# CHAPTER 25

# Climate change risk adaptation and greenhouse gas

**ALBURY TO ILLABO** ENVIRONMENTAL IMPACT STATEMENT

ARTC | INLAND RAIL
An Australian Government Initiative

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# 25. Climate change risk adaptation and greenhouse gas

## 25.1 Summary

A preliminary climate change assessment was undertaken to consider climate change risks, opportunities and adaptations to inform the design process. During both construction and operation, risks to rail infrastructure from the increased frequency and intensity of extreme weather events, increased rainfall, bushfires and rising temperatures are considered likely. The sustainability management plan for the proposal adopts a combined mitigation and management approach that addresses the avoidance of risk, designing out risk where possible and practicable, as well as outlining procedures for the management of risks that may be unavoidable. Further consideration of the potential for climate change risks would be undertaken to support detailed design.

A preliminary greenhouse gas (GHG) assessment of Scope 1 sources[1] was undertaken based on current design information and construction methods. The proposal would bring a small increase in GHG emissions through combustion of diesel fuel by plant, equipment and vehicles during construction and maintenance and loss of carbon sequestration through vegetation clearance. However, the Inland Rail program is expected to reduce carbon emissions by 750,000 tonnes per year from 2050 and bring a net GHG emission improvement by moving a higher proportion of freight from road to rail.

The proposal would be constructed and operated in accordance with the *Inland Rail Environment and Sustainability Policy* (ARTC, 2021) and *Sustainability Strategy* (ARTC, 2020b) and include the implementation of a Sustainability Management Plan and the pursuit of an Inland Rail program 'Excellent' rating against version 1.2 of the IS rating scheme.

## 25.2 Climate change risk and adaptation

### 25.2.1 Approach

This chapter provides a summary of the climate change risk assessment, and assessment of greenhouse gas emissions of the Albury to Illabo (A2I) section of the Inland Rail program (the proposal). This assessment also considers the requirements outlined in the Infrastructure Sustainability Council (ISC) Infrastructure Sustainability (IS) rating scheme v1.2 for climate change (IS credits Cli-1 and Cli-2) and the Inland Rail Climate Change Risk Assessment Framework.

#### Secretary's Environmental Assessment Requirements

The Secretary's Environmental Assessment Requirements (SEARs) related to the climate change risk assessment, and where in the EIS these have been addressed, are detailed in Appendix A: Secretary's Environmental Assessment Requirements.

#### Relevant legislation, policies and guidelines

Relevant policies, guidelines and standards to this assessment include:

- *ARTC Inland Rail Climate Change Risk Assessment Framework*
- *National Climate Resilience and Adaptation Strategy* (Department of the Environment, 2015a)
- *National Greenhouse and Energy Reporting Act 2007* (Cth)
- *Environment Protection and Biodiversity Conservation Act 1999* (Cth)
- *AS 5334:2013 Climate Change Adaptation for Settlements and Infrastructure – A Risk Based* Approach (Standards Australia, 2013)
- *AS/NZS ISO 31000:2018 (AS/NZS 2018) Risk Management – Principles and Guidelines* (Standards Australia, 2018)
- *Climate Change Impacts and Risk Management –A Guide for Business and Government* (Department of Environment and Heritage and Australian Greenhouse Office, 2006)
- *Climate Change in Australia: Projections for Australia's NRM Regions - Central Slopes Cluster Report* (CSIRO and Bureau of Meteorology (BoM), 2015a)

[1] Scope 1 emissions are direct GHG emissions. These emissions are produced from sources that are owned or controlled by the company.

- *Guide to Climate Change Risk Assessment for NSW Local Government* (Office of Environment and Heritage (OEH), 2011a)
- Checklist for best practice adaptation planning and implementation (OEH, undated)
- Transport for New South Wales' *Climate Risk Assessment Guidelines* (Transport for NSW (TfNSW), 2021b)
- *Technical Guide for Climate Change Adaptation for the State Road Network* (RMS, in draft)
- *Biodiversity Conservation Act 2016* (NSW)
- *Infrastructure Sustainability Planning Guidelines V1.2* (ISCA, 2016)
- *Infrastructure Sustainability Technical Manual V1.2* (ISCA, 2018)
- *Infrastructure Sustainability Rating Tool Scorecard V1.2* (ISCA, 2020 release).

Further detail on key international, national, and state policies and guidelines is provided in Table 25-1.

