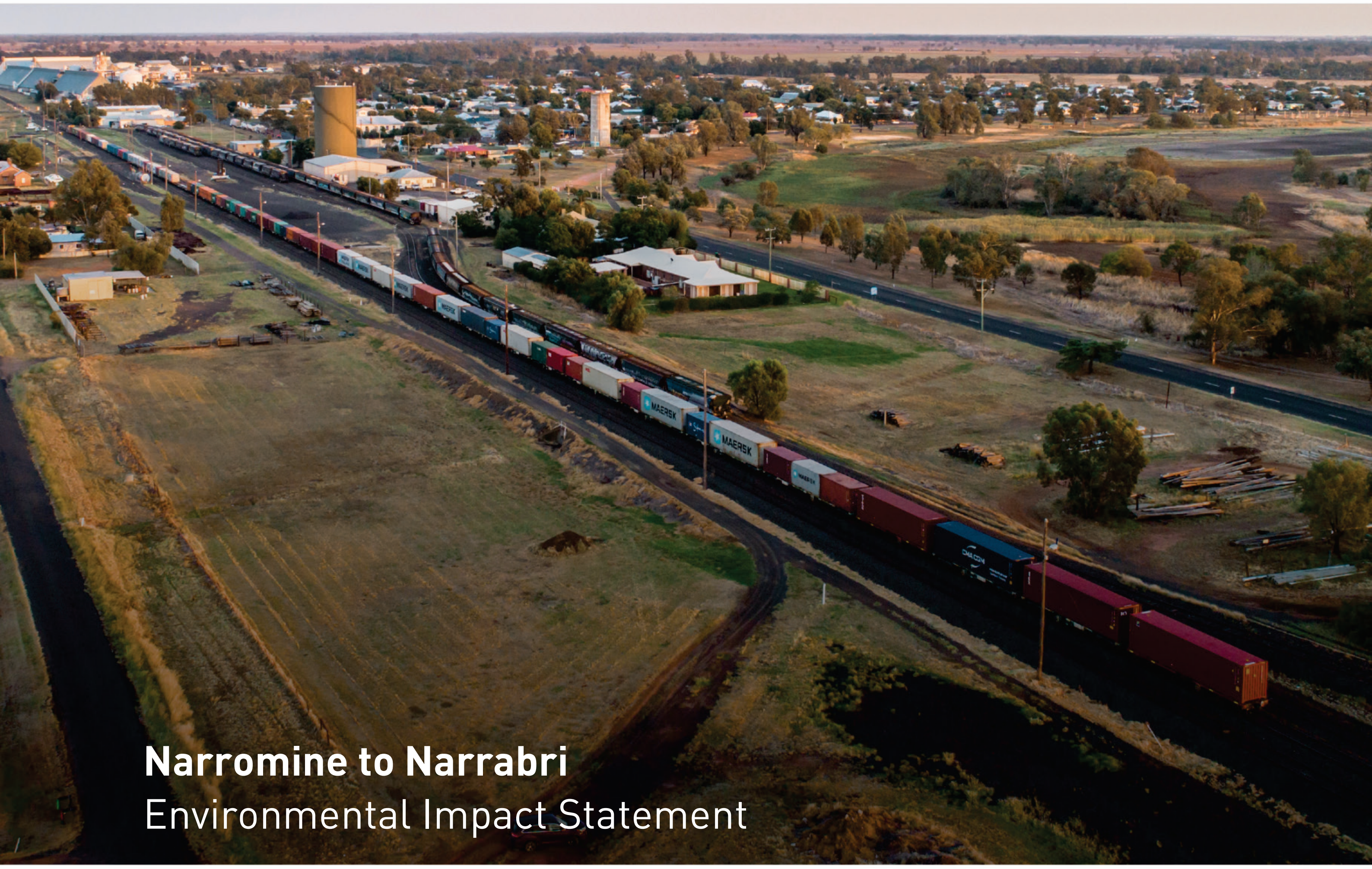
PART D

EIS synthesis and conclusion

INLAND RAIL

CHAPTER D4
Climate change



Narromine to Narrabri

Environmental Impact Statement

ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

IR_1929

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D4. Climate change

This chapter provides the climate change assessment for the Narromine to Narrabri project (the proposal). Additional information on climate change projections, climate change risks and proposed adaptation measures is provided in Appendix H.

