard is not considered to be efficient. Sections of new track could be constructed to:

- A higher standard (not currently used in Australia), or
- Existing Class 1 standards.

A higher standard

A higher standard would provide benefits in the form of increased line speed and higher axle loads. As considerable sections of existing track will be used, axle loads will be restricted to the limits of the existing track (reorganising loads along the route is not considered to provide operational benefits). Additional capital expenditure would be required to build track to a higher specification, and this would allow trains to travel with higher axle loads at higher speeds over these new sections of track. To operate at higher speeds new rollingstock would be required as existing rollingstock is tailored for current Class 1 track standards. However the operator could only use the rollingstock to its full potential on those parts of the inland route built to the new, higher specification.

Existing Class 1 standards

Adopting existing or similar standards for both existing and new track offers considerable benefits: rail operators could operate their rollingstock as they currently do on the network; current maintenance routines and techniques could be applied on the inland route; and construction methods, materials and equipment would remain unchanged. High speed services (above 115km/h) could still operate on the route, but would be required to operate at a lower axle load.

For the above reasons we have developed design standards for the inland railway that are consistent with existing standards for Australian railways. A combination of new track (constructed to Class 1C for increased speed and tonnage) and existing Class 1 and Class 2 track (existing standards) would be adopted for the railway. Any existing Class 3 track would be upgraded to Class 1C to allow for higher axle loads than are permitted on Class 3.

It is reasonable to assume that higher train operating speeds would be possible if the rollingstock used on the railway were to be upgraded in the future. It is not possible at this time to predict the track structure that would be required for future operations. Also, an overall upgrade of rollingstock may not occur within the life of the initial track structure. However the design of the new alignment, i.e. the position of the track on the ground, essentially has an infinite life. It should therefore be designed with 'future-proofing' in mind.

In the 'greenfields' areas new alignments should be designed for possible future high speed operation by adopting large radius curves wherever it is practical without incurring undue extra capex. Many of the greenfields sites are in very open terrain, with few constraints on alignment design, therefore there is ample opportunity for maintaining large radii. Laying heavier rail and sleepers or the deepening of formations could occur in the course of any future upgrading of the line.

In the case of underbridges, the incremental additional cost of building these structures to higher standards is small compared to the cost of replacement or upgrading of a bridge prior to the end of its service life. Underbridges should therefore be designed with potential future loads in mind. The current ARTC design standard for bridges (BDS 06) which uses a rating of 300-LA from the Australian Bridge Design Code has been adopted for underbridges built on the inland railway.

2.2 Existing standards

This study has used ARTC standards as the governing rail standard, with other standards referenced where they are considered more appropriate. Although it is acknowledged that Inland Rail may be owned or operated by ARTC or a private company, ARTC standards are considered the most relevant. As a minimum, Inland Rail would need to be compatible with the other ARTC freight lines.

ARTC has a new set of standards in draft form that could be applicable to this project. At this stage they have not been authorised for use so they are not referenced here, but indications are that they will only have the effect of slightly reducing capex on some of the trackwork.

The Melbourne-Brisbane Inland Rail Alignment Study relates to three states: Victoria, NSW and Queensland, and each of these jurisdictions has different standards or legislation relating to issues such as environmental management or hydrology. Where standards differ between states, they have been identified where relevant.

2.3 Project scope of works

The Melbourne-Brisbane Inland Rail Alignment Study's general extent of works includes the following:

- Operations;

- Permanent way;
- Civil earthworks;
- Bridges, viaducts and culverts, including hydrology;
- Road works and level crossings;
- Signalling and communications;
- Tunnel structures;
- Management of environmental issues.

2.3.1 Context

For the purpose of this project there are three types of works:

- New greenfield track;
- Upgraded existing track;
- Use of existing track.

The standards applied in each of these areas will vary depending on whether the works involve new or upgraded track and structures.

Details of the type of works to be undertaken in specific sections of track are described in Working Paper No. 10: Development of Route.

3. Operations

3.1 Summary

Operational standards are based on the characteristics of the reference train described below.

Although no maximum load is proposed for trains operated by Inland Rail, certain maximum loads are estimated for illustrative purposes. Ruling gradients and their implications are discussed, and some of the current constraints provided by infrastructure and potential constraints from trains are highlighted. Further optimisation of gradients will take place in Stage 3 of the study. A maximum freight speed of 115 km/h is proposed.

Double stacking of containers has been assumed during Stage 2 of the study. Optimisation during Stage 3 may change the assumption, but this will only affect operations during later stages of this study.

3.2 Reference train

The ARTC Train Operating Conditions Manual (TOC Manual) details the length, power and load that are required for trains to meet fast intermodal freight (superfreighter) timings over the existing coastal route between Albury and Brisbane. The TOC Manual was used to define a typical train that might be operating when the inland railway opens. The chosen rollingstock is in service now, and has a maximum speed of 115 km/h. This reference train consists of the following elements:

- Three 3,220 kW, AC drive diesel electric locomotives, 22 m long, weighing 134 t each, and able to operate on 21 t axle load track. These are similar to the existing AC drive locomotives currently used on interstate freight services;
- Seven five-pack bogie container well wagons, each 105 m long, weighing 100 t tare and capable of carrying 20 TEU double stacked. These are similar to RQZY or RRZY type wagons;
- Thirty-eight (38) bogie container flat wagons, each 25.75 m long, weighing 22 t tare and capable of carrying 4 TEU single stacked. These are similar to CQMY type wagons.

The present maximum length possible on the interstate network (1,800 m) was used as the maximum length for this study because of the importance of inter-operability between the existing network and the inland railway.

The train is carrying 292 TEU of containers loaded to 10 t per TEU gross, i.e. including the weight of the containers.

Although the inland railway is being designed to allow double stacking, current experience on the east–west corridor shows that achieving 100% double stacking on every train is difficult due to the combination of container sizes presented for loading, allowable axle loads and weight distribution. The reference train is therefore double stacked for 40% of its length.

The gross total trailing load of the reference train is 4,456 t.

3.2.1 Maximum load

The following discussion uses current ARTC guidance to indicate current maximum loads, and does not represent a suggested maximum load limit for the inland railway.

If track axle loads could rise from the current 20 tal[1], and more favourable weight distribution within containers can be arranged, some of the constraints on double stacking would be eased. This would allow a greater proportion of double stacking per train than is currently experienced. Within the 1,800 m maximum length, 16 fully double stacked five-pack bogie well wagons (allowing the most container height combinations) might carry around 320 TEU, weighing 3,200 t at 10 t per TEU. Adding the tare weight of the sixteen wagons gives a gross trailing load of 4,800 t.

Another method of estimating maximum loads is provided by ARTC's code of practice for operations and safeworking. This provides some guidance on maximum loads outside NSW, and suggests that trains should have a minimum of 1.54 kW of locomotive power for each tonne of load in order to run at the fastest timings between Melbourne and Albury. The three locomotives on the reference train can generate up to 9,660 kW. With this motive power, ARTC guidance suggests a trailing load of 6,272 t on the inland railway.

3.3 Gradient

3.3.1 Standards

ARTC has a standard for gradients on new track. (ARTC Engineering Standard TDS 09), which states that the steepest desirable gradient is 1 in 200. However, significant sections of existing track for the inland railway already have grades steeper than 1 in 100 up to 1 in 50. For the purposes of this study a target grade has been set as the compromise between achieving operating conditions and reducing initial capital costs associated with construction at flatter grades. The target grade depends upon the existing infrastructure and terrain and is contained in Table 4-1, Existing situations and various treatment options for track. A discussion of target grades and operating conditions is contained below.

3.3.2 Existing ruling gradients

All of the route options considered in Stage 2 of the study pass through Heathcote Junction in Victoria, on the existing coastal route. There is a 20 km section at Heathcote Junction with many rising gradients of 1 in 50, which all Inland Rail trains would have to use. This is the ruling gradient in Victoria.

In NSW, the ruling gradients for each existing line direction are laid out in the TOC Manual, which notes that the practical ruling gradient restrictions applied may be eased where the momentum effect of trains allows.

[1] Current restriction between Melbourne and Albury at 115km/h

Table 3-1 Ruling gradients in NSW

Section	Ruling gradient by ARTC line direction	
	Northbound	Southbound
Albury to Culcairn	1 in 80	1 in 80
Culcairn to Henty	1 in 90	1 in 65
Henty to The Rock	1 in 80	1 in 80
The Rock to Wagga Wagga	1 in 66	1 in 60
Wagga Wagga to Junee	1 in 40	1 in 40
Junee to Cootamundra	1 in 50	1 in 40
Cootamundra to Stockinbingal	1 in 75	1 in 75
Stockinbingal to Forbes	1 in 100	1 in 80
Forbes to Parkes	1 in 80	1 in 90
Parkes to Narromine	1 in 100	1 in 100
Narromine to Dubbo	1 in 70	1 in 60
Dubbo to Merrygoen	1 in 75	1 in 75
Merrygoen to Binnaway	1 in 75	1 in 75
Binnaway to Gap	1 in 100	1 in 100
Gap to Gunnedah	1 in 75	1 in 65
Gunnedah to Narrabri	1 in 75	1 in 50
Narrabri to Moree	1 in 100	1 in 75
Moree to Camurra	level	level
Camurra to North Star	1 in 100	1 in 100

In Queensland, a new standard gauge alignment is proposed and therefore there is no existing ruling gradient.

3.3.3 Effect of gradients on trains

Even with three powerful locomotives, the reference train will be strongly affected by gradients. Any gradient steeper than 1 in 2,000 will prevent the reference train from maintaining the maximum 115 km/h.

The steady speed of a train travelling up a gradient, reached when the power of the locomotives at full throttle balances the effects of gravity, is known as the balancing speed.

If the train is operating at full power and travelling at 115 km/h approaching the bottom of a hill, it would take a long steady gradient to bring the train down from that maximum speed to the balancing speed.

Using 'Rameses' train performance simulation program, and typical train resistance figures used internationally[2], the balancing speed was estimated for the reference train. The following chart and graphs show the outputs:

[2] Canadian National figures used.

Table 3-2 Balancing speed on various gradients for reference train

Grade	Balancing speed (km/h)
1 in 40	23.77
1 in 50	29.42
1 in 60	34.77
1 in 80	43.83
1 in 100	51.65
1 in 133	63.00
1 in 150	67.75
1 in 286	88.00

The current average timetabled speeds of superfreighter trains on the coastal route timetable were found to be 63 km/h and 88 km/h over sections of hilly and flat terrain respectively. The continuous gradients that would result in those balancing speeds are shown for comparative purposes.

Rameses output graphs show the distance taken to fall to the steady balancing speed, assuming that the train starts climbing the gradient at 115 km/h.