**TABLE 25-1 KEY POLICY AND GUIDELINES**

| Legislation, policy or guideline | Relevance to the proposal |
|---|---|
| **International** | |
| Paris Agreement under the United Nations Framework Convention on Climate Change | In 2015, the Australian Government announced its commitment to a target of reducing GHG emissions by 26 to 28 per cent below 2005 levels by 2030, building on its previous target of 5 per cent below 2000 emission levels by 2020, irrespective of what other countries do. The Australian Government submitted this new target as its intended nationally determined contribution to the United Nations Framework Convention on Climate Change for negotiation at the 21st Conference of the Parties (COP21) held in Paris in December 2015. Key outcomes of the Paris Agreement include (Department of Foreign Affairs and Trade, 2016):<br>▸ a target to keep global temperature increase to well below 2°C and pursue efforts to keep warming below 1.5°C above pre-industrial levels<br>▸ all countries to set emissions reduction targets from 2020, with an agreement to review and strengthen targets every five years<br>▸ transparency and accountability rules to provide confidence in countries' actions and track progress towards targets<br>▸ promoting action to adapt and build resilience to climate impacts<br>▸ financial, technological and capacity building support to help developing countries implement the Agreement. |
| **National** | |
| Australian Government's Direct Action Plan | The plan sets out how the 2030 emissions reduction target will be achieved. The Emissions Reduction Fund, as part of the Direct Action Plan, aims to reduce Australia's GHG emissions by creating positive incentives to adopt better technologies and practices to reduce emissions. |
| Australian Government's National Climate Resilience and Adaptation Strategy | The strategy was released on 2 December 2015 and provides a set of principles to guide effective adaptation and build the resilience of communities, the economy and the environment. The guiding principles include priorities for shared responsibility, climate change risks factored into decision making, a risk-management approach based on the best available scientific data, assisting the vulnerable, collaboration with stakeholders, and the need to revisit decisions and outcomes over time. |
| **State (NSW)** | |
| *Climate Change Policy Framework for NSW* | The policy aims to maximise the economic, social and environmental wellbeing of NSW in the context of a changing climate. The framework considers current and emerging policy settings both nationally and internationally. The framework sets out two aspirational long-term objectives; achieve net-zero emissions by 2050 and make NSW more resilient to a changing climate. In making NSW more resilient to a changing climate, the NSW Government role includes:<br>▸ implementing policies to plan for climate change risks and provide targeted support<br>▸ assessing and effectively managing climate change risk to government assets and services<br>▸ advocating for action to support effective adaptation. |
| *Technical Guide for Climate Change Adaptation for the State Road Network* (draft) | The draft provides guidance for state road network projects that require climate change adaptation in response to changes in climate processes. While the Technical Guide has been developed considering the former Roads and Maritime Services (RMS) processes, it aligns with the broader NSW Government initiatives and programs responding to climate change impacts and, as a result, been referenced within the SEARs for the proposal. |

### Methodology

A climate change risk assessment has been undertaken for the proposal in accordance with the climate change risk assessment process developed by ARTC for the entire Inland Rail program. A proposal-specific assessment was carried out in line with the program-wide assessment, with specific risks and adaptation measures proposed, where appropriate.

The climate change impact assessment has followed the following approach:

- review of existing environment, climate change data and projections based on the data available from the Australian Bureau of Meteorology (BOM), the NSW and ACT Regional Climate Modelling (NARCliM)
- assessment of the proposal in response to the risk identified for a Representative Concentration Pathway (RCP) 8.5 against near future (2030) and far future (2090) time frames to identify proposal-specific impacts
- identification of adaptation actions based on the potential risks and impacts identified within the risk assessment
- reassessment to determine residual risk and ongoing management strategies.

The assessment of climate change risk and vulnerability was undertaken in accordance with relevant legislation and guidelines, including with *AS5334-2013 Climate change adaptation for settlements and infrastructure – a risk-based approach and satisfy climate risk* (Standards Australia, 2013), *AS/NZS ISO31000-2018 Risk management – principles and guidelines* (Standards Australia, 2018), the climate adaptation requirements of the IS rating tool and ARTC's Inland Rail Project Risk Management Framework. It has also taken into consideration state-specific guidance documents, such as Transport for New South Wales' *Climate Risk Assessment Guidelines* (TfNSW, 2021b).

The assessment considered climate projections at a 10-km resolution (NARCliM) with specific adaptation actions incorporated within the proposal as measures to mitigate the impact of the associated climate change risk.

As ARTC do not own and/or operate rollingstock, nor has the proposal included rollingstock, consideration about impacts resulting from climate change towards rollingstock has not been included in the scope of this assessment. In certain instances where impacts to rollingstock would have an impact on operation or maintenance of the proposal (indirect impacts), consideration was given in the risk assessment and through the identification of adaptation responses.

## 25.2.2 Existing and future climate

In 2016, for the first time, global temperatures had been confirmed to have risen by 1°C since pre-industrial levels. The Paris Climate Change Accord (effective 4 November 2016) seeks to limit climate change to under 2°C with a target of 1.5°C (United Nations Framework Convention on Climate Change (UNFCCC), 2016). Seeking to achieve these targets presents a significant challenge and, even at 1°C, the earth's climate and weather systems are experiencing considerable changes.

The State of the Climate 2020 confirms the long-term warming trend over Australia's land and oceans, showing that Australia's climate has warmed by 1.44°C since 1910. The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (IPCC, 2021) states with high confidence that Australia is already experiencing impacts from recent climate change, including a greater frequency and severity of extreme weather events. Other observed trends include an increase in record hot days, a decrease in record cold days and increases in extreme fire weather.

### Observed local climate

The proposal is located within the Murray Murrumbidgee climate region, including the NSW side of the Murray River. Lying west of the Great Dividing Range, the landscape is dominated by large floodplains and unconfined river valleys.

According to the *AdaptNSW Murray Murrumbidgee Climate Change snapshot* (OEH, 2014b), the region experiences a very distinct seasonal variation in temperature. The average maximum temperatures during summer is 34°C and the average minimum temperature is 6°C in the region. The region also experiences around 50 cold nights (minimum temperatures below 2°C) per year.

Rainfall varies between 400–800 millimetres (mm) per annum in the south west slopes. Rainfall is relatively uniform throughout the year across much of the region, with marginally higher rainfall during winter and spring. The region has experienced considerable rainfall variability in the past with periods of both wetter and drier conditions. During much of the first half of the 20th century the region experienced drier conditions. The first decade of the 21st century saw a long period of below average rainfall during the Millennium Drought. This dry period ended with two of the wettest years on record for Australia (2010–2011), with 2010 being the third wettest year on record for NSW. Extreme fire weather conditions occur on average one day per year at Hay and five days per year at Wagga Wagga, and are more likely to occur in summer and spring months.

The closest BoM weather station to the proposal is located in Wagga Wagga. This station is located adjacent to the proposal and the data collected at this station is considered to be representative of the proposal site. Table 25-2 presents key local climatic conditions recorded by the weather station.