D4.1 Assessment approach

A description of the approach to the assessment is provided in this section, including the legislation, guidelines and/or policies driving the approach and the methodology used to undertake the assessment.

D4.1.1 Legislative and policy context to the assessment

Relevant legislation, policies and guidelines

Climate change has the potential to alter the frequency, intensity and distribution of extreme weather-related natural hazards, including more intense and frequent heat waves, droughts, floods and storm surges. The risk of climate change impacts on rail infrastructure needs to be considered as part of the design process, as structures need to be designed to last for many years and, therefore, need to be resilient to climate change.

Climate change adaptation planning and risk management is an evolving field. Responses to reduce the risks of climate change broadly fall into two categories: mitigation and adaptation. Using the definitions of the Inter-governmental Panel on Climate Change (IPCC, 2013), mitigation aims to reduce human effects on the climate system by implementing strategies to reduce greenhouse gas sources and emissions, and to enhance greenhouse gas sinks. Adaptation refers to adjustments in response to actual or anticipated climate changes or their effects, to moderate harm or to exploit beneficial opportunities. Infrastructure design and planning needs to incorporate adaptation measures, based on the assessed risk of climate change to a proposal.

Relevant policies, guidelines and standards include:

- *National Climate Resilience and Adaptation Strategy* (Australian Government, 2015)
- *Climate Change Impacts and Risk Management—A Guide for Business and Government* (Australian Greenhouse Office, 2006)
- *NSW Climate Change Policy Framework* (OEH, 2016b)
- *AS 5334-2013 Climate change adaptation for settlements and infrastructure—A risk-based approach* (Standards Australia, 2013)
- *AS/NZS ISO31000-2009 Risk management—Principles and guidelines* (Standards Australia/Standards New Zealand Standard Committee, 2009)
- *Draft Technical Guide for Climate Change Adaptation for the State Road Network* (Roads and Maritime Services, 2015a)
- *AGIC Guideline for Climate Change Adaptation* (Australian Green Infrastructure Council, 2011)
- ARTC's *Inland Rail Sustainability Strategy* (ARTC, 2019b).

Secretary's Environmental Assessment Requirements

The SEARs relevant to climate change, together with a reference to where they are addressed in the EIS, are provided in Appendix A.

D4.1.2 Methodology

The climate change risk assessment followed the approach set out in the draft *Technical Guide for Climate Change Adaptation for the State Road Network* (Roads and Maritime Services, 2015a) (the Technical Guide). The climate change risk assessment involved:

- Reviewing information on the proposal and its geographic context, including historical climate conditions and establishing future climate conditions for the NSW Central Slopes area
- Developing projections of the future climate in the study area
- Determining climate projection scenarios for the assessment using the Climate Futures Tool and data from the Bureau of Meteorology for the Central Slopes sub-cluster region

- Assessing risks with 'business-as-usual' risk controls in place (those which account for the potential impacts of climate variability but not those associated with projected climate change) and prioritising each risk
- Identifying potential adaptation measures and/or design strategies for the priority climate change risks.

The long-term nature of the effects of climate change make it difficult to pinpoint potential impacts within relatively short duration and near-term events such as those associated with construction of the proposal. As a result, the focus of the climate change assessment is on the potential risks over the operational life of the proposal.

The assessment approach and key tasks are summarised in Figure D4.1.