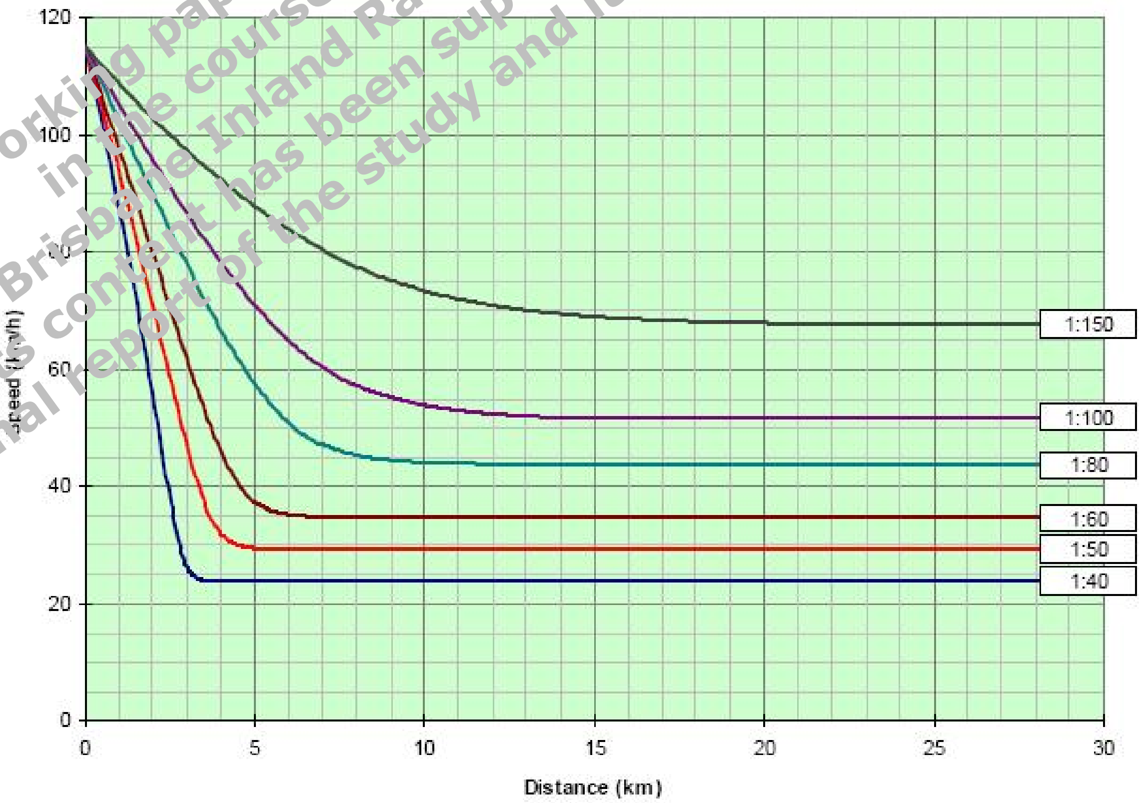

Figure 3-1 Train speed when climbing

Figure 3-1 assumes there are no other resistances other than internal ones and headwind created by the forward motion of the train. Curves and side winds are not included in the calculations, and resistance arising from these can be quite considerable.

The modelling shows that a steady 1 in 80 gradient will slow the reference train to 43 km/h after 8 km, and that a steady 1 in 100 will slow the train to 51 km/h in 11 km.

3.3.4 Optimising gradients

Wherever possible the design will use the flattest gradient possible. In adverse terrain this will have a considerable impact on construction costs due to the increased amount of earthworks and length of tunnels or viaducts. The cost of building easy gradients versus the increased journey time and reduced carrying capacity of building steeper gradients will need to be optimised in Stage 3 of the study. There is the potential to further optimise those gradients designed at 1 in 80 during Stage 2 of the study. For example, short steep gradients may be acceptable where they can be shown to have no effect on operations, such as a bridge over an existing road.

3.4 Maximum speed

The current maximum speed of freight trains on the interstate network is 115 km/h. Stage 1 of the study used benchmarking information relating to the existing coastal route. It concluded that a desirable transit time of 27 hours could be achieved along the existing track in the Study Area if it could be upgraded to a standard similar to the existing coastal route, where the maximum speed is 115k km/h.

Existing freight rollingstock is constructed for a maximum line speed of 115 km/h. If the inland railway is built for a higher maximum speed, most freight rollingstock would require a completely new design of bogie to take advantage of the new maximum. This would be very expensive for train operators.

There is no proposal to increase maximum line speeds for freight trains on the ARTC network, and therefore any rollingstock purchased to travel at higher speeds would either be dedicated for use on Inland Rail, or would not be using its full design potential when used elsewhere. There are therefore network benefits to using 115 km/h as the maximum speed for the inland railway.

The study has not considered the needs of passenger services over routes that may be used by Inland Rail. Passenger rollingstock is capable of up to 160 km/h, and has lower axle loads than freight rollingstock. This means there is the potential for differential line speeds, where passenger services can operate at more than 115 km/h subject to limits on axle loads.

3.5 Double stack trains

At Stage 1 of the study capacity analysis assumed that double stacking of containers on trains would take place on the inland railway. Double stacking has very little impact on the operating cost analysis in Stage 2 of the study, although it has a major impact on the cost of tunnels. If in Stage 3 of the study further optimisation of alignments requires that single stack trains be considered, the operational impact will be that because the capacity of each train would be reduced, more trains may be required to carry a particular annual tonnage of containers. This influences capacity planning, such as timetabling, the number of trains required, and the number of passing loops.

3.6 Axle loads

The following discussion details the methodology used in Stage 1 to consider the operational impact of various axle load standards.

3.6.1 Locomotive axle loads

The 134 t locomotives now being used on interstate freight trains have an axle load of 22.3 t, but are allowed to operate on lines of 20 and 21 tal at restricted speeds. To allow unrestricted operation at 115 km/h, 23 tal track will be required.

3.6.2 Wagon axle loads

A typical wagon capable of carrying 4TEU weighs 22 t tare, and within an axle load of 21 t could carry 15.5 t per TEU. 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, a maximum total payload of 4,690 t and a maximum trailing load of 6,164 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 a typical single stack train could take full advantage of a 23 tal.

Double stacking requires using 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 have more axle load constraints than single stack ones.

If limited only by an axle load of 23 t the maximum load that a train comprising 40% double stacked containers with 292 TEU could carry would be a payload of 5,110 t and 6,624 t gross. This assumes that vehicle tare weights remain the same and that the increased axle load is fully passed on as payload weight capacity gain. This load would require the use of four locomotives.

Higher axle loads should increase the percentage of double stacking relative to current practice. This is because there can be greater use of articulated wagon sets, which increases the length of the train that can be loaded. There would also be greater flexibility over the weight distribution of the containers on each wagon.

If wagons were developed with the same tare weights as existing ones but were designed to take advantage of 25 t axle loads, a double stack train could carry a payload of 5,764 t and would weigh 7,300 t gross. This exceeds the haulage power of five locomotives, the current maximum number of locomotives allowed to haul trains. This maximum also suggests the very high average load of 19.75 t per TEU. This suggests that a 23 tal is much more likely to be fully used by a typical double stack train than 25 t under current operating regimes.

The low average weight per TEU of typical containers means that train operators are unlikely to be able to maximise the benefits available for single stack trains if axle loads were increased from 21 t to 23 t in the current market. However future increases in load densities would mean that 21 t axle loads would ultimately 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. This would be brought about through greater use of articulated wagons and more flexibility in the use of double stacking.

This discussion does not consider the potential demand for higher axle loads from other traffic types, such as coal in US standard wagons at 32.5 tal.

Between Narrabri and Werris Creek, and between Oakey and Acacia Ridge, coal is expected to dominate traffic, and therefore determine maximum axle load. This has not been discussed in Stage 2.

Operationally, locomotives must be capable of hauling 23 tal trains at a maximum speed of 115 km/h; it is also desirable now for container train loads.

4. Permanent way

4.1 Methodology

The proposed methodology for this project is that different levels of work will be required, and different standards followed, depending on both the geographic location and the existing infrastructure.

In the case of greenfields alignments, the standards adopted depend on the physical terrain, and whether it relates to high speed inland areas or medium speed mountainous areas.

In the case of areas where existing track is used, the amount of work proposed and the standards to be followed depend on the existing class of track and whether the proposed track follows the existing alignment or whether it involves local deviations.

In the case of areas used by existing traffic, the work proposed may be influenced by the needs of other traffic; in particular those of narrow gauge traffic in Queensland.

Table 5–1 summarises the different types of existing situations and the various treatment options for tracks. Where required the alignment grades will need to include compensation for horizontal curvature to achieve the target grades.

Table 4-1 Existing situations and various treatment options for track

Situation	Track treatment option	Proposed trackwork	Target speed (km/h)	Target grade[3]
Greenfields	New high speed inland alignment	New construction to Class 1C	115	1 in 80
	New medium speed mountainous alignment	New construction to Class 1C	60–80	1 in 50
Existing Class 3/5 tracks	Existing alignment	Reconstruction to Class 1C	115	1 in 80
Existing Class 2 tracks	Existing alignment or	Essential upgrades only (i.e. bridges)	100 where possible	existing max 1 in 50
		Reconstruction to Class 1C	115	1 in 80
	Local deviations	New construction to Class 1C	115	1 in 80
Existing Class 1 tracks	Existing alignment	Essential upgrades only (i.e. bridges)	115 where possible	existing
	Local deviations	New construction to Class 1C	115	1 in 80
Existing narrow gauge corridors	Dual gauge	Reconstruction to Class 1C equivalent	115 where possible	existing max 1 in 50
	Independent standard gauge track	New construction to Class 1C	115	1 in 80 where possible

Although the target grade is 1 in 80, there are sections of track where the existing alignment is at 1 in 50. Where the track (or associated infrastructure such as bridges) is to be upgraded, the gradient will be left unchanged due to the cost of track re-grading. Similarly, through mountainous terrain, the option of further reducing the target grade to 1 in 50 will be

[3] Compensated to account for the additional resistance from curves

investigated where the cost of construction to 1 in 80 cannot be justified in terms of operational benefits. This is reflected in Table 4-1.

4.2 Specific criteria

Track

Where the track conditions are acceptable for axle load and speed the track will not be upgraded. Generally Class 3 track will be upgraded to Class 1C, with Class 1 and 2 track remaining unchanged. A brief summary of the differences between Class 1C, 1, 2 and 3 are outlined in the following table (summarised from ARTC standard TDS11).