TABLE 25-2 WAGGA WAGGA WEATHER STATION KEY DATA

| Weather variable | Observed data |
|---|---|
| Month of highest mean rainfall | October |
| Average rainfall in month of maximum rainfall | 40 to 55.8 mm |
| Mean annual rainfall | 571 mm |
| Mean maximum temperature in summer | 29.6°C to 31.9°C |
| Mean maximum temperature in winter | 12.8°C to 17.4°C |

## Climate variables

Selecting relevant climate change variables is critical input to the climate change risk assessment process. Selection of these is based on the following factors related to the broader context and nature of the proposal:

- the location of the proposal in an area is projected for increased temperature and solar radiation
- the location of the proposal in an area subject to decreased annual rainfall resulting prolonged periods of drought
- the location of the proposal in an area projected for an increase in extreme rainfall with subsequent flooding of local waterways.

Primary climate effects are those climate variables that are directly influenced or changed as a result of global warming or climate change. These include things such as air and sea surface temperature, precipitation, wind and solar radiation. Secondary climate effects are those variables that are derived from primary effects that are still influenced by a changing climate. These include things such as increased risk of bush fire weather and drought.

The climate variables relevant to the proposal are:

- primary climate effects:
  - increase in mean surface temperature
  - reduced average annual rainfall
  - increased solar radiation
  - increased frequency and intensity of extreme rainfall
  - increased atmospheric carbon dioxide.
- secondary climate effects:
  - increased temperature and frequency of heatwaves
  - increased frequency of bushfire weather
  - increased frequency and intensity of flood and flash flood events
  - increased frequency and intensity of drought
  - increased frequency and intensity of storm events and wind speed

## Climate projections scenarios

In order to assess the level of climate change risks to the proposal, the current climate science and model projections have been investigated for the identified climate variables relevant to the proposal based on available data sources. Reflecting ARTC's commitment to future-proofing Inland Rail, and the requirements of the climate change credits in the IS rating scheme, this climate change risk assessment has used two data sources for climate change projections:

- AdaptNSW and NARCliM developed by the OEH (2014a; 2014b), which provide projections at the 10-km resolution
- Commonwealth Scientific and Industrial Research Organisation and Bureau of Meteorology Climate Futures (CSIRO and BoM, 2015b), which supplements the information available from the NARCliM projections for a number of key climate variables.

The CSIRO and BoM present climate data through the Climate Futures tool in the form of Cluster Reports, which are regional downscaled climate projects across eight regions in Australia. Based on the location of the proposal, the Central Slopes Cluster Report has been used to inform this assessment.

### Timescales

Rail infrastructure has a varied expected design life depending on the component. For the purposes of this assessment, it has been assumed that the following design lives would be applied to rail components:

- electrical, signalling and communications components—20 years
- earthworks—50 years
- concrete infrastructure (e.g. bridges, culverts, sleepers) and railway tracks—100 years.

Based on these design lives, construction of the proposal occurring in 2024 and the latest available climate data, the time periods selected for assessment are 2030 (near future) and 2090 (far future). 2030 was considered appropriate for short-term impacts on construction of the proposal (assuming construction would be finished by 2025 with initial operation occurring soon after). Climate change projections for 2090 are considered relevant to the longer term operation and maintenance of the proposal given the expected design life. Projections, where available, for 2070 were considered as a means of confirming long-term trends.

### Detailed projections

A summary of the current climate science available for the Murray Basin (Timbal B. et al., 2015) using the RCP 8.5 data and the *Murray Murrumbidgee Summary* (OEH, 2014c) using the Special Report on Emissions Scenarios (SRES) A2 data are provided in Table 25-3.

The RCP 8.5 data and SRES A2 data were used as current global emissions trajectory suggests the planet is tracking along these scenarios and represents a worst-case scenario to help guide risk assessment and adaptation planning.

**TABLE 25-3 DETAILED CLIMATE CHANGE PROJECTIONS FOR MURRAY BASIN/MURRAY MURRUMBIDGEE FROM INLAND RAIL CLIMATE CHANGE RISK ASSESSMENT FRAMEWORK**

| | | NarCliM AdaptNSW (OEH)/Climate Futures CSIRO and BOM | |
|---|---|---|---|
| | | SRES A2 High Emissions / RCP 8.5 High Emissions | |
| Climate variable | Baseline data | 2030 | 2090 |
| Temperature mean annual (°C) | – | 0.9 | 3.8 |
| Temperature max annual (°C) | – | 1.1 | 4.1 |
| Temperature min annual (°C) | – | 0.9 | 3.5 |
| Hot days (number over 35°C) | 7.1 | 12 | 29 |
| Frost days (number under 2°C) | 91 | 81 | 43 |
| Rainfall annual (%) | – | -1 | -5 |
| Rainfall summer (%) | – | 1 | 6 |
| Rainfall autumn (%) | – | -1 | 0 |
| Rainfall winter (%) | – | -5 | -13 |
| Rainfall spring (%) | – | -6 | -12 |
| Wind speed (%) | – | 0.1 | -0.6 |
| Solar radiation (%) | – | 1 | 2.2 |
| Number of severe fire danger days | 3.6 | 4.6 | 7.6 |

## 25.2.3 Potential impacts

There were 43 climate change risks identified as part of the risk assessment process for the proposal. Of these risks, seven were identified as relevant to the construction process, while 42 were considered relevant to operation of the proposal (with some risks relevant to both construction and operations). Table 25-4 presents the construction risks as well as their risk rating, while Table 25-5 presents the 'very high', 'high' and 'medium' risks considered relevant to the operation phase of the proposal. Risks that were identified as being 'low' have been considered within this process; however, are not a key focus area of the assessment.