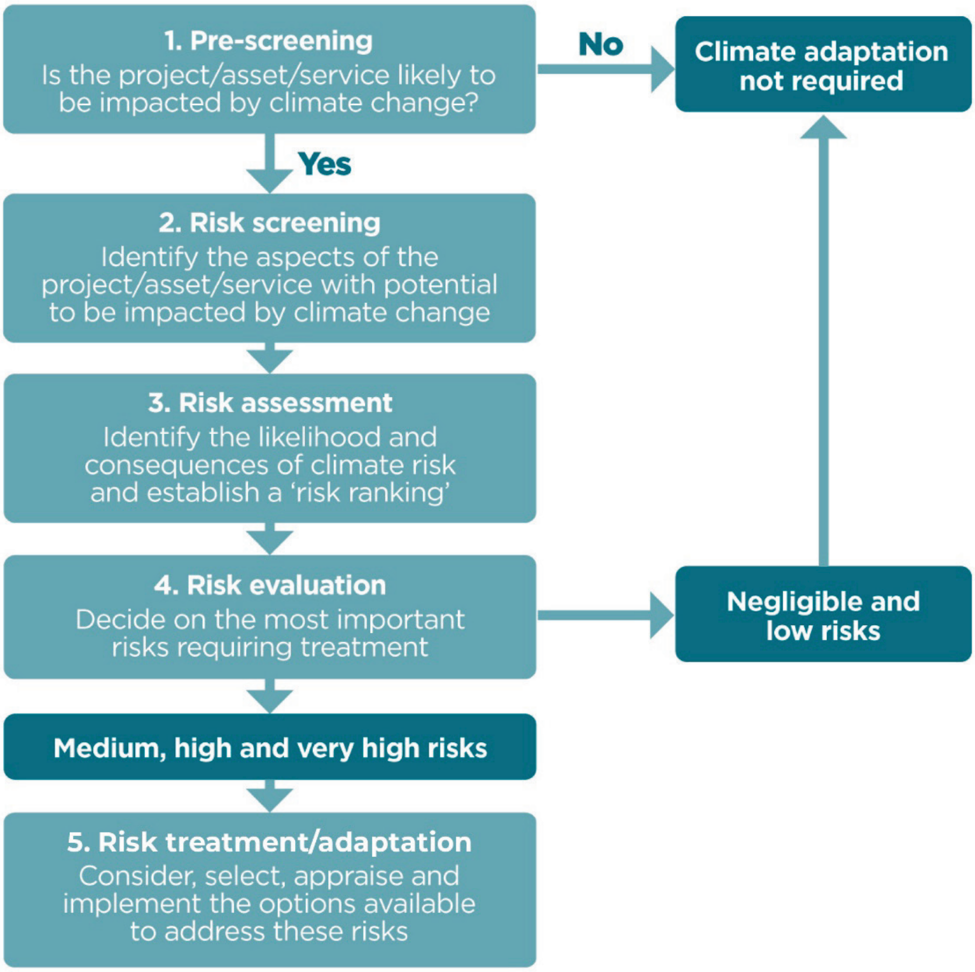

FIGURE D4.1 CLIMATE CHANGE ASSESSMENT—KEY STEPS

Adopted climate change projections

The climate change factors used for the current risk assessment were derived using the Climate Futures Tool (Clarke et al., 2011) and climate change in Australia modelling data from CSIRO and the Bureau of Meteorology.

The climate change projections for the proposal were identified for the following three time periods, which broadly reflect the operational lifespan of the proposed infrastructure:

- 2030: assets and systems with shorter operating lives, such as signalling and communications systems, and level crossings
- 2070: assets and systems with longer operating lives, such as rail tracks and underground drainage
- 2090: 'permanent' assets, which are ongoing features of the proposal, such as bridges and embankments.

To develop projections for the study area, the Representative Concentration Pathways (RCP) were adopted for the three timeframes. A moderate RCP (RCP4.5) and an extreme RCP (RCP8.5) were each used for 2030, 2070 and 2090 scenarios, to reflect the more pronounced level of uncertainty as the timescale of the projection is extended.

Further detail on the methodology and sources used to obtain the climate projections for the study area are provided in Appendix H.