Table 4-2 Track standards

Class	Axle Load	Max. Speed (km/h) - Freight	Sleeper Type
1C	25t	80	Concrete
1	25t	80	Timber/Steel
2	21t	80	Timber/Steel
3	19t	70	Timber/Steel

As per ARTC Standard TDS 11, the standard classification of lines for new or upgraded track will be Class 1C. The details are:

Table 4-3 Track details

Track component	Specification
Rail section	60 kg/m standard carbon with optional head hardened rail
Ballast depth	300 mm below sleeper
Ballast grade	standard
Sleeper type	heavy duty concrete
Sleeper spacing	600 mm
Ballast shoulder width	400 mm
Track gauge	standard, 1,435 mm
Track centres	4,000 mm, main line where straight or curve radius exceeds 1,000 m
	4,000 mm minimum (varies) where curve radius is less than 1,000 m
	5,835 mm, main line (where signals are required to be placed between the tracks)
	5,900 mm, crossing loops
	6,400 mm duplicated track (where constructed adjacent to an existing track)

The above track specification will be capable of the following performance.

Table 4-4 Track performance

Criteria	Performance
Maximum axle load	25 t (typically 80 km/h)
Maximum speed	115 km/h for 21 t axle load freight
	160 km/h for 19 t axle load such as XPT trains

Geometry

As per ARTC Standard TDS 09, Mainline Track Geometry and train modelling requirements, the criteria are:

Minimum target radius	800 m
Minimum length of a transition curve	75 m
Minimum vertical curve radius	5,600 m
Maximum superelevation	125 mm
Maximum superelevation deficiencies	+/- 75 mm
Maximum rate of change of deficiency	35 mm/sec

Horizontal clearance

Minimum horizontal clearances from track centres, as specified in ARTC Standard BDS12 Structure Gauge 1994, are shown below.

2,400 mm	signals and associated equipment
3,000 mm	signal bridges and temporary construction works adjacent to tracks
3,500 mm	piers, columns, deflection walls between tracks
4,300 mm	structures, cuttings, station buildings, signal bridges on platforms, columns and footbridges and other structures adjacent to tracks where no access road is required
5,000 mm	other structures located adjacent to tracks where no access road is required
6,200 mm	other structures and cuttings adjacent to tracks where access road is required

Access roads will be provided only where necessary to enable vehicular access to essential equipment.

Absolute minimum transit space clearance must be in accordance with the current ARTC standards for the new work (kinematic envelope plus 200 mm).

Vertical clearance

Vertical clearances need to comply with ARTC 2008 draft Clearances Strategy V4, Sept 2008, for rollingstock outline F (refer to Figure 4-1).

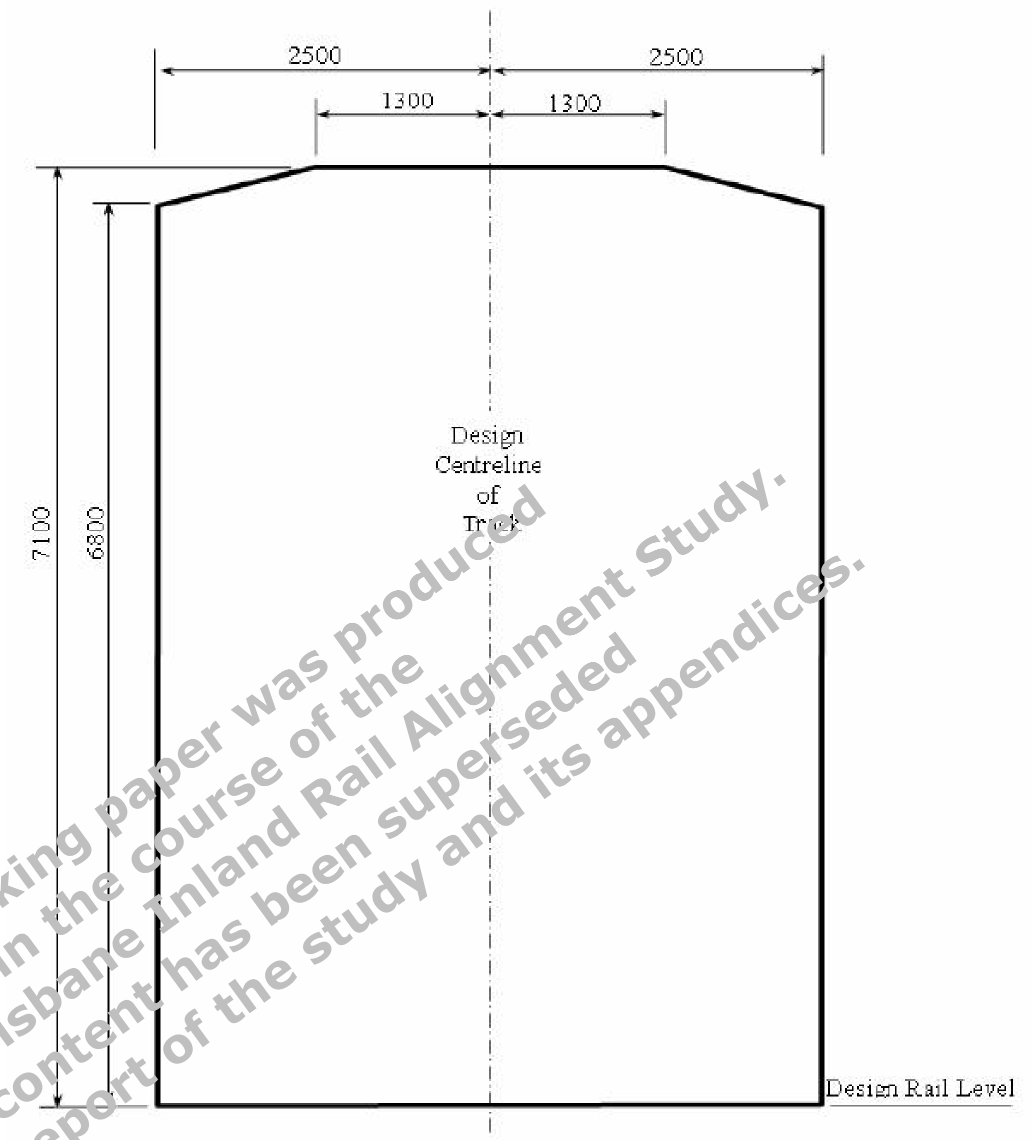

Figure 4-1 Rollingstock outline F — structure outline

Horizontal and vertical alignment design criteria, formation and earthwork

The reference standards for the above criteria are ARTC standards: TDS08, TDS09 and TDS11. In addition to the mentioned standards, the type of freight train (maximum speed, axle load and ruling grade) forms important references.

Structure gauge

The proposed structure gauge is Outline F — 7.1 m high x 5 m wide (double stack profile).

Turnouts

All turnouts will be standard high speed tangential on co-planar track and typical of ARTC standards.

Track structure

All new and upgraded works will be Class 1C for main line track. Refer to Figure 5–1 for the main line track:

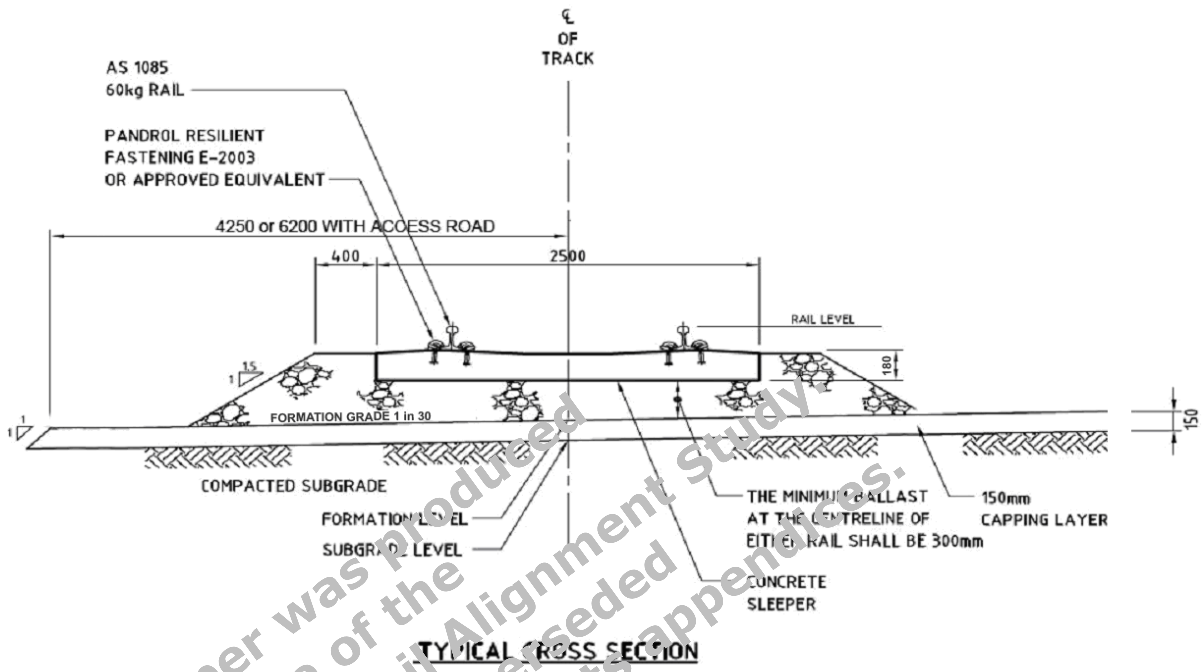

Figure 4-2 Main line track

Table 4-5 Design life

Element of the works	Life
Track support and fastening systems (including noise and vibration mitigation measures)	50 years
Buffer stops	40 years
Trackbed foundations	100 years
Track and base	50 years

5. Signalling and communications

The design for the signalling and control systems will be determined by the capacity requirements for the line. The track configuration being considered is for a single line with simple passing loops and a number of rail crossings. ARTC has a long-term strategic plan to adopt Advanced Train Management System (ATMS) across their network.

Under serious failure, ATMS operates as a train order system. If ATMS is still under development at the time of construction then a train order working with electrified points machines would be a suitable interim safe working system.

5.1 Advanced Train Management System (ATMS)

ATMS is a technology currently under development with Australian Government funding that promises higher throughput of trains than traditional signalling systems. It uses radios to provide in-cab signalling. ARTC has identified this technology as the system of choice for the future replacement of existing safeworking systems to maximise capacity of its network.

Under partial failure, ATMS has a variety of degraded modes of operation. Under serious failure, the railway will be operated under a train order system. If a non-ATMS equipped train (or ATMS train with degraded running) is present on the system, train order principles apply and safe separation distances are increased around the non-ATMS train.

