adani™


Adani Mining Pty Ltd

# NORTH GALILEE BASIN RAIL PROJECT

## Environmental Impact Statement

## Chapter 17 Climate and natural hazards

November 2013

# Table of contents



# Table index



# Figure index

# 17. Climate and natural hazards

## 17.1 Introduction

### 17.1.1 Purpose of the chapter

This chapter identifies and assesses the climatic conditions and natural hazards that may affect the overall running and management of the site and should be considered during the planning, construction and operation of the North Galilee Basin Rail Project (NGBR Project). The assessment considers different climatic conditions along the approximately 300 km length of the final rail corridor (nominally 100 m wide) and provides an assessment of potential climate and natural hazard impacts relevant to the NGBR Project. The assessment takes into account the following variables:

- Temperature
- Extreme heat (days above 35 °C)
- Annual rainfall
- Windspeed
- Relative humidity
- Tropical cyclones
- Solar radiation
- Evaporation
- Bushfire risk
- Sea level rise.

An assessment of climate change related natural hazards has been conducted, measuring the possible frequency of identified hazards (likelihood) and potential consequence of the hazard occurring to determine an overall risk rating. Mitigation measures have been identified to reduce the likelihood and consequence of these impacts and their effects on the NGBR Project.

The impacts addressed within this chapter provide a description of the vulnerability of the NGBR Project to existing and future climatic conditions, including the effects of climate change. The desktop assessment and management of flood impacts are addressed as part of Volume 1 Chapter 9 Water resources and are not covered in this assessment.

This chapter relates specifically to existing climate and natural hazards, and should be read in conjunction with the following chapters:

- Volume 1 Chapter 9 Water resources
- Volume 1 Chapter 10 Air quality
- Volume 1 Chapter 11 Greenhouse gas
- Volume 1 Chapter 12 Noise and vibration
- Volume 1 Chapter 18 Hazard, risk, health and safety

This climate and natural hazards chapter was prepared in accordance with the Terms of Reference (TOR) for the NGBR Project. A table that cross-references the contents of this chapter and the TOR is included as Volume 2 Appendix A Terms of Reference cross-reference.

All mitigation and management measures identified in this chapter are included within Volume 2 Appendix P Environmental management plan framework.

## 17.2 Methodology

### 17.2.1 Study area

The study area for this climate and natural hazards chapter was defined by the meteorological regions intersected by the NGBR Project. These regions were represented by Bureau of Meteorology (BOM) weather stations located at Clermont, Collinsville and Bowen Airport.