Risk assessment

The climate change risk assessment was undertaken using ARTC's climate change risk assessment framework. This included an assessment of severity or consequence of risks with respect to: safety; assets (closure of); finance; environment; regulatory involvement; reputation and schedule. Risk likelihood was assessed cumulatively over the applicable asset life. Each risk was rated as low, medium, high or very high. Risks identified as medium or higher were considered for mitigation.

Further detail on the methodology of the risk assessment is provided in Appendix H.

D4.2 Existing and future climate

D4.2.1 Existing climate

The overall climate of the study area is characterised by seasonal patterns in temperature and rainfall typical of inland NSW. Hot summers are characteristic of the area and with temperatures of 43 degrees Celsius or higher recorded during December and January.

Historical climate data obtained from the following Bureau of Meteorology weather stations at Trangie Research Station (ID 51049), Narrabri West Post Office (ID 53030) and Narrabri Airport AWS (ID 54038) indicated that over the recorded period:

- Yearly average temperatures have increased in the study area by approximately 0.2 to 0.6 degrees Celsius per decade
- Total annual rainfall has decreased between 0 to 10 millimetres (mm) per decade
- The highest recorded rainfall occurs during the December to February period
- Narrabri experiences a higher volume of rainfall during summer than Narromine; however, both locations have similar average temperature ranges
- The general climatic conditions and the type of climate experienced have low variability.

D4.2.2 Climate projections

A summary of climate projections for Narromine and Narrabri for 2030 to 2090 is provided in Table D4.1. Detailed climate change predictions adopted for the risk assessment are listed in tables H-4 and H-5 in Appendix H.

TABLE D4.1 OVERVIEW OF FUTURE CLIMATE

Attribute	Climate projection
Temperature	Temperatures are projected to increase by an average of 0.6 to 1.5°C by 2030, with average temperatures increasing by 3.1 to 5.2°C by 2090 and maximum temperatures increasing by 3.3 to 5.6°C. Days with maximum temperatures above 35°C are projected to experience an approximate threefold increase in frequency by 2090. The incidence of days over 40°C is projected to increase up to eightfold. Days with maximum temperatures over 45°C are currently very uncommon in the region between Narromine and Narrabri, with the incidence averaging less than once in 5 years. By 2090, they could occur one to five times per year.
Rainfall	Average annual rainfall is projected to change marginally by 2030; however, by 2090, annual rainfall could decrease from 500 mm to 400 mm at Narromine and from 650 mm at Narrabri to 550 mm. Summer rainfall is generally projected to increase but winter and spring rainfall is projected to fall by 2090. Extreme daily rainfall totals are projected to increase in line with air temperature and, under a 2090 scenario, daily rainfall totals could increase from 160 mm at Narrabri to as much as 200 mm. Australian Rainfall and Run-off projects that extreme daily rainfall events could increase by approximately 21.3% from historical levels by 2090.
Windspeed	Average wind speeds are not projected to change significantly with climate change by 2090. Winds are projected to remain stronger through spring and early summer than at other times of the year and may weaken slightly at other times.

Attribute	Climate projection
Humidity and evaporation	Relative humidity is projected to decline slightly in eastern Australia. Potential evapotranspiration will increase with temperature, with the change projected to be less than 5% by 2030 and as much as 10–20% by 2090 (RCP8.5; Kirono and Wilson, 2015).
River and storm water flows, groundwater recharge	Soil water storage is projected to change in line with rainfall and potential evaporation. It is projected to decline in eastern Australia in all seasons (Mpelasoka et al., 2015) but by a greater extent during winter and spring, due to rising temperatures and declining rainfall in those seasons. Drier soils will lead to reductions in annual average run-off, river flows (by up to 60% in eastern Australia) and groundwater recharge. Due to increased intensity of extreme rainfall events, riverine floods may be enhanced by climate change.

Climate change variables

The following climate change variables were identified for the proposal based on the location of the proposal and the projected climate conditions:

- Increased frequency and intensity of rainfall events resulting in river and stormwater flooding
- Increase in bushfires and fire weather conditions
- Drought
- Increase in extreme weather events and storms
- Extreme high temperatures
- Combined changing climatic conditions.