5.2 Train Order Working (TOW)

Train order working (TOW) is provided for consideration should ATMS still be under development at the time construction starts. Further details of TOW can be found in ARTC document SDS 19 'Train Orders' ARTC Engineering (Signalling Standard).

The basis of train order working is issuing an 'order' that is acted upon by the train crew. The order permits the train crew to drive the train to a specific infrastructure marker, such as a location board, yard limit board, shunt limit board or clearance board.

The motorised points can be operated remotely by the controller, by push buttons located near the points, or from the locomotive by the train driver as the train approaches the loop. The last option normally gives the driver between 5 km and 7 km from the loop to operate the points remotely.

5.3 Interface design requirements

Level crossings

Level crossings will be designed to ARTC standards in keeping with ALCAM protocols. Further details on level crossings can be found in section 6.5.3.

Rail crossings

It is assumed that the majority of at-grade rail crossings along the line will be with other ARTC lines.

At locations where a different infrastructure controller controls the crossed line, changes will be required to the controller's signalling system to ensure there is safe management of train movements across the intersection.

In all cases, it is assumed Inland Rail will control train movements through rail crossings.

Spurs/junctions

Connections to other lines should be designed for TOW to ARTC standards. Trains operating ATMS will be armed/disarmed as they enter/exit the line.

Yards

It is assumed operations in yards will not be managed under ATMS. Yards should be signalled according to complexity and usage.

5.4 Power requirements

The power requirements will be based on the TOW standard configuration, with some additional requirement for Trackside Interface Units (TIUs) required to connect the trackside equipment to the ATMS telecommunications system.

5.5 Asset monitoring

Stand-alone asset monitoring systems that use the telecommunications system will be required, including but not limited to hot axle box detection, wheel impact load detection, dragging equipment detection, trackside signalling assets and power systems monitoring.

5.6 Current design standards

The design would have to comply with current common and state ARTC signalling design and construction standards.

Table 5–3 Design life

Element of the works	Life
Communication systems	20 years
Track side equipment housings	30 years
Cabling and support systems	25 years

5.7 Telecommunications

The telecommunications strategy for ATMS is to use a commercially available 3G network (currently Telstra) with satellite communication as a backup. The system will provide the non-vital voice and data link between the train and the Network Control Centre, and the trackside equipment and the Network Control Centre. This may develop to a 4G network by 2015.

6. Civil

6.1 Introduction

Civil design covers the works required to construct the rail corridor including:

- Bridges (under bridges, over bridges, water crossings and grade separations);
- Culverts;
- Viaducts;
- Roads, including access tracks and road diversions;
- Level crossings;
- Cuttings;
- Embankments.

Viaducts will generally only be used where topography makes the use of culverts or embankments uneconomical or unfeasible.

6.2 Earthworks

6.2.1 Cuttings

The proposed route traverses hundreds of kilometres of terrain and will encounter many different geological and soil units. Due to the high degree of variability in depth and thickness of individual stratums within mapped units and landscapes at the scale of this project, the terrain will be categorised into the following five geotechnical units:

- Hard rock;
- Soft rock;
- Aeolian soils;
- Alluvial soils;
- Gilgai/black soils.

Cut slopes in rock will require design based on consideration of the site specific constraints for the cutting locations including ground conditions, tolerable risk, maintenance considerations, earthworks balance requirements and face support. Some allowance for the full face support of sections in very poor rock, such as through fault zones, can also be considered.

6.2.2 Embankments

There are specific problems that may occur on a route of the length of the inland railway that pose special problems and therefore need to be addressed by an engineering solution. Some known construction problems are set out below.

6.2.3 Treatments

Black soil (gilgai)

It is not practicable to excavate and replace black soil as it is in places more than 5 m deep, and replacement fill might have to be hauled for long distances due to the lack of local availability of borrow pits. It is therefore necessary to use a construction method that can provide a stable base for the track while also being within a realistic cost.

A construction method has been developed following consideration by our geotechnical advisers with advice from the RTA, QR and local councils. The proposed embankment construction method is shown in the figure below.

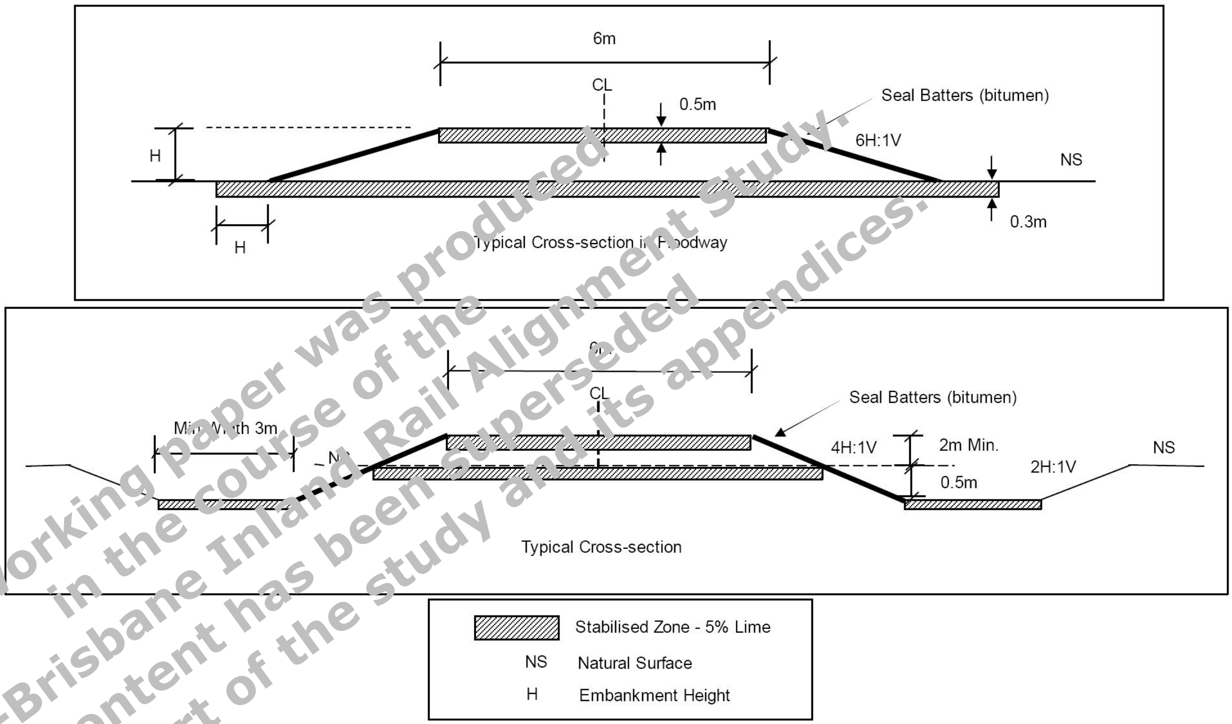

Figure 6-1 Formation construction in black soil

Aeolian soils

If the soil is too thick to excavate, it can be stabilised in place using cement as an additive and followed by compaction with water. This is effective when the soil can be contained, similar to construction on sand. If the surrounding aeolian soil is to be left in place it will need to be either cement stabilised or have hydromulch or similar applied to prevent it from migrating.

Once the natural surface has been stabilised, embankment construction can proceed as normal on top of it. The standard formation sections will apply to the embankment construction in this case.

6.3 Water Crossings

6.3.1 Methodology

Where the alignment intersects a waterway one of the following treatments will be used.

Table 6-1 Water crossing types

Type	Location	Span	Structure	Comments
Type 1 water crossing and others	Greenfield only	12–18 m spans	1200 deep Super T + 200 in situ slab	Will be used for single spans less than 18m and double (i.e. 2) spans with total length between 25.5 m and 36 m only.
Type 2 water crossing and others	Greenfield only	18–25 m spans	1515 deep Super T + 200 in situ slab	Will be used for single spans between 18 m and 25 m, double i.e. 2) spans with total length between 36.5 m and 50 m and for all other multi spans. Use this type as typical where ever possible (unless Type 1 is required).
Type 3 water crossing and others	Brownfield only	15–18 m spans	Standard RailCorp plans (no slab)	All upgrades including base case bridges. To be used for all brownfield sites with adequate vertical clearance where ever possible.
Type 4 water crossings only	Greenfield or brownfield	up to 5 m	Culvert	Only to be used where vertical clearance (top of rail to ground less than 4 m, say) is not adequate (i.e. height not enough for the waterway) for a bridge.
Type 5 water crossings only	Brownfield only	up to 5 m	Culvert with link slab	Only to be used as an option where track possession periods are more limited than normal (say less than 36 hrs)

Note that these water crossing types may be used in multiples, resulting in multiple spans or multiple culverts.

6.3.2 Hydrology

Hydrology studies shall be used to estimate water flows to adequately size culverts and determine track and bridge levels.

Specific criteria

The following criteria will be used for the hydrology assessment. These criteria have been based on RailCorp standard ESC420 in lieu of a relevant ARTC standard.

- Longitudinal drainage - 1 in 50 year annual return interval storm event;
- Minimum subsoil drainage size - 225 mm diameter and grade 1 in 200;
- Maximum pit spacings - 50 m;
- Minimal longitudinal drainage pipe sizes - 300 mm diameter and velocity 0.6m/s;
- Cross drainage - 1 in 100 year ARI storm event;
- Minimum cross drainage pipe sizes - 450 mm diameter;
- Maximum outlet velocities - 6.0 m/s;
- Minimum cess drain grade - 0.3%;
- Drainage design based on Rational method as outlined in Australian Rainfall and Runoff;

- Probable Maximum Flood Estimation (PMF) — Tunnel entry and exit;
- DRAINS modelling program or similar used for longitudinal carrier pipe sizing;
- Cross drainage to be sized for inlet and outlet control conditions and accommodates the 100-year ARI storm event;
- Sediment and erosion control measures to be incorporated into the design;
- Bridges and culverts will be sized to pass 1% AEP flows without causing adverse impacts to either velocities, affluxes or general flood behaviour;
- The maximum allowable afflux and velocity will be site specific and determine in the detail design phase in combination with flood studies and local guidelines;
- 0.5 m freeboard above the 1% AEP flood level;
- The minimum design life for drainage infrastructure shall be 50 years.

6.4 Bridges, viaducts and culverts

6.4.1 Typical details

The criteria set out below shall apply to bridges, culverts, viaducts and associated structures including retaining walls.

6.4.2 Specific criteria

The designs for bridges and culverts will comply with the Australian Bridge Design Code AS5100 and ARTC standard BDS06.

Loading

Rail bridge design axle load	32.5 t axle load (see ARTC Standard BDS 06)
Road bridge	SM1600 loading in accordance with S5100.2
Flood loading	2000 year return interval for ultimate event
	20 year return interval for service event
Flood flow velocities	in accordance with flood study

For bridges, a higher axle load has been specified than for rail. This is to allow the flexibility for heavier rollingstock at a future date without requiring the significant capital cost of upgrading structures on the alignment.