Risks have been grouped by the following climate variables:

- extreme heat, temperature increase and solar radiation increase—9 risks
- extreme rainfall, reduced average rainfall—21 risks
- extreme weather events and storms—4 risks

- harsher fire weather—8 risks
- multi hazard event—1 risk.

## Construction

Due to previous events experienced in and around the rail corridor, and observed and projected trends, risks to rail infrastructure, by way of physical damage, delays in schedule and potential risks to human health and safety are likely. The increased frequency and intensity of extreme weather events, increased rainfall, bushfires and rising temperatures are already causing strain on existing rail networks and associated infrastructure.

Table 25-4, below, presents the climate change risks during the construction of the proposal prior to mitigation, for all risks identified as medium or above. Low risks have been excluded as they do not require the same level of consideration as the very high, high and medium risks.

**TABLE 25-4 CLIMATE CHANGE RISKS TO PROPOSAL CONSTRUCTION (2030) PRIOR TO MITIGATION**

| Risk ID | Risk impact description | Likelihood | Consequence | Risk rating | Risk type |
|---|---|---|---|---|---|
| **Climate hazard—increased intensity of extreme rainfall events** | | | | | |
| CCR 1 | Extreme rainfall and flooding resulting in delays to construction schedule and cost impacts | Possible | Major | High | Direct |

## Operation

Based on the climate change risk assessment for the proposal, extreme rainfall events, flooding and extreme heat will present the highest risk in both the near future and far future. Risks associated with these events involve:

- increased flooding, resulting in inundation of track and trackside infrastructure (signalling/communications equipment and drainage basins)
- increased incidents of extreme events (heat, rainfall and bushfire and more severe impacts of extreme events) leading to greater potential impacts on power supply and demand (both internal and external to the rail corridor), and network (communications) interruption
- increased heat events leading to track buckling and subsequent disruption of service.

Table 25-5 presents the very high, high and medium risks (excluding low risks) identified for the proposal during operation prior to mitigation for the period of 2030. Low risks have been excluded as they do not require the same level of consideration as the very high, high and medium risks.

**TABLE 25-5 CLIMATE CHANGE RISKS TO PROPOSAL OPERATION (2090) PRIOR TO MITIGATION**

| Risk ID | Risk impact description | Likelihood | Consequence | Risk rating | Risk type |
|---|---|---|---|---|---|
| **Climate hazard—Temperature increase: more hot days and warm spells** | | | | | |
| CCR 2 | Risk to business continuity as a result of heat event (e.g. increased incidence of delayed services) | Likely | Minor | Medium | Direct |
| CCR 3 | Increase in hot days resulting in track twisting (buckling), which could lead to derailment of trains along the rail line | Possible | Moderate | Medium | Direct |
| CCR 4 | Extreme heat leading to increased power demand and/or failure of power infrastructure (i.e. substations, low voltage (LV)/high voltage (HV) switchboards) resulting in interruptions to power mains supply with increased frequency and duration of power outages | Likely | Minor | Medium | Indirect |
| CCR 5 | Increased incidence of extreme heat limiting the ability for ARTC to attract workers due to undesirable conditions | Likely | Minor | Medium | Indirect |
| CCR 6 | Rollingstock or hot works igniting fire due to hot, dry and windy conditions | Likely | Minor | Medium | Direct |
| **Climate hazard—Increased intensity of extreme rainfall events** | | | | | |
| CCR 7 | Risk to health and safety of staff (e.g. conductor, emergency crews) working along the rail corridor due to velocity and flow of flooding (e.g. flash flooding events) | Likely | Minor | Medium | Direct |
| CCR 8 | 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 | Likely | Moderate | High | Direct |

| Risk ID | Risk impact description | Likelihood | Consequence | Risk rating | Risk type |
|---|---|---|---|---|---|
| CCR 9 | More intense rainfall could lead to flooding of tracks and assets, inundation of drainage infrastructure reducing the safety of running conditions with resulting service disruption. | Likely | Moderate | High | Direct |
| CCR 10 | Increase in intense rainfall could result in overtopping leading to damaged infrastructure | Likely | Major | Very High | Direct |
| CCR 11 | Longitudinal scour through water running along embankment, impacting on embankment | Likely | Moderate | High | Direct |
| CCR 12 | Inundation of adjacent road network and signalling equipment causing potential isolation of assets due to flooding | Likely | Minor | Medium | Direct |
| CCR 13 | More intense rainfall could lead to flooding of tracks and assets, inundation of drainage infrastructure, increasing maintenance and insurance premiums costs | Almost Certain | Minor | Medium | Direct |
| CCR 14 | Inundation of adjacent road network impacting on ability of emergency response to reach the corridor | Likely | Minor | Medium | Direct |
| CCR 15 | Extreme rainfall and flooding causing damage to non-rail structures potentially impacting operations | Possible | Moderate | Medium | Direct |
| CCR 16 | 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 | Possible | Moderate | Medium | Direct |
| CCR 17 | Increased intense rainfall and flooding resulting in scour damage to adjacent properties | Likely | Moderate | High | Direct |
| CCR 18 | Potential blockages of drainage infrastructure caused by the movement of debris during flood | Likely | Minor | Medium | Direct |
| CCR 19 | Increased rainfall intensities leading to greater discharges, which leads to increased hydraulic impacts (e.g. afflux) on adjacent properties | Likely | Moderate | High | Direct |
| **Climate hazard—Decrease in average rainfall** | | | | | |
| CCR 20 | Structural deterioration, soil subsidence, erosion, movement and cracking as a result of increased variability of periods of wetting and drying, reducing integrity of tracks, bridges, embankments and signalling infrastructure with potential structural failure | Unlikely | Major | Medium | Direct |
| CCR 21 | Structural deterioration, soil subsidence, erosion, movement and cracking as a result of increased variability of periods of wetting and drying, causing increases in monitoring and maintenance programs | Likely | Minor | Medium | Direct |
| **Climate hazard – Increase in extreme weather events and storms** | | | | | |
| CCR 22 | Damage to tracks/siding, electrical, communications infrastructure and other structures due to higher wind speeds and falling debris requiring repair and/or replacement and an increase in capital costs | Possible | Moderate | Medium | Direct |
| **Climate hazard—Harsher fire-weather conditions** | | | | | |
| CCR 23 | Bushfire damaging rail infrastructure including trackside infrastructure (e.g. signals, communications equipment requiring increased operational costs) | Possible | Moderate | Medium | Direct |
| CCR 24 | Bushfire events leading 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 | Possible | Moderate | Medium | Indirect |
| CCR 25 | Bushfire event along the Inland Rail corridor, resulting in stoppage of freight along the rail and subsequent severing of community evacuation and access/egress points for emergency services | Possible | Major | High | Indirect |