### 17.2.2 Data sources

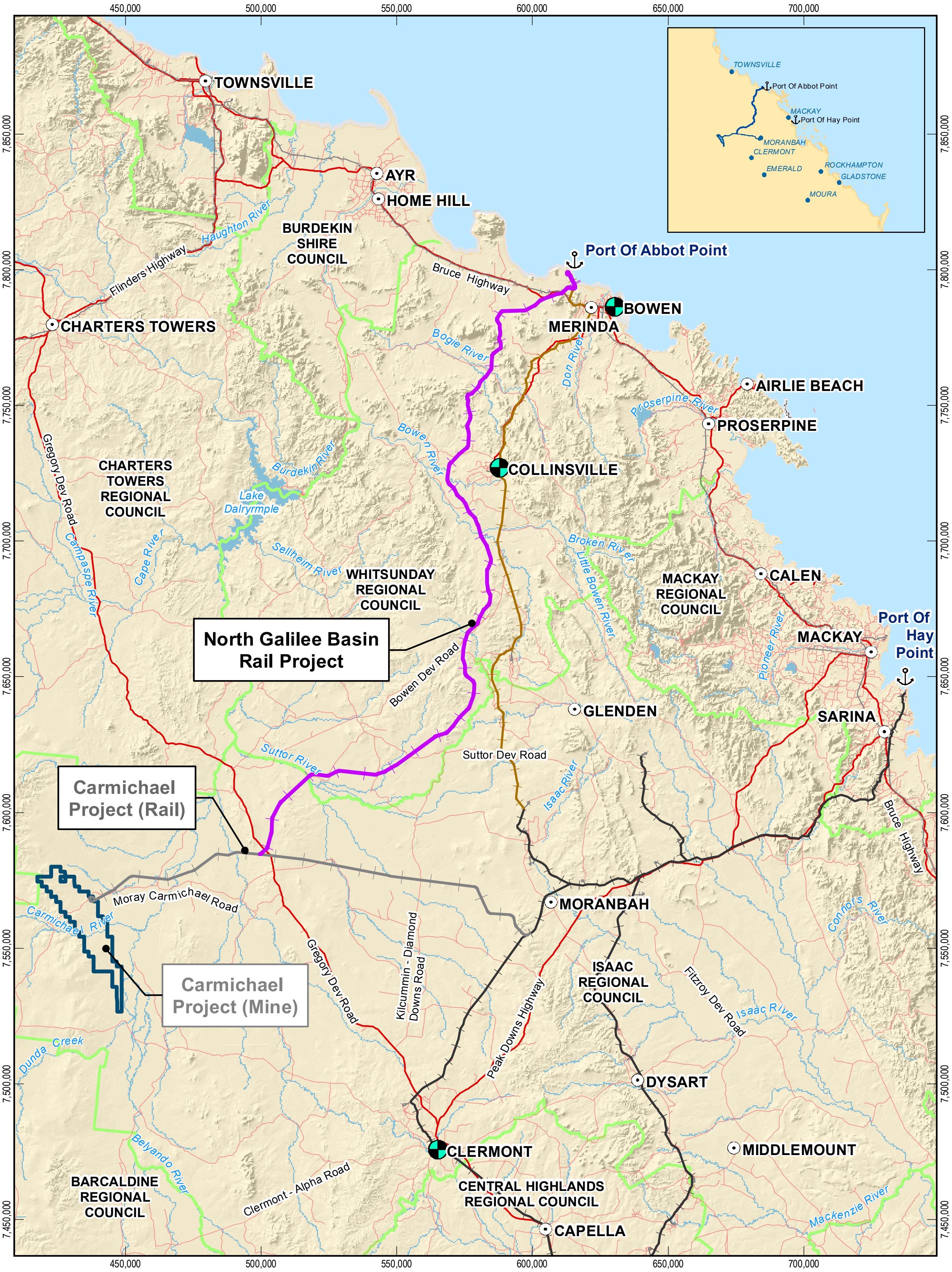
The existing climate was described with reference to data from weather stations operated by BOM. The final rail corridor is a nominal 100 m wide corridor that covers a range of climatic conditions from central inland highlands to coastal plains. These different climatic conditions result in corresponding variability in the type of weather and natural hazards likely to be experienced along the NGBR Project. As such, three reference points along the alignment were selected to best represent the different climatic environments. Historic weather records from the following BOM stations were collected:

- Clermont Post Office (site number 035019; 1910 – 2011), located approximately 100 km south east of the southern extent of the final rail corridor
- Collinsville Post Office (site number 033013; 1955 – 2013), located approximately 20 km south east of the final rail corridor near Collinsville
- Bowen Airport (site number 033257; 1907 – 2013), located approximately 10 km south east of the northern extent of the final rail corridor in the vicinity of Abbot Point. Note: the Bowen Airport weather station site was established in 1987. Bowen Post Office meteorology station, approximately 3.3 km from the Bowen Airport weather station, was used for historic weather data dating from 1907 to 1987.

The location of the weather stations in relation to the final rail corridor is shown in Figure 17-1.

Reference points chosen in the various NGBR Project technical reports are based on a specific analysis for that technical discipline. Data collected as part of the air quality assessment for the NGBR Project is reflected in this chapter to describe the existing environment, to the extent where there is correlation in the reference points used (namely Collinsville Post Office and Bowen Airport). Other reference points of the air quality assessment not referenced in this chapter – while satisfying particular technical requirements for air quality assessment – were not required to adequately represent the different climatic conditions identified for this chapter.