Clearances

Overbridge clearance	7.1 m
Underbridge clearance road	5.3 m in accordance with AS5100.1

Design life

Structural elements including retaining and deflection walls	100 years
Permanent ground anchors and rock bolts	100 years
Buildings and other structural elements	50 years.

6.5 Roads

6.5.1 Methodology

Where the alignment intersects an existing road one of the following treatments will be used, as shown in Table 6-4 Road crossing criteria.

Table 6-2 Treatments for an alignment intersecting with an existing road

Treatment	Suitable for
Terminate road	Minor roads and tracks where alternative route is available to another crossing
Terminate road and construct new road to alternative crossing	Minor roads and tracks where another crossing is available but there is no suitable direct route
Construct level crossing with passive controls	Minor roads and tracks with no alternative crossing and adequate lines of sight.
Construct level crossing with active controls	Major roads where traffic levels do not warrant a grade separated crossover
Grade separated crossing	Major roads such as highways and freeways

Road overbridges will be in accordance with the table below.

Table 6-3 Road overbridges

Type	Location	Span	Structure	Comments
Type 1 two-lane road overbridge	Greenfield or brownfield	up to 18 m with walls	RTA planks	Only to be used where railway corridor is narrow (i.e. in the order of 20 m).
Type 2 four-lane road overbridge	Greenfield or brownfield	up to 18 m with walls	RTA planks	Only to be used where railway corridor is narrow (i.e. in the order of 20 m).
Type 3 two-lane road overbridge only	Greenfield or brownfield	18–34 m with soil batter	Super T	For spans greater than 18 m.
Type 4 four-lane road overbridge only	Greenfield or brownfield	18–34 m with soil batter	Super T	For spans greater than 18 m.

More detailed information on crossings and the justification for crossing type can be found in Table 6-4 Road crossing criteria.

6.5.2 Specific criteria

Standards

There are several road design standards used throughout Australia. The AustRoads publications cover the whole of Australia for a range of subjects including:

- asset management;
- bridge technology;

- pavement technology;
- project delivery;
- project evaluation;
- road design;
- road safety;
- traffic management;
- road transport planning.

Each state in Australia has its own set of design guides and standards. These are very similar, with small variations. Sometimes the design guides and standards contain more detail than the AustRoads guides. Each state has tailored its standards and guide to suit the local conditions.

The Road and Traffic Authority (RTA) have developed several guides and manuals, the main one is the *Road Design Guide*, which is supplemented by *Technical Directions* in particular areas.

VicRoads have *Road Design Notes* and a *Road Design Guideline*, where the two conflict, the *Road Design Note* takes precedence. This is very similar to the *Road Design Guide* and *Technical Directions* in NSW.

The Queensland Department of Main Roads has the *Road Planning & Design Manual*, whose purpose is to set the policy and framework for the planning and design of new and upgraded roads in the state. The manual comprises an agreed set of corporate standards that includes consideration of local circumstances.

Technical information available from state road authorities in NSW, Victoria and Queensland can be used as supplements to the AustRoads guides to assist in tailoring the design to suit the local conditions.

Additional reference may also need to be made to local council requirements along the rail corridor. However, it is unlikely that any requirements would change the outcomes of the Stage 3 study.

Design life

Concrete road pavements	40 years
Flexible road pavements	20 years
Drainage structures and inaccessible pipe systems	100 years
Sign support structures and other roadside furniture	50 years.

6.5.3 Crossing classification

Specific criteria for determining the crossing type for the cost calculations is contained below.

Table 6-4 Road crossing criteria

Class	Definition	State classifications	Crossing type
Freeway	High volume, high speed roads declared as freeway; generally comprising dual carriageway and full access control and grade-separated intersections; i.e. no direct access from adjoining properties or side roads and all crossings are by a means of ramps. Single carriage sections forming part of declared freeways may be included in this category. These roads may be declared motorway, freeway or expressway.	Freeway — VIC Motorway — NSW Freeway/motorway — QLD	Grade separated — i.e. bridge, viaduct or tunnel
Highway	Roads that are of importance in a national sense, and/or are a major intrastate through route, and/or principal connector roads between capitals and/or major regions and/or principal towns. Most are national or state highways but there may be exceptions.	Highway — VIC Primary Road — NSW Highway — QLD	Grade separated
Arterial	A road that is a major connector between freeways, and/or national or state highways, and/or major centres, and/or principal towns, or have a major tourist importance or which the main function is to form the principal avenue of travel for metropolitan traffic movements not catered for by roads of higher functional status.	Arterial — VIC Arterial — NSW Secondary – QLD	Grade separated
Sub-arterial	A road which acts as a connector between primary and/or arterial roads, or an alternative route for arterial roads, or the commonly used link between smaller localities or a principal avenue for massive traffic movement not catered for by roads of higher functional status.	Sub-arterial — VIC Sub-arterial — NSW Secondary — QLD	Level 3B main road active level crossing — inclusive of half-boom barriers, bells and flashing lights. Minimum provision.
Collector road	A road which provides for major traffic movement between roads of a higher order or to local street systems. Usually hard surface, although may be improved, loose surface formation.	Collector — VIC Distributor — NSW Local collector — QLD	Level 3B main road active level crossing minimum provision.
Dedicated bus way	A road that has been dedicated as a rapid bus-only transit way.	Dedicated bus way — NSW No equivalent VIC	Level 3B main road active level crossing minimum provision.

Class	Definition	State classifications	Crossing type
Local	A sealed or improved loose surface formation road providing property access	Local - VIC Local — NSW Street/Local — QLD	Level 3A minor road active level crossing — inclusive of bells and flashing lights. Minimum provision
Urban service lane	A road in an urban environment that does not service a building frontage and only has one traffic lane. Generally these are service lanes to access the back of a property and they are not used for a postal address.	NSW only No equivalent — VIC/QLD	Passive crossing — warning signs only
Private or restricted	Road of any construction not maintained by local government and not used by public traffic.	QLD only No equivalent — VIC/NSW	Passive crossing with appropriate signs
Track; 2-wheel drive	Unimproved roads, the construction which is minimal. These roads are generally only passable in two-wheel drive vehicles during fair weather and are used predominantly by local traffic Driveways are also included, regardless of construction.	Track 2-Wheel Drive — VIC Track-vehicular — NSW 4WD and tracks — QLD	Passive crossing with appropriate signs
Track; 4-wheel drive	Unimproved roads which are generally only passable with 4-wheel drive vehicles.	Track 4-wheel drive — VIC Track-vehicular — NSW 4WD and tracks — QLD	Passive crossing with appropriate signs
Path	A track that is not capable of and/or not permitted to carry vehicular traffic. Generally for the use of pedestrians, horse riders and/or cyclists	Walking track — VIC Bicycle path — VIC Path — NSW Bikeway/walkway/malls — QLD	Passive crossing with signs Where pedestrian use is heavy and not associated with roads, consider grade separation or active control crossing.
Access way	A vehicular road/track generally only accessible by major service providers to maintain their infrastructure and emergency service agencies.	Access way — NSW Unconstructed and/or dedicated — QLD No equivalent VIC	Level 5B Active Crossing with special control and train running information
Unknown	The road is depicted, but the classification is not defined or determined.	VIC only. No equivalent NSW/QLD	Depends on finalised road category
Proposed	Road centreline alignments that have been received from plans and are yet to be constructed or construction completed.	Proposed — VIC Unconstructed and/or dedicated — QLD Construction lines — QLD No equiv category— NSW.	Depends on finalised road category, there will be no action until road is built

7. Tunnels

7.1 General

The inland rail alignment will require new tunnels, mainly located in the range crossing areas of Queensland.

These tunnels may range from around 6 km long to 300 m in length with conditions varying between each location and depth below natural ground surface. Geotechnical conditions will change between locations, and may require differing construction methods and designs to accommodate location conditions. Geotechnical conditions encountered may have a strong influence on construction method (TBM or road header), noting that the range contains hard rock (basalts) and a mixture of many different types of other soils and rock types.

Tunnelling methods will depend on many factors including likely ground conditions and final tunnel size and layout.

To accommodate double stacked containers as per ARTC 2008 draft Clearances Strategy V4, Sept 2008, TBM tunnel diameters would need to be approximately 12 m. The following figures show typical tunnel cross-sections.