### 25.2.4 Mitigation and management

## Approach to mitigation and management

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.

Table 25-6 outlines associated mitigation and adaptation measures to reduce the impact of climate change risks to the proposal for all of the risks deemed 'high' or 'very high' prior to mitigation. Identified measures include a combined approach that addresses the avoidance of risk, designing out risk where possible and practicable, as well as procedures for the management of risks that may be unavoidable.

The adaptation options identified below have been either integrated into the design and current procedures or are scheduled to be addressed in the detailed design and delivery of the proposal.

The sustainability management plan for the proposal Chapter 27: Approach to mitigation and management would include the adaption measures actions relevant to the proposal.

**TABLE 25-6 CURRENT AND PLANNED ADAPTATION OPTIONS**

| Risk ID | Risk impact description | Adaptation measure | Timing |
|---|---|---|---|
| **Climate hazard—Increased intensity of extreme rainfall events** | | | |
| CCR 1 | Extreme rainfall and flooding resulting in delays to construction schedule and cost impacts | Ensure appropriate planning, safety procedures and programming allows for work to stop during extreme weather events. Suitable planning should be in place to safely secure and relocate any construction equipment, and all staff are aware of safety procedures in an extreme weather event. | Construction |
| CCR 8 | 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 | **Design**<br>Qualitative and quantitative flooding assessment has been conducted on the reference design. Where quantitative flood modelling has been completed, an RCP8.5 climate change model has been completed. In all cases, it has been shown that the flood modelling impact to the enhancement sites does not change when considering an RCP8.5 flood model.<br>Further consideration of flooding is to be undertaken during detailed design.<br>Where feasible, opportunities for improvements/adaptations would be included in the reporting.<br>The detailed design is to nominate specific treatments where needed.<br>**Operation**<br>Monitoring and responding to extreme weather events procedure. | Reference design<br>Detailed design<br>Operation |
| CCR 9 | More intense rainfall could lead to flooding of tracks and assets, inundation of drainage infrastructure reducing the safety of running conditions with resulting service disruption | | |
| CCR 10 | Increase in intense rainfall could result in overtopping leading to damaged infrastructure | | |
| CCR 11 | Longitudinal scour through water running along embankment, impacting on embankment | Drainage and flooding velocities at rail embankment have been considered in the flooding assessment and, with consideration of the RCP8.5 flood model, there is negligible change based on the reference design.<br>Further consideration of longitudinal scour is to be undertaken during detailed design.<br>Where feasible, opportunities for improvements/adaptations would be included in the reporting such as riprap or other mattress type erosion controlling systems. | Reference design<br>Detailed design |
| CCR 17 | Increased intense rainfall and flooding resulting in scour damage to adjacent properties | Drainage and flooding velocities have been considered in the flooding assessment, and with consideration of the RCP8.5 flood model, there is negligible change based on the reference design.<br>Further consideration of scour to adjacent properties is to be undertaken during detailed design.<br>Where feasible, opportunities for improvements/adaptations to reduce potential scour damage would be included in the reporting. | Reference design<br>Detailed design and construction |
| CCR 19 | Increased rainfall intensities leading to greater discharges, | Qualitative and quantitative flooding assessment has been conducted on the reference design. Flood | Reference design |

| Risk ID | Risk impact description | Adaptation measure | Timing |
|---|---|---|---|
| | which leads to increased hydraulic impacts (e.g. afflux) on adjacent properties | assessment demonstrates afflux, velocity and hazard are compliant against the impact criteria, when considering the RCP8.5 flooding scenario.<br>Further consideration of discharge to adjacent properties is to be undertaken during detailed design.<br>Where feasible, opportunities for improvements/adaptations to reduce potential hydraulic damage would be included in the reporting. | Detailed design |
| **Climate hazard—Harsher fire-weather conditions** | | | |
| CCR 25 | Bushfire event along the Inland Rail corridor, resulting in stoppage of freight along the rail and subsequent severing of community evacuation and access/egress points for emergency access | Monitoring and responding to extreme weather events procedure. | Operation |

## List of mitigation measures

Measures that would be implemented to address potential climate change impacts are provided in Table 25-7.

**TABLE 25-7 CLIMATE CHANGE MITIGATION MEASURES**

| Stage | Ref | Impact/issue | Mitigation measure |
|---|---|---|---|
| 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 as described for CCR8, CCR9, CCR10, CCR11, CCR17 and CCR19 in Table 25-6. |
| 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 as described for CCR1, CCR8, CCR9, CCR10, CCR11, CCR17 and CCR19 in Table 25-6. |
| Operation | CC3 | Climate change risk management | Operational management and maintenance procedures would address potential climate change risks and adaptation measures as described for CCR8, CCR9, CCR10 and CCR25 in Table 25-6. |

## Effectiveness of mitigation measures

The proposed management measures have been developed to provide a pathway to achieving Inland Rail's climate change commitments outlined in the *Inland Rail Environment and Sustainability Policy* (ARTC, 2021), being 'Design for climate change resilience'. These are consistent with those implemented on similar infrastructure projects and are effective.