D4.3 Assessment results

A total of 39 climate change risks were identified as part of the climate change risk assessment for the proposal. Of the risks identified, 1 was rated as very high, 6 risks were rated as high, 17 were rated as medium and 15 were rated as low.

Extreme rainfall events, flooding, increased periods of drought, extreme heat and increase in bushfire and fire weather conditions are expected to present the highest risks in the future. Risks associated with these events involve:

- Increased flooding, resulting in inundation of rail infrastructure, drainage systems, structural scouring, wash out of foundations and inundation of water-sensitive assets (such as electrical equipment)
- Changing flood patterns and behaviour
- Increased incidents of extreme events (heat, rainfall and bushfire) resulting in impacts on power supply, network interruption, track buckling and disruption of service
- Increase in incidence of dangerous fire weather conditions and, possibly, uncontrollable fires resulting in damage to infrastructure, operational costs, power failure, stoppage of freight and associated impacts.

Table D4.2 lists the risks rated as medium and higher prior to the implementation of mitigation. The full results of the risk assessment are provided in Appendix H, Table H-7.

TABLE D4.2 CLIMATE CHANGE RISKS RATED MEDIUM OR HIGHER (PRIOR TO MITIGATION)

Climate hazard	Risk impact description	Risk rating
Temperature increase—more hot days and warm spells	Increased risk to business continuity as a result of increased heat events (e.g. increased incidence of delayed services).	Medium
	Increase in hot days results in track twisting (buckling), which could lead to derailment of trains along the rail line.	Medium
	Increased extremes of heat lead to increased power demand and/or failure of power infrastructure (i.e. substations, LV/HV switchboards) resulting in interruptions to mains power supply with increased frequency and duration of power outages.	Medium

Climate hazard	Risk impact description	Risk rating
Increased intensity of extreme rainfall events	Increased frequency of extreme rainfall events leads to flash flooding events, which increases risk to health and safety of staff (e.g. conductor, emergency crews) working along the rail corridor due to velocity and flow of flooding.	Medium
	More intense rainfall (and increased runoff volume from catchment) could lead to flooding of tracks and assets, inundation of drainage infrastructure and damage due to scour.	High
	More intense rainfall could lead to flooding of tracks and assets and inundation of drainage infrastructure, reducing the safety of running conditions with resulting service disruption.	High
	Increase in intense rainfall could result in overtopping, leading to damaged infrastructure.	Very high
	More intense extreme rainfall events lead to longitudinal scour through water running along embankment, impacting on embankment.	High
	Increased extreme rainfall results in inundation of adjacent road network and signalling equipment, causing potential isolation of assets due to flooding.	Medium
	More intense extreme rainfall events lead to flooding of tracks and assets, inundation of drainage infrastructure, increasing maintenance and insurance premiums costs.	Medium
	More intense extreme rainfall events lead to inundation of adjacent road network impacting on ability of emergency response to reach the corridor.	Medium
	Increased frequency and intensity of extreme rainfall and flooding causing damage to non-rail structures potentially impacting operations.	Medium
	The projected periodic extreme dry and wet periods may increase the potential for erosion of substrate and ballast materials, causing increase washout. This could cause infrastructure instability, train derailment and disruption in the event of collapse.	Medium
	Increased intense rainfall and flooding resulting in scour damage to adjacent properties.	High
	Climate change projects a greater incidence of flooding, greater afflux and potentially more debris as a result of temperature changes. Potential blockages of drainage infrastructure caused by the movement of debris during flood.	Medium
	Increased rainfall intensities lead to greater discharges, which leads to increased hydraulic impacts (e.g. afflux) on adjacent properties.	High
Decrease in average rainfall	Structural deterioration, soil subsidence, erosion, movement and cracking, as a result of increased variability of periods of wetting and drying (especially periods where there is a swift transition from dry to wet), reducing integrity of tracks, bridges, embankments and signalling infrastructure, with potential structural failure.	Medium
Increase in extreme weather events and storms	Increase in the frequency and intensity of storm events results in closure of rail line (due to damage to communications equipment, for safety purposes or loss of power supply/increased frequency and duration of power outages) with subsequent delays.	Medium
	Increase in the frequency and intensity of storm events and subsequent higher winds, resulting in damage to level crossings and associated signage, resulting in safety issues for trains and motorists.	Medium
Harsher fire-weather conditions	Increase in the frequency and intensity of bushfires, which cause greater-than-expected damage to rail infrastructure, including trackside infrastructure (e.g. signals and communications equipment requiring increased operational costs).	Medium
	Increased frequency and intensity of bushfire events leads to damage to power supply infrastructure or a need to cut supply, resulting in interruptions to power supply (particularly signalling and communications equipment) with increased frequency and duration of power outages.	Medium