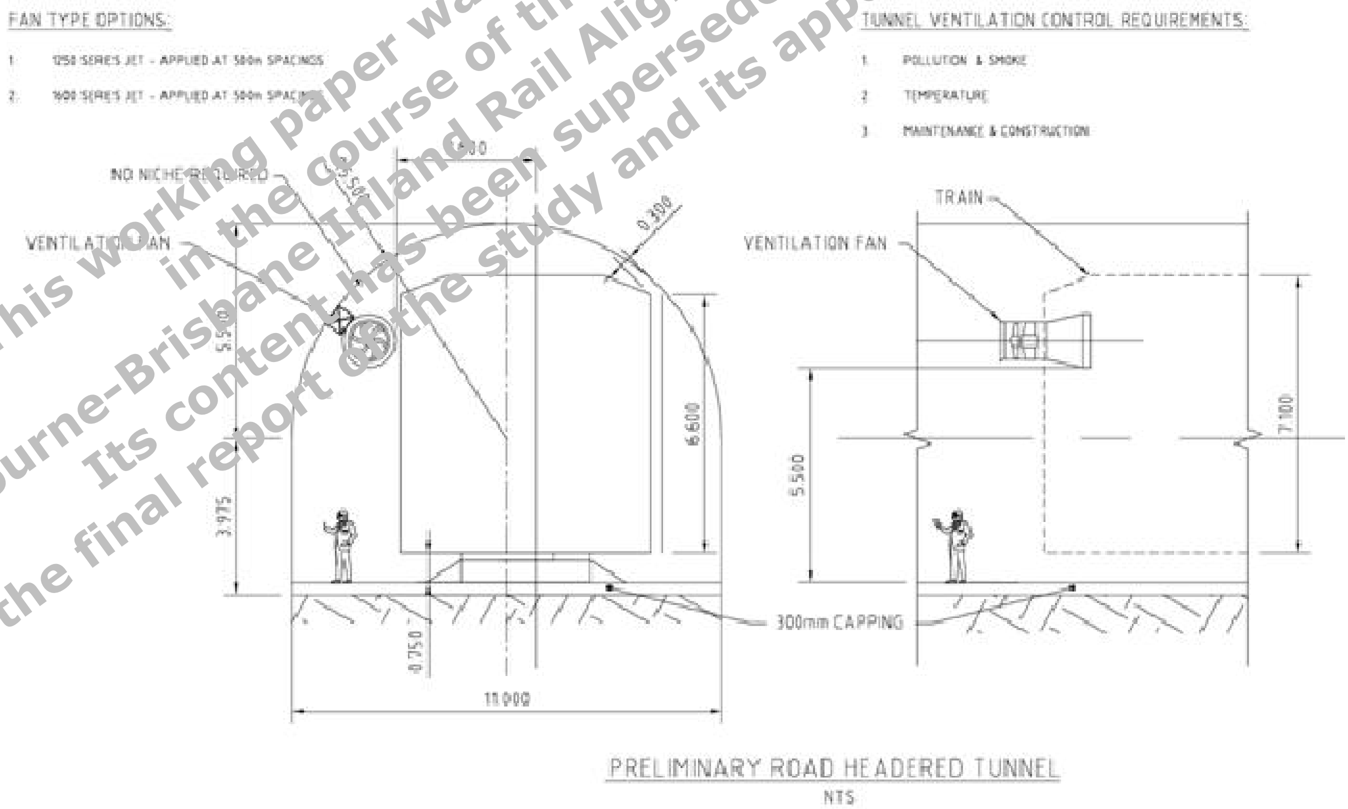

Figure 7-1 Typical section for road header tunnel

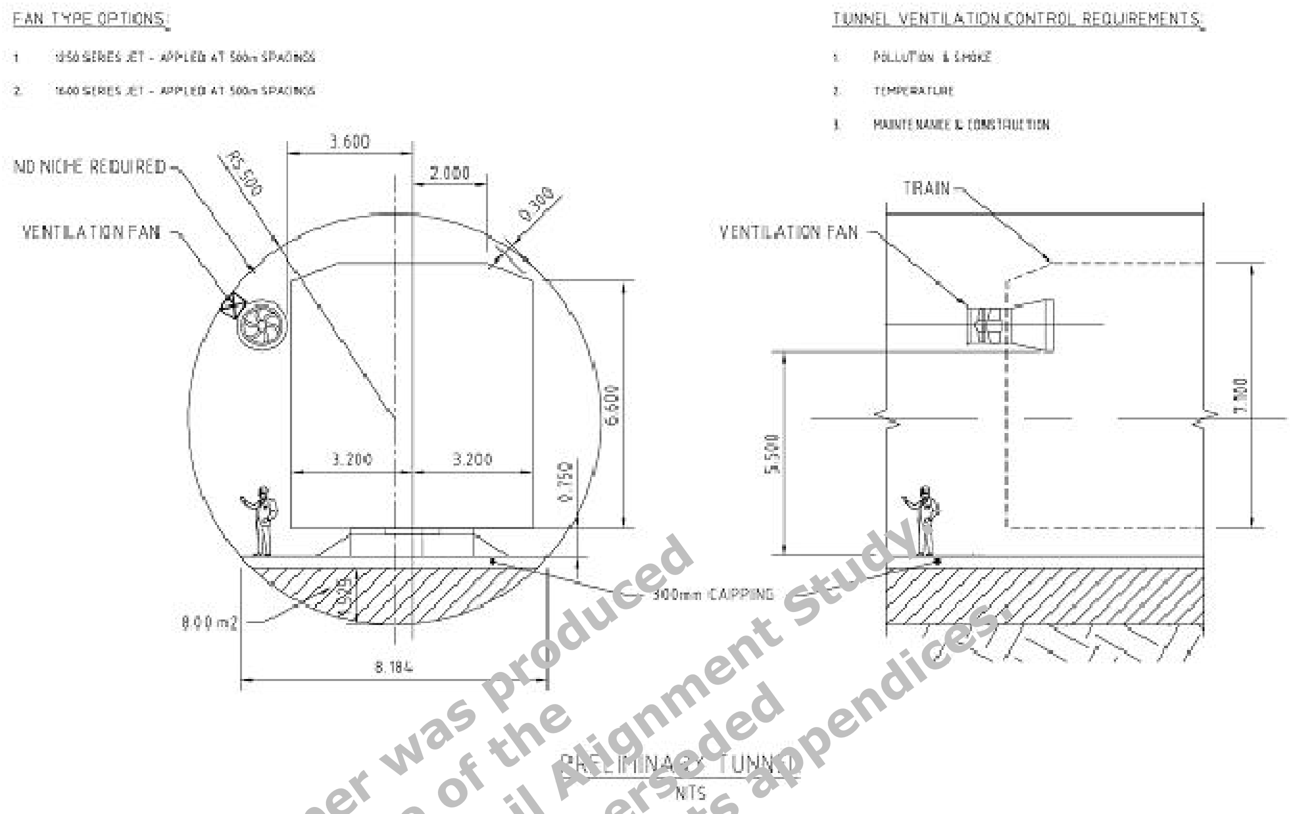

Figure 7-2 Typical section for TBM tunnel

7.2 Design process

The design process for the tunnel will begin with a geotechnical assessment of the ground along the proposed alignment. This will provide a preliminary ground model and recommendations for additional site investigation needed to understand the material and conditions through which the tunnel is to be excavated. This data will feed into reviews of the alignment and into decisions for the tunnelling methods to be adopted.

Further investigation will be required to develop a detailed ground model and allow design parameters to be derived. The model will eventually provide essential data, including lithology, ground structures, rock mass characterisation, in situ stresses and groundwater.

7.3 Specific criteria

7.3.1 Space proofing/tunnel cross-sections

The size and shape of the excavation required to meet the operational requirements of the tunnel, as well as the functional requirements needed for its safe construction, all feed in to the space-proofing exercise, which forms an essential input to the decision regarding tunnelling method.

A major element of this is the size and shape of the kinematic envelope of the traffic through the tunnel. It will therefore be necessary to establish at an early stage of the project the nature of the traffic to be carried (single or double stacked, freight or passenger) and the number of tracks required.

7.3.2 Design loads and design cases

Design loads and loading cases will be developed taking account of key factors including in-situ stresses, groundwater, depth of overburden, rock mass properties and the excavation shape and size. Consideration will also be given to fire loads and live and dead loads. Appropriate factors will be applied to all loads, individually and in loading combinations to provide an appropriately robust and durable design.

7.3.3 Design life

The design life for structural elements shall be 100 years. In practice this means indefinite life, but heavy maintenance may be needed at unknown times after 100 years.

7.3.4 Watertightness and durability

It is proposed that the tunnel will be designed with a pressure relieved or drained lining, where ground and ground water conditions permit. Under normal operating conditions the water pressure on the tunnel lining would be significantly less than the full hydrostatic pressure.

7.3.5 Tunnel linings

Tunnel linings will be designed in accordance with the appropriate standards. They will also meet the standards of the relevant state rail authority, Australian Standards and PIARC publications. If a relevant Australian Standard does not exist for the design of any element of the project works then British Standards (Specification of Tunnelling, British Tunnelling Society or ICE) will be applied or, if these do not exist, recognised international standards meeting best practices will be adopted.

7.4 Fire and life safety

Instead of directly applicable design standards for freight tunnels, this section lists design processes and various criteria that may be used in considering tunnel fire and life safety. Ultimately these requirements would be decided during a concept design phase, and would need a proper risk analysis.

7.4.1 Fire life safety process and proposed approach

The fire and life safety assessment will follow the methodology in the International Fire Engineering Guidelines (IFEG) [3]. The assessment is expected to be combination of qualitative and quantitative assessments intended to demonstrate that an acceptable level of fire and life safety will be provided by the tunnel's design.

Egress options

The egress system will be determined in conjunction with an assessment of egress times and the onset of untenable conditions.

Walkway

It is envisaged that there will be a walkway at track level, which will provide a desirable 850 mm footpath width and a minimum 600 mm clear width to enable the crew to walk past a stopped locomotive and associated rollingstock. However, these widths are minimums. Due to tunnel geometry required for construction methods, the space available for walkways is often greater as shown in Figure 7-1 Typical section for road header tunnel and Figure 7-2 Typical section for TBM tunnel.

Grades in tunnels

The egress assessment will consider the affect of grades of up to maximum of 1 in 60 on egress times.

Track structure

As part of the development design phase, the use of concrete track instead of ballast track will be considered with respect to fire and life safety.

Structure

The fire and life safety assessment will include an assessment of the structural requirements with respect to fire as well as methods of achieving the required fire resistance level (FRL).

The required FRL will need to be determined at the design stage based on likely fire loads and fuels, and implications of structural failure.

7.5 Tunnel ventilation

7.5.1 Specific criteria

Design ambient conditions for locomotive operation are assumed to be 50°C for freight locomotives. This represents the tunnel air temperature adjacent to the cooling air intake of the trailing locomotive, not the maximum tunnel air temperature behind the trailing locomotive.

Design ambient temperature would be based on the location of the tunnels using historical data. An example is outlined below.

Queensland: approximately 30°C (based on Bureau of Meteorology data).

Table 7-1 Bureau of Meteorology data

Site	Toowoomba Post Office Site: 041103	University of Queensland Gatton Site: 040082	Glenlogan field station Site: 040454
Mean daily temperature in hottest month	28.2°C/January	31.5°C/January	30.3°C/December
Mean no. days >= 40°C	0.0	1.1	0.3
Highest maximum temperature recorded	37.7°C	44.5°C	42.1°C

Typical values for in-tunnel air quality are listed in Table 7-2.

Table 7-2 Tunnel air quality limits

Pollutant	Time weighted average (TWA) over eight-hour working day	Short-term exposure limit (STEL)
Carbon monoxide CO	34 mg/m³/30 ppm	230 mg/m³/200 ppm for 15 min
Nitrogen monoxide NO	30 mg/m³/25 ppm	45 mg/m³/35 ppm for 15 min
Nitrogen dioxide NO_2	6 mg/m³/3 ppm	9 mg/m³/5 ppm for 15 min

- Time to purge tunnel of pollution/heat — based on design headway less time for train to transit tunnel;
- Longitudinal ventilation for smoke control (fire) — depends on design fire size (to be advised);

- Engine air and oxygen demand — this depends on the trains to be used and the expected loading and grades.
-

7.6 Tunnel construction and equipment

Table 7-3 Summary of tunnel construction and equipment

Item	NFPA 130
Emergency telephones	240 m spacing*
Cross-passage spacing	240 m spacing*
Emergency exit stairways	If required from egress study
Fire rating of tunnel dividing walls if used	Two hours
Fire rating doors to cross passages if used	1.5 hours
Emergency lighting	Required
Walkways	Required and may be either track level or raised
Automatic fire protection	Not required in tunnel proper
Hydrants	Spacing to NFPA 14
Portable fire extinguishers	To local jurisdiction requirements.
Flammable and combustible liquids intrusion	Restrictions on tank and accidental spill locations
Emergency ventilation fans (EVF) start up time	Nominated
EVF temperature rating	2500°C for one hour
EVF power supply	Two independent sources
Cabling	Low smoke zero halogen

8. Environmental standards and guidelines

8.1 Overview

Environmental standards and guidelines considered in the study were limited to those with implications for the route alignments and those that could affect costs.