The mitigation measures would reduce the level of risk uncertainty that climate change poses to this proposal and, as such, a greater understanding of risk and degree of confidence can be placed in the design. The proposal is also targeting the following IS rating tool credits as follows:

- Cli-1 Climate change risk assessment
- Cli-2 Adaptation measures.

Achievement of these credits would verify the proposal's response to climate change risk assessment and adaptation against the industry best-practice approach.

## Interaction between mitigation measures

The sustainability management plan would be considered during development of the proposal's Construction Environmental Management Plan (CEMP) and operational environmental management plan (described in Chapter 27: Approach to mitigation and management) 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.

Mitigation measures that are relevant to the management of climate change risk impacts are included in:

- Chapter 18: Hydrology, flooding and water quality, specifically details measures that address detailed design and construction planning to respond to flooding risk at enhancement sites.

## Residual risk assessment

A residual risk assessment for the proposal was undertaken to apply the relevant adaptation measures identified in the above section for all 'very high' and 'high' risks. The residual risk assessment can be found below in Table 25-8. In addition, adaptation actions identified contributed towards treating all 'medium' risks, resulting in a number of those 'medium' risks having their corresponding residual risks revised to 'low'. Adaptation measures have been specifically identified and incorporated in the design to address specific climate change risks, which satisfies the SEARs. As a result of these adaptation measures, no residual 'very high' or 'high' risk ratings remain for the proposal.

While uncertainty regarding future climate projections exists, particularly to 2090, the adaptation measures identified as part of this climate change risk assessment would result in a lowering of residual risks to the rail corridor across future scenarios.

Residual risks rated as 'medium' would continue to be reviewed during detailed design to identify opportunities to further reduce these risks. This would be in line with proposal's target to achieve the above-mentioned IS rating tool credits.

**TABLE 25-8 CLIMATE CHANGE RESIDUAL RISK ASSESSMENT**

| Risk ID | Risk impact description | Risk rating (prior to mitigation) | Mitigation measures | Likelihood | Consequence | Risk rating | Risk type |
|---|---|---|---|---|---|---|---|
| **Climate hazard—Increased intensity of extreme rainfall events** | | | | | | | |
| CCR 1 | Extreme rainfall and flooding resulting in delays to construction schedule and cost impacts | High | CR2 | Possible | Moderate | Medium | Direct |
| CCR 8 | 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 | CC1, CC2, CC3 | Likely | Minor | Medium | Direct |
| CCR 9 | More intense rainfall could lead to flooding of tracks and assets, inundation of drainage infrastructure, reducing the safety of running conditions with resulting service disruption | High | CC1, CC2, CC3 | Possible | Minor | Medium | Direct |
| CCR 10 | Increase in intense rainfall could result in overtopping, leading to damaged infrastructure | Very High | CC1, CC2, CC3 | Possible | Minor | Low | Direct |
| CCR 11 | Longitudinal scour through water running along embankment, impacting on embankment | High | CC1, CC2 | Possible | Moderate | Medium | Direct |
| CCR 17 | Increased intense rainfall and flooding resulting in scour damage to adjacent properties | High | CC1, CC2 | Possible | Moderate | Medium | Direct |
| CCR 19 | Increased rainfall intensities leading to greater discharges, which leads to increased hydraulic impacts (e.g. afflux) on adjacent properties | High | CC1, CC2 | Possible | Moderate | Medium | Direct |

| Risk ID | Risk impact description | Risk rating (prior to mitigation) | Mitigation measures | Likelihood | Consequence | Risk rating | Risk type |
|---|---|---|---|---|---|---|---|
| **Climate hazard—Harsher fire-weather conditions** | | | | | | | |
| CCR 25 | Bushfire event along the Inland Rail corridor, resulting in stoppage of freight along the rail and subsequent severing of community evacuation and access/egress points for emergency services | High | CC3 | Unlikely | Major | Medium | Indirect |

## 25.3 Greenhouse gas and energy

### 25.3.1 Approach

#### Secretary's Environmental Assessment Requirements

The SEARs related to the GHG and energy made reference to the further assessment requirements identified in the Scoping Report for the proposal. This identified that a Scope 1 GHG assessment would be prepared based on the Australian National Greenhouse Accounts Factors 2008, prepared by the Australian Government Department of Climate Change.

Further detail is provided in Appendix A: Secretary's Environmental Assessment Requirements, including reference to where these have been addressed in the EIS.

#### Legislative and policy context

In 2015, the Australian Government announced a commitment to target a reduction in GHG emissions by 26 to 28 per cent below 2005 levels by 2030. This target was submitted to the UNFCCC at the 21st Conference of the Parties (COP21) that was held in Paris in December 2015. The Australian Government ratified the Paris Agreement on the 9th of November 2016. The Australian Government's *Direct Action Plan* (Department of Environment and Energy (DoEE), 2015) outlines policies that provide positive incentives for businesses and communities to reduce emissions, including the Emissions Reduction Fund and the Safeguard Mechanism to ensure that the 2030 emissions reduction target will be achieved.

The *National Greenhouse and Energy Reporting Act 2007* (Cth) (NGER Act) provides a national framework for corporations to report on GHG emissions and energy usage. Annual threshold values are specified for both facilities and corporations, where emissions must be reported if estimated emissions exceed the thresholds.

The National Greenhouse and Energy Reporting (Measurement) Determination 2008 provides methods for quantifying GHG emissions and energy usage from production and consumption of energy by a facility, and from operation of the facility.