The methodology for the review of climatic characteristics, seasonal conditions and extreme climatic events in relation to the NGBR Project involved a literature review of relevant, available information. Climate projections utilised data from Local, State and Commonwealth Government sources, including the most current publications and data from BOM and the Commonwealth Scientific and Industrial Research Organisation (CSIRO).




LEGEND

- Town
- Major Port
- BOM weather station
- Major Road
- Minor Road
- Other Rail Network
- Goonyella System
- Newlands System
- Watercourse
- Local Government Area
- Carmichael Project (Rail)
- Carmichael Project (Mine)
- North Galilee Basin Rail



1:2,000,000 (at A4)

0 10 20 30 40 50

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

**Adani Mining Pty Ltd**
North Galilee Basin Rail Project

| | |
|---|---|
| Job Number | 41-26457 |
| Revision | A |
| Date | 29 Aug 2013 |

BOM weather station locations

Figure 17-1


G:\41\26457\06 GIS\Maps\MXD\0350_Climate_NatHaz\41_26457_0351_rev_a.mxd



Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com





Data Source: © Commonwealth of Australia (Geoscience Australia): Town, Railways, Watercourses (2007); DERM: LGA, (2011), Hillshade (2009); DMR: State Roads (2008); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011); Adani: Alignment Opt9 Rev3 (2012), NGBR: Alignment Opt6 Rev 2 (2013); GHD: Assessed weather location (2013). Created by: MS

### 17.2.3 Relevant legislation, policies and standards

The assessment was undertaken in accordance with the principles of the following legislative acts, policies and standards:

- *Disaster Management Act 2003*
- Mackay District Disaster Management Plan
- Isaac Regional Council and Whitsunday Regional Council disaster management plans
- State Planning Policy, Draft for Consultation (Department of State Development, Infrastructure and Planning 2013b)
- Queensland Coastal Plan – State Policy for Coastal Management (Department of Environment and Heritage Protection 2012)
- Coastal Protection State Planning Regulatory Provision (Department of State Development, Infrastructure and Planning 2013a)
- State Planning Policy 1/03, Mitigating the Adverse Impacts of Flood, Bushfire and Landslide (Department of Local Government and Planning 2003)
- AS/NZS ISO 31000:2009 Risk management – Principles and guidelines (Standards Australia 2009)
- HB 203:2012 Managing environment related risk (Standards Australia 2012)
- DR AS 5334 Draft for Public Comment Australian Standard, Climate change adaptation for settlements and infrastructure (Standards Australia 2011).

Descriptions of the above legislation and policies are provided in Volume 1 Chapter 20 Legislation and approvals.

### 17.2.4 Regional data

Localised rainfall data, mean wind speed, mean and maximum temperature for the three identified BOM stations was obtained from ClimSystems, a modelling software company who used an ensemble of up to 16 Global Climate Models (GCMs) to run data projections up to the period 2100. Mathematical simulations or computer models of the atmosphere and ocean are the principal tools for estimating the response of the climate to increases in greenhouse gases. The most sophisticated of these tools are the GCMs, which express mathematically what is known of the processes that dictate the behaviour of the atmosphere and the ocean.

ClimSystems use an ensemble of GCMs (which also includes data from the CSIRO model), to generate localised projections for a specific region from a baseline. Climate projections for the three BOM weather stations located at Clermont, Collinsville and Bowen were obtained using SimCLIM software to determine predicted change in rainfall under two scenarios:

- A1FI (2070 scenario) – long-term, extreme change scenario, outlines a future that remains largely fossil fuel intensive. This represents a long-term, extreme or near worst case scenario, useful to identify potential long-term challenges
- A1B (2030 scenario) – near-term moderate change scenario which outlines a balance across all energy sources, whereby there is no heavy reliance on one particular energy source, either renewables or fossil fuels. This represents a near-term moderate change scenario, used to represent a shorter term moderate scenario to be considered.