Management of many environmental aspects of the project is governed by legislation or best practice guidelines such as the 'Blue Book' or 'Managing Urban Stormwater: Soils and Construction' (Landcom 2004). This publication contains erosion and sediment control management guidelines and control measures that should be considered and implemented during the planning and construction phases of a project. Because many of the standards and guidelines in that field are not considered to have significant cost or alignment implications, they have not been considered at this stage.

Standards and guidelines that were considered are described below. They include relevant state guidelines relating to noise and vibration assessment.

8.2 Acoustic guidelines

Inland Rail will involve the operation of rail services in Victoria, NSW and Queensland. However there will be no change to rail operations in Victoria as the inland route would use existing track south of Junee that is currently used for rail freight traffic between Melbourne and Brisbane. As such, acoustic guidelines will be applied to determine the design objectives that should be adopted for operational rail noise and vibration in NSW and Queensland where there would be changes in rail freight operations over existing track or through greenfield areas.

State-specific rail noise and vibration criteria detailed below have been derived from appropriate regulatory guidelines.

8.2.1 New South Wales guidelines

The Protection of the Environment Operations Act, 1997 (POEO Act) regulates noise generation and prohibits the generation of 'offensive noise' as defined by the POEO Act. The NSW Department of Environment and Climate Change (DECC) provides guidance for the assessment and management of environmental impacts of noise and vibration from rail developments in the *Interim Guidelines for the Assessment of Noise from Rail Infrastructure Projects*, (NSW Interim Guidelines, 2007).

The NSW Interim Guidelines also require rail noise to be considered where a project potentially influences rail traffic volumes and where services are to operate on shared rail corridors, with potential increases in rail noise influence.

Table 9-1 details noise design triggers for residential land uses. Noise triggers for sensitive land uses other than residential are detailed in Table 9-2. The noise objectives are designed to inform the planning process in determining requirements for detailed assessment of operational noise from the proposed rail development.

Noise trigger levels are for rail noise only and do not include contribution from additional ambient noise sources.

Table 8-1 Airborne rail traffic noise trigger levels for residential land uses

Airborne noise trigger levels			
Type of development	**Noise trigger level**		**Comment**
	Day (7 am–10 pm)	**Night** (10 pm–7 am)	
New rail line development	Development increases existing rail noise and resulting rail noise levels exceed:		These numbers represent external levels of noise that trigger the need for an assessment of the potential noise impacts from a rail infrastructure project. An ‘increase’ in existing rail noise levels is taken to be an increase of 2 dB(A) or more in L_{Aeq} in any hour or an increase of 3 dB(A) or more in L_{AMax}.
	60 $L_{Aeq(15h)}$ 80 L_{AMax}	55 $L_{Aeq(9h)}$ 80 L_{AMax}	
Redevelopment of existing rail line	Development increases existing rail noise and resulting rail noise levels exceed:		
	65 $L_{Aeq(15h)}$ 85 L_{AMax}	60 $L_{Aeq(9h)}$ 85 L_{AMax}	

Noise levels for residential land use are to be assessed 1 m from the most affected facade.

Table 8-2 Airborne rail traffic noise trigger levels for sensitive land uses

Sensitive land use	**Noise trigger levels dB(A)**	
	New rail line development	**Redevelopment of existing rail line**
	Development increase existing rail noise levels by 2 dB(A) or more in L_{Aeq} in any hour **and** resulting rail noise levels exceed:	
Schools, educational institutions — internal	40 dB(A) $L_{Aeq\ (1hr)}$	45 dB(A) $L_{Aeq\ (1hr)}$
Places of worship — internal	40 dB(A) $L_{Aeq\ (1hr)}$	45 dB(A) $L_{Aeq\ (1hr)}$
Hospitals	60 dB(A) $L_{Aeq\ (1hr)}$	60 dB(A) $L_{Aeq\ (1hr)}$
Hospitals — internal	35 dB(A) $L_{Aeq\ (1hr)}$	35 dB(A) $L_{Aeq\ (1hr)}$
Passive recreation	L_{Aeq} as per residential noise level value in Table 3-1 (excluding maximum noise level component)	
Active recreation	65 dB(A) $L_{Aeq\ (1hr)}$	65 dB(A) $L_{Aeq\ (1hr)}$

For sensitive receivers, noise levels are to be assessed at the most affected point within 50 m of the area boundary.

8.2.2 Queensland guidelines

Operational planning acoustic criteria are outlined in the *Environmental Protection (Noise) Policy, 1997* and referenced in the *Queensland Rail Railway Noise Management: Code of Practice, 1999*.

Planning noise levels specified below are to be assessed as 24-hour period average noise level and maximum single pass-by event, neither of which should be exceeded. The noise criteria are to be assessed at 1 m from the most affected façade of residential and sensitive receivers:

- 65 dB(A) $L_{Aeq, T}$ 24-hour average
- 87 dB(A) L_{Amax} single pass by level.

8.2.3 Sleep disturbance

Guidance for the assessment of potential sleep disturbance has been adopted from Australian Standard AS 2107:2000 *Acoustics — Recommended Design Sound Levels and Reverberation Times for Building Interiors*.

Internal noise levels conducive for sleep in areas adjacent to main roads, typical of an urban/suburban environment, are 'satisfactory' 30 dB(A) L_{Aeq} and 'maximum' 40 dB(A) L_{Aeq}. In areas of negligible transportation influence, indicative of sensitive noise environments noise levels of 'satisfactory' 25 dB(A) L_{Aeq} and 'maximum' 35 dB(A) L_{Aeq} are recommended.

Likely received internal noise impacts for the purpose of sleep disturbance assessment are typically determined through a 10 dB(A) reduction to noise impacts received at the external facade. The 10 dB(A) reduction is indicative of noise reduction performance afforded from an open window (10% total surface area opening).

The sleep disturbance criteria are considered applicable for all states.

8.2.4 Ground-borne noise

The NSW Interim Guidelines adopt ISO 14837 *Mechanical vibration — Ground-borne noise and vibration from rail systems* and define ground-borne noise as:

> *Noise generated inside a building by ground-borne vibration generated from the pass by of a vehicle on a train.*

The NSW Interim Guidelines recommend that ground-borne noise levels are relevant only where they are greater than the airborne noise from the railway and considered audible within habitable rooms of affected properties.

Ground-borne noise triggers designed to identify whether ground-borne noise impacts require an assessment are recommended in the NSW Interim Guidelines. The noise triggers, detailed in Table 9-3 are conservative and derived for potential ground-borne noise impact during periods of low background noise in suburban locations. The guidance acknowledges higher ground-borne noise triggers may be suitable for urban locations where background noise levels are higher.

In the absence of ground-borne noise guidance for Victoria and Queensland, the NSW Interim Guidelines will be used to assess potential ground-borne noise impacts.

Table 8-3 Ground-borne internal noise trigger levels (all developments)

Receiver	Time of day	Noise trigger level dB(A)
		Development increases existing rail noise levels by 3 dB(A) or more and resulting rail noise levels exceed:
Residential	Day (7am–10pm)	40 L_{AMax} (slow)
	Night (10pm–7am)	35 L_{AMax} (slow)
Educational institutions places of worship	When in use	40–45 L_{AMax} (slow)

Note: specified noises levels refer to rail transportation noise, no ambient sources are to be included

noise levels assessed at centre of most affected room, where greater than airborne noise levels

slow = slow response setting on sound level meter

8.2.5 Vibration criterion

Part 1 and Part 2 of Australian Standard AS2670.–1990 *Evaluation of human exposure to whole-body vibration* provide guidance to measure and evaluate perceptible vibration at receivers, and vibration levels influencing building structures.

In the absence of specific vibration criteria in state guidelines, NSW DECC's *Assessing Vibration: Technical Guidelines* (DECC, 2006) have been adopted for rail vibration assessment levels in Victoria, NSW and Queensland.

Vibration from rail pass-by events are classed within the guidance as an intermittent vibration sources. Recommended acceptable receiver intermittent vibration dose values (VDV) to minimise potential disturbance at sensitive receiver locations are detailed in Table 9-4.

Night time (10pm to 7am) has been adopted as the sensitive period for potential disturbance to residential receivers. VDV levels acceptable during daytime have been applied at all other sensitive receiver locations.

Table 8-4 Acceptable intermittent vibration levels for rail pass by events (DECC)

Location	Daytime (7am to 10pm)		Night time (10pm to 7am)	
	Preferred value	Maximum value	Preferred value	Maximum value
Residential	0.20	0.40	0.13	0.26
Critical areas[1]	0.10	0.20	0.10	0.20
Offices, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops (commercial)	0.80	1.60	0.80	1.60

Note: all vibration levels $m/s^{1.75}$

1 - Examples include hospital operating theatres, precision laboratories

Table 8-5 Ground-borne internal noise trigger levels (all developments)

Receiver	Time of day	Noise trigger level dB(A) Development increases existing rail noise levels by 3 dB(A) or more and resulting rail noise levels exceed:
Residential	Day (7 am–10 pm)	40 L_{AMax} (slow)
	Night (10 pm–7 am)	35 L_{AMax} (slow)
Educational institutions places of worship	When in use	40–45 L_{AMax} (slow)

Note: specified noise levels refer to rail transportation noise, no ambient sources are to be included

noise levels assessed at centre of most affected room, where greater than airborne noise levels

slow = slow response setting on sound level meter

8.2.6 Vibration criterion

Part 1 and Part 2 of Australian Standard AS2670.2-1990 *Evaluation of human exposure to whole-body vibration* provide guidance to measure and evaluate perceptible vibration at receivers, and vibration levels influencing building structures.

In the absence of specific vibration criteria in state guidelines, NSW DECC's *Assessing Vibration: Technical Guidelines* (DECC, 2006) have been adopted for rail vibration assessment levels in Victoria, NSW and Queensland.

Vibration from rail pass-by events are classed within the guidance as an intermittent vibration sources. Recommended acceptable received intermittent vibration dose values (VDV) to minimise potential disturbance at sensitive receiver locations are detailed in Table 2-4.

The night time (10pm to 7am) has been adopted as the sensitive period for potential disturbance to residential receivers. VDV levels acceptable during daytime have been applied at all other sensitive receiver locations.