Climate hazard	Risk impact description	Risk rating
Harsher fire-weather conditions [continued]	Increase in the frequency and intensity of bushfire events along the Inland Rail corridor, resulting in stoppage of freight along the rail and subsequent severing of community evacuation and County Fire Authority access/egress points.	High
	Increase in the frequency and intensity of bushfire events along the Inland Rail corridor, resulting in more frequent stoppage of freight along the rail and subsequent impacts on customer goods not being delivered.	Medium

D4.4 Mitigation and management

D4.4.1 Approach

Approach to mitigation and management

Climate change

The outcome of the climate change risk assessment is a priority list of risks for which a range of possible adaptation responses can be developed. Some identified risks may require immediate practical adaptation response or modifications to design, while others may require further investigation.

The suggested adaptation measures for the proposal, developed as an outcome of the climate change risk assessment, are listed in Appendix H (Table H-8). These measures would be considered to reduce the impact of climate change risks to the proposal. The identified measures include a combination of risk-avoidance measures, design considerations, where possible and practicable, as well as procedures for the management of risks that may be unavoidable.

Example adaptation measures include:

- Accounting for climate change throughout the design process for critical assets/infrastructure
- Ensuring specifications for temperature tolerance of electrical and electronic equipment allows for future climate change (taking into account its intended lifespan)
- Investigating the potential to future-proof power supply design to allow for replacement and upgrade to more resilient technology.

Further consideration of the potential for climate change risks would be undertaken to support detailed design. This would include updating the climate change risk assessment in accordance with *AS 5334-2013 Climate change adaptation for settlements and infrastructure—A risk based approach* (Standards Australia, 2013) and the Technical Guide. The risks and potential adaptations identified by the preliminary assessment would be considered and adaptation measures implemented where reasonable and feasible.

The sustainability management plan for the proposal (described in chapter D5) would include the adaption measures actions relevant to the proposal.

These measures would be reviewed as part of the detailed design process, and incorporated into the design and operating procedures as far as practicable.

Expected effectiveness

The proposed management measures provided in section D4.4.2 have been developed to provide a pathway to achieving Inland Rail's climate change commitments. These are consistent with those implemented on similar infrastructure projects and are expected to be effective.

Interaction between measures

The sustainability management plan would be considered during development of the proposal's CEMP and operational environmental management plan (described in chapter D5) to ensure consistency with regards to the approach to sustainability and climate change.

Climate change risk adaptation measures would be incorporated into the sustainability management plan. The climate change adaptation measures are provided in Appendix H.

D4.4.2 List of mitigation measures

Measures that will be implemented to address potential climate change impacts are provided in Table D4.3.

TABLE D4.3 CLIMATE CHANGE MITIGATION MEASURES

Stage	Ref	Impact/issue	Mitigation measures
Detailed design/ pre-construction	CC1	*Climate change risk management*	The climate change risk assessment would continue to be refined as the design of the proposal progresses. The adaptation measures identified for the proposal would be reviewed and final measures would be incorporated into the design where practicable.
Construction	CC2	*Climate change risk management*	The adaptation measures identified for the proposal would be reviewed and final measures would be implemented during construction as far as practicable.
Operation	CC3	*Climate change risk management*	Operational management and maintenance procedures would address potential climate change risks and adaptation measures.