In NSW, the NSW Climate Change Policy Framework commits NSW to the aspirational objectives of achieving net zero emissions by 2050 and helping NSW to become more resilient to a changing climate (OEH, 2016a).

#### Greenhouse Gas Protocol

The Greenhouse Gas Protocol establishes an international standard for accounting and reporting of GHG (World Resource Institute (WRI), 2004). The protocol describes a project's GHG emissions as being either direct or indirect, which can be delineated into the following three scopes for reporting purposes (also depicted in Figure 25-1):

- Scope 1 emissions are direct GHG emissions. These emissions are produced from sources that are owned or controlled by the company.
- Scope 2 emissions are electricity-related indirect GHG emissions. These emissions are created from offsite generation of electricity, which is purchased and consumed by the reporting company. The Scope 2 emissions are physically produced offsite, at the electricity generation facility.
- Scope 3 emissions are other indirect GHG emissions. These emissions are produced by sources that are not owned or controlled by the reporting company but are a result of the company's activities.

GHG emissions are reported in terms of tonnes of carbon dioxide equivalent (t $CO_2$-e), where a Global Warming Potential (GWP) index is applied to non-$CO_2$ gases to determine the equivalence. Some of the most commonly assessed GHGs are carbon dioxide ($CO_2$), sulphur hexafluoride ($SF_6$), methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs).

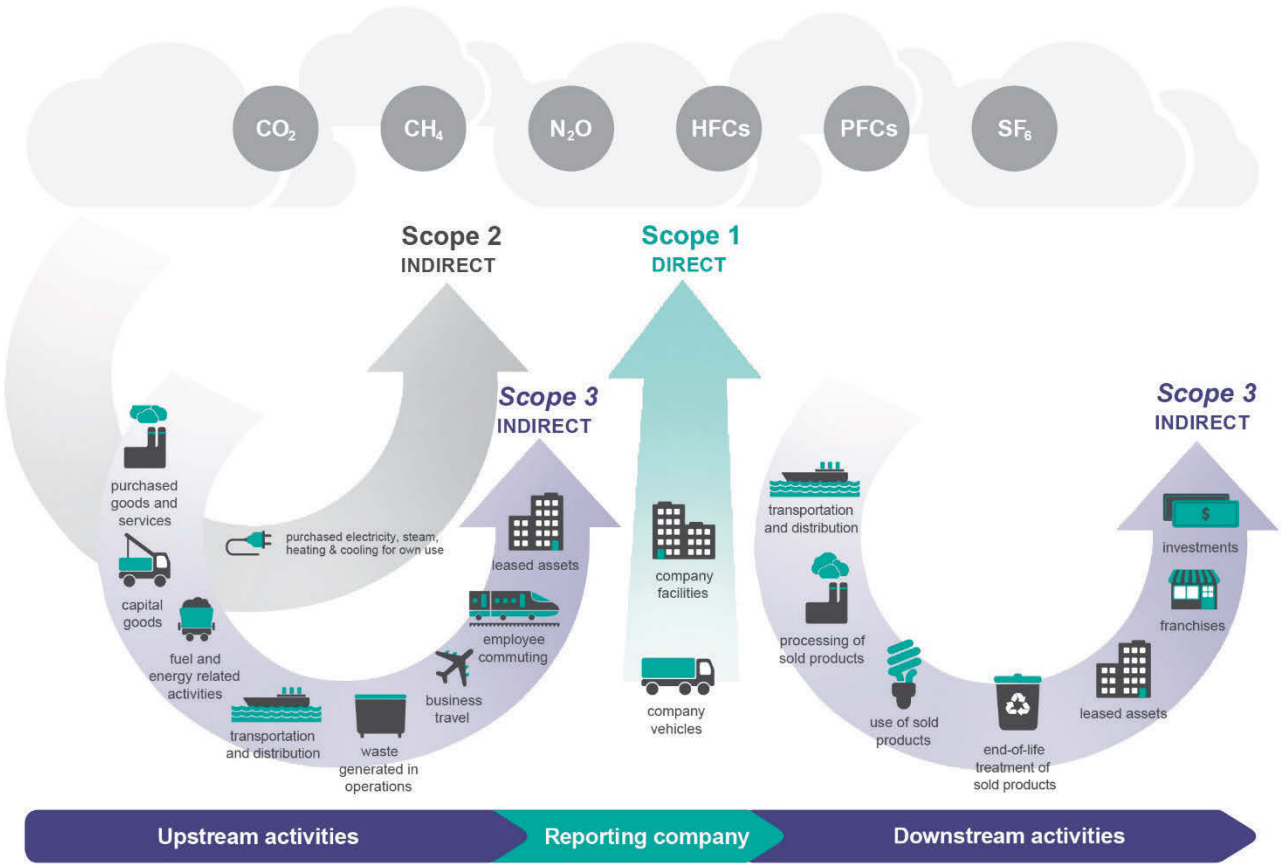


**FIGURE 25-10 OVERVIEW OF SCOPES AND EMISSIONS ACROSS A VALUE CHAIN (WRI, 2004)**

## Methodology

The methodology for this assessment has been based on the following tools and protocols:

- ARTC's Inland Rail Greenhouse Gas Assessment Tool
- National Greenhouse Accounts Factors (Department of Industry, Science, Energy and Resources, 2020).

The key tasks for the assessment involved:

- identification of the likely sources of GHG emissions associated with construction and operational phases of the proposal
- quantification of the GHG emissions associated with each GHG source (Scope 1)
- identification of opportunities (mitigation measures) to reduce GHG emissions.

The GHG assessment is a preliminary estimate based on current design information and construction methods. At the time of completing this assessment, only limited operational and maintenance detail was available. The assessment of operational energy use and associated GHG emissions was based on a 100-year design life.