Appendix A

Standards

Track geometry standards

Number	Title	RIC Document
TBA	Base Operating Condition Standards of Track Geometry	C 2009
TBA	Base Operating Condition Standards of Track Geometry — Standing Orders	C 2011
TBA	Operating Safety Standards for Track	C 2010

The Track Geometry Standards shown above have not been reformatted to ARTC standard format. These standards shall be regarded as ARTC standards until replaced. New standards have been developed and submitted to the regulator for material change.

Other references include for the design of permanent way include:

- The ARTC Code of Practice;
- Relevant ARTC internal documents.

Track design

Number	Title	RIC Document
ETD-02-03	Concrete sleepers (heavy duty) — design	N/A
ETD-02-04	Resilient rail fasteners for heavy duty concrete sleepers — design	N/A
TDS02	Specification for vibration isolation rail fasteners	C 3304
TDS03	Standard fishbolts, washers and nuts	TS 3371
TDS04	Timber bearers and transom standards	C 3102
TDS05	Steel sleepers specifications	C 3110
TDS06	Basic siding track design standards	TS 3202
TDS08	General standards for formation and earthworks	TS 3421
TDS09	Mainline track geometry	C 2200
TDS10	Industrial railway design standards	TS 3203
TDS11	Standard classification of lines	TS 3101
TDS12	Standards for formation capping material	TS 3422
TDS15	Infrastructure requirements for unit train loading and unloading facilities for coal and mineral products	C 2203

Track procurement

Number	Title	RIC Document
TPS02	Preassembled double glued joint specification	TS 3396
ETA-02-01	Timber sleeper, turnout and bridge transom specification	N/A
ETA-04-01	Ballast specification	N/A
ETA-01-01	Manufacture and testing of pre-assembled glued insulated rail joints	N/A
TPS06	Specification for the supply of field assembled mechanical insulated joint components	C 3365

Right of way

Number	Title	RIC Document
RDS01	Standard fencing	TS 3921
RDS02	Metallic lineside fencing in electrified areas	C 4501
RDS03	Standard trackside warning board signs	TS 3941

Turnouts

Number	Title	RIC Document
ETA-03-03	Technical Specification for Manufacture of Components for points and Crossing Structures	N/A
LDS01	Catch point design and clearance beyond catchpoints	TS 3504
LDS02	Standard turnouts	TS 3502
LDS03	Turnouts — component definitions	TS 3501

Bridges and structures design

Number	Title	RIC Document
AS5100	Bridge design	N/A
	Road underbridge — RTA Specifications and RTA Bridge Policy Manual	N/A
BDSO1	Bridges and structures: description and numbering	TS 4151
BDSO2	Derailment protection of existing supporting structures	AP 6111
BDSO3	Underbridge transoms — design and fixing requirements	C 4005
BDSO4	Underbridge walkways	C 4009
BDSO5	Guard rails — configuration standards	TS 31 200 101 SP
BDSO6	Structures — design standards	TS 30 000 301 SP
BDSO7	Buried corrugated metal structures — configuration and design	TS 31 000 301SP
BDSO8	Transit space handbook — system overview	C 2100
BDSO9	Transit space policy	C 2101
BDS10	Transit space handbook — corridor strategies	C 2102
BDS11	Transit space Standards	C 2103
BDS12	Structure gauge 1994	C 2104
BDS13	Application of kinematic envelope	C 2105
BDS14	Infringement of corridor space standards	C 2106
BDS15	Base operating standards for clearances	C 2107
BDS16	Clearances at platforms	C 2108
BDS17	Transit space for special loads	C 2109
BDS18	Transit space handbook commentary	C 2110
BDS19	Track centre clearance signs for yards	C 2111
BDS20	Configuration standards — bridge ends	TS 31 400 101 SP

Bridges and structures safety

Number	Title	RIC Document
BSSO1	Safety refuges and handrail devices for trackside structures	C 4010

Earthworks

Number	Title
AS1141	Methods for Sampling and testing aggregates part 11 — particle size distribution by dry sieving
AS1152	Test sieves
AS1289	Methods of testing soils for engineering purposes
AS1348	Road and traffic engineering — glossary of terms. Part 1 — road design and construction
AS1726	Geotechnical site Investigations
AS2758	Aggregates and rock for engineering purposes
AS3798	Guidelines on earthworks for commercial and residential development
AS3725	Loads on buried pipes

Pavements

Number	Title
AS1141	Methods for sampling and testing aggregates
AS1152	Specification for test sieves
AS1160	Bitumen emulsions for the construction and maintenance of pavements
AS1289	Methods of testing soil for engineering purposes
AS1348	Road and traffic engineering — glossary of terms
AS1379	Specification and Supply of concrete
AS2008	Residual bitumen for pavements
AS2150	Hot mix asphalt — a guide to good practice
AS2157	Cutback bitumen
AS2357	Mineral fillers for asphalt
AS2341	Methods of testing bitumen and related road making products
AS2758	Aggregates and rock for engineering purposes
AS2891	Methods of sampling and testing asphalt
AS3582	Supplementary cementitious materials for use with Portland cement
AS3600	Concrete structures
AS3798	Guidelines on earthworks for commercial and residential development
AS3972	Portland and blended cements
RTA QA Spec R116	Asphalt (dense grade and open grade)
RTA QA Spec R82	Lean-mix concrete sub base
RTA QA Spec R83	Jointed concrete base
Austroads 2002	Guide to the selection and use of bituminous emulsions
Austroads 2004	Pavement design: a guide to the structural design of road pavements

Number	Title
Austroads 1999	Guide to traffic engineering practice series
RTA 2000	Road design guide
DMR 1980	Interim guide to lines and markings

Number	Title
RTA 3071	Selected materials for formation
RTA 3051	Unbound and modified base and sub base materials for surfaced road pavements
RTA 3052	Material to be bound (MTBB) for base and sub base materials for surfaced road pavements
Austroads 1998	APRG Report No.21 — a guide to the design of new pavements for light traffic

Hydrology

- RailCorp Civil Engineering Standard — *Earthworks Construction Procedures*, Ref. C1100
- RailCorp Civil Engineering Standard — *General Standards for Formation & Earthworks*, Ref. TS 3421
- RailCorp Engineering Practices Manual — *Track Drainage — Design & Construction* Ref RTS 3433
- Australian Rainfall and Runoff (1998)
- Estimation of Probable Maximum Precipitation in Australia. (Method will be determined by location.)
- Floodplain Management in Australia: Best Practise Principles and Guidelines (SCARM Report 73)
- Waterway Design (Austroads 1994)
- IECA Best Practise Erosion and Sediment Control (2008)
- Queensland Rail and RailCorp Civil Engineering Standards
- Road Runoff and Drainage — Environmental Impacts and Management. (AP-R180)
- Guidelines for Treatment of Stormwater Runoff from the Road Infrastructure (AP-R232 03)
- Soil and Construction — Volume 1 — 4th Edition, March 2004
- Australian Rainfall and Runoff (1998)

Hydrology legislation — Victoria

- Water Act 1989 — Section 208 (may need to confirm)
- Local stormwater management legislation — refer Section 2, Planning, Environment and Land Requirements

Hydrology legislation — NSW

- Environmental Planning & Assessment Act (1979) — refer Section 2, Planning, Environment and Land Requirements.
- Water Act 2000

Hydrology legislation — Queensland

- Queensland Urban Drainage Manual (2008)
- Environmental Protection Act (1994)
- Integrated Planning Act (1997)

Bureau of Meteorology — Australia

- Estimation of Probable Maximum Precipitation in Australia. Generalised Short Duration Method — June 2003

Roads and Traffic Authority, NSW QA specifications

- RTA R2 (July 2001) *Erosion and Sediment Control (temporary)*
- RTA R11 *Stormwater Drainage* (Feb 2004)
- RTA R15 *Kerb and Gutter* (May 2000)
- RTA R23 *UPVC Pipes* (Feb 2000)
- RTA R32 Subsurface Drainage — Materials (Aug 2003)
- RTA R33 *Trench Drains* (June 2000)

Tunnels

- Australian Standard AS3600 Concrete Structures
- AS5100–5 Bridge Design Code-Concrete
- Concreting Institute of Australia, Shotcreting in Australia — Recommended practice
- ITIG, *A Code of Practice for Risk Management of Tunnel Works*
- ABI and BTS *The Joint Code of Practice for Risk Management of Tunnel Works*
- Workplace Health and Safety, *Tunnelling Code of Practice*
- Design Principals of Steel Fibre Reinforced Concrete for Tunnelling Works, German Concrete Association

Tunnel fire — Australian regulatory references

The fire and life safety design will be developed with reference to the following:

- Railway Fire and Life Safety Guidelines
- The requirements of the emergency services involved.[4]
- Australasian Fire Authorities Committee
- The International Fire Engineering Guidelines
- The relevant Australian Standards

Tunnel — other regulatory references

- NFPA 130 — Standard for Fixed Guideway Transit and Passenger Rail Systems (really only applicable to passenger rail but elements may be considered)[5]
- NFPA 101 — Life Safety Code

Tunnel — regulatory references

- Guidance Note [NOHSC:3008(1995)] — Department of Employment and Workplace Relations

[4] The NSWFB follow the requirements of the RailCorp F&LS Guidelines.

[5] It is noted that this is not considered applicable to freight systems. However the sections applicable to egress shall be used for guidance.

- National Exposure Standards [NOHSC:1003(1995)] — Department of Employment and Workplace Relations

Tunnel — other references

- Health and Safety Executive, UK
- Note that the Australian NOHSC do not specify a STEL for nitrogen monoxide (NO), however the Health and Safety Executive in the UK have a STEL for NO as 45 mg/m³ (35 ppm), while maintaining similar TWA and STEL for the other pollutants. The UK standard has been used for the purposes of this study
- PIARC, Road Tunnels – Vehicle Emissions and Air Demand for Ventilation, 05.14.B, 2004
- PIARC, Pollution by Nitrogen Dioxide in Road Tunnels, 05.09.B, 2000
- PIARC, Fire and Smoke Control in Road Tunnels, 05.05.B, 1999

Track construction

Number	Title	RIC Document
ETC-00-01	New Track Construction	N/A
ETC-01-01	Relaying with new 60 kg/m Rail and Concrete Sleepers	N/A
ETC-01-02	Rail Straightening	N/A
ETC-01-03	Welding Existing Rails to Continuous Welded Rail	N/A
ETC-02-02	Installation of Resilient Fastening Assemblies in Dog Spiked Track	N/A
ETC-03-01	Turnout Replacement	N/A

Civil construction

Number	Title	RIC Document
ETC-04-01	Full Section and Shoulder Ballast Cleaning	
ETC-08-01	Earthworks for New Tracks and Formation Widening	
ETC-10-01	Drainage	