As per section 6.13 of the Scoping Report, referenced by the SEARs, only Scope 1 sources have been considered, with emissions associated with the combustion of diesel from locomotive operations excluded on the basis that these are not the responsibility of the proponent. Other scope 2 and 3 sources are considered within the Infrastructure Sustainability Rating Tool.

### 25.3.2 Estimated greenhouse gas emissions

GHG emissions for the following sources were estimated for the proposal:

- loss of carbon sequestration (vegetation clearance)
- combustion of diesel fuel (by plant, equipment and vehicles) during construction and maintenance.

The estimated Scope 1 GHG emissions for the proposal is summarised in Table 25-9. Combustion of diesel fuel is expected to be the most significant construction phase source of GHG emissions. Loss of carbon sequestration is minor given majority of the proposal site has been previously disturbed.

The following provides an indicative understanding of activities most significantly contributing to this diesel consumption during construction:

- earthworks, structural works, trackwork (approximately 93 per cent)
- transport of bulk materials and deliveries (approximately four per cent)
- loss of carbon sequestration (approximately 3 per cent).

**TABLE 25-9 SUMMARY OF ESTIMATED CONSTRUCTION SCOPE 1 GREENHOUSE GAS EMISSIONS**

| Construction activity | Energy use (MJ) | Scope 1 emissions (T, $CO_2$-e) |
|---|---|---|
| **Construction** | | |
| Construction equipment | 629,787,049 | 44,211 |
| Transportation of materials | 16,322,782 | 1,151 |
| Loss of carbon sequestration (vegetation clearance) | - | 1,356 |
| **Sub-total** | **646,109,831** | **46,718** |
| **Operation** | | |
| Ongoing inspections and maintenance activities—vehicle fuel consumption emissions | 1,148,397 | 81 |
| Ongoing inspections and maintenance activities—equipment fuel consumption emissions | 12,154,361 | 853 |
| **Sub-total** | **13,302,758** | **934** |
| **Total** | **659,412,589** | **47,652** |

While the proposal would bring a small increase in operational GHG emissions when viewed as an individual package, one of the key benefits of the program is a reduction in GHG emissions. This would be achieved through the following program benefits:

- reduced road freight through major east coast highways and cities, reducing road-based transport emissions
- reduced congestion for other road users, bring improved efficiency for other road users
- faster, straighter, flatter transport pathway, reducing energy required for transport
- increased freight capacity, increasing scales of efficiency
- faster transport times, reducing idle and unnecessary fuel consumption.

The Inland Rail program is expected to bring a net GHG emission improvement compared to not completing the Inland Rail program. Moving freight by rail is four times more fuel efficient than moving freight by road. The Inland Rail program would reduce carbon emissions by 750,000 tonnes per year from 2050 (ARTC, 2015).

### 25.3.3 Mitigation and management

#### Approach to mitigation and management

The proposal would be constructed and operated in accordance with the *Inland Rail Environment and Sustainability Policy* (ARTC, 2021) and *Sustainability Strategy* (ARTC, 2020b). This outlines sustainability objectives, targets and commitments for the proposal, which includes minimisation of GHG emissions and sets a target for the Inland Rail program to reduce GHG emissions by 15 per cent across the design, construction and operation phases of the proposal. These commitments include the implementation of a Sustainability Management Plan, and the pursuit of an Inland Rail program 'Excellent' rating against version 1.2 of the IS rating scheme.

The Sustainability Management Plan would guide the design, construction and operation of the proposal including management measures to reduce GHG emissions from the proposal.

#### Mitigation measures

Measures that will be implemented to address GHG emissions are listed in Table 25-10.

**TABLE 25-10 GREENHOUSE GAS EMISSIONS MITIGATION MEASURES**

| Stage | Ref | Impact/issue | Mitigation measure |
|---|---|---|---|
| Pre-construction/ construction | GHG1 | GHG emissions | GHG emissions will be managed and minimised as part of the Sustainability Management Plan, which will be implemented to assist in pursuing 'Design' and 'As Built' rating targets of Excellent under the ISC rating scheme for the Inland Rail Program. |

## Effectiveness of mitigation measures

The proposed management measures have been developed to provide a pathway to achieving Inland Rail's sustainability commitments outlined in the *Inland Rail Environment and Sustainability Policy* (ARTC, 2021), being 'Reduce greenhouse gas emissions'. These are consistent with those implemented on similar infrastructure projects and are effective.

The proposal is also targeting the following IS rating tool credits:

- Ene-1 Energy and carbon monitoring and reduction
- Ene-2 Use of renewable energy.

Achievement of these credits would verify the proposal's response to GHG emissions and energy against industry best-practice approach.

## Interactions between mitigation measures

The sustainability management plan would be considered during development of the proposal's CEMP and operational environmental management plan (described in Chapter 27: Approach to mitigation and management) to ensure consistency with regards to the approach to minimising GHG emissions. Approaches to minimise GHG emissions measures would be incorporated into the sustainability management plan.

## Residual impacts

Residual impacts are impacts of the proposal that may remain after implementation of the management and mitigation measures detailed in this section and Table 25-10. These are summarised in Table 25-11.

Further information on the approach to the environmental risk assessment, including descriptions of criteria and risk ratings, is provided in Appendix E: Environmental risk assessment.

**TABLE 25-11 RESIDUAL RISK MANAGEMENT—GREENHOUSE GAS EMISSIONS**

| Stage | Potential impact | Pre-mitigated Rating | Mitigation measures | Residual risk rating | How residual impacts would be managed[1] |
|---|---|---|---|---|---|
| Construction | Emissions of GHGs during construction from embodied energy in materials, or emissions from construction plant and vehicles | Medium | GHG1 | Low | N/A |

1. For residual impacts with a risk rating of medium or above