The two scenarios are the projections provided by CSIRO to give an estimate of the average climate around these years under future emission scenarios. The scenarios take into account the consistency among climate models. The 75$^{th}$ percentile variance change was used from the ClimSystems output data, to represent the extreme high percentiles for the 2030 and 2070 scenarios. Due to the large number of GCMs used for the model, the wide variance provides minor anomalies within the data set. Therefore the 75$^{th}$ percentile is considered a more conservative parameter to be used for the assessment. These scenarios were used as part of the climate and natural hazards assessment (refer Section 17.4.1) and do not describe the existing climatic conditions of the region.

### 17.2.5 Climate and natural hazard assessment

A climate and natural hazards risk assessment was undertaken, which included the following process:

- Conduct a literature review of existing climate conditions and natural hazard risks and climate change predictions
- Identify climate-sensitive infrastructure and assets that may be at risk under a potential climate change related natural hazard scenario
- Undertake a high level risk assessment in accordance with AS/NZS ISO 31000:2009 Risk management – Principles and Guidelines and Managing Environment Related Risk
- Develop appropriate possible mitigation measures.

Climate data and future projections were collated and the variation between the existing climate conditions and climate change projection were assessed to identify risks.

Each identified risk was analysed by estimating its likelihood and consequence of occurrence, as outlined in the risk matrix in Table 17-1. Descriptors for the scales of likelihood and consequence are outlined in Table 17-2 and Table 17-3 respectively.

Qualitative measures of consequence were developed based on the risk criteria outlined in the current AS 5334:2013 Climate change adaptation for settlements and infrastructure - A risk based approach.

Table 17-1 Risk matrix

| Likelihood | Consequence | | | | |
|---|---|---|---|---|---|
| | Major | Severe | Moderate | Minor | Insignificant |
| Almost certain | Extreme | Extreme | High | Medium | Medium |
| Likely | Extreme | Extreme | High | Medium | Medium |
| Possible | High | High | Medium | Medium | Low |
| Unlikely | High | Medium | Medium | Low | Low |
| Rare | Medium | Medium | Medium | Low | Low |

Table 17-2 Descriptors for the scales of likelihood of an event or risk arising

| Likelihood rating | Recurrent risks | Single event |
|---|---|---|
| Almost certain | Could occur several times per year | More likely than not – probability of occurring greater than 50% |
| Likely | May arise about once per year | As likely as not – 50/50 chance |
| Possible | May arise once in 10 years | Less likely than not but still appreciable – Probability less than 50% but still quite high |
| Unlikely | May arise once in 10 to 25 years | Unlikely but not negligible – Probability low but noticeably greater than zero |
| Rare | Unlikely during the next 25 years | Negligible – probability very small, close to zero |

Table 17-3 Descriptors for the scales of consequences associated with a risk

| Consequence descriptors | Asset delivery, reliability and management |
|---|---|
| Major | Long-term failure of significant infrastructure and service delivery affecting all parts of the community, ongoing external support at large scale required. |
| Severe | Mid to long-term failure of significant infrastructure and service delivery affecting large parts of the community, external support required. |
| Moderate | Midterm failure of (significant) infrastructure and service delivery affecting some parts of the community, widespread inconveniences. Repair/replacement expected to take greater than 72 hours. |
| Minor | Isolated cases of short- to mid-term failure of infrastructure and service delivery, localised inconvenience to the community and business anticipated to extend up to 72 hours. No long-term impact on integrity or operation of the infrastructure. |
| Insignficant | Inconsequential short-term failure of infrastructure and service delivery, no disruption to the public services and utilities. |

### 17.2.6 Qualifications

The local climate and seasonal conditions described in this chapter are based on relevant information available for the NGBR Project study area. Localised variation regarding the climate and extreme climatic events may exist which are not described or accounted for here. The level of detail of this assessment was limited to the information provided in the North Galilee Basin Railway Concept Design Report (Aarvee Associates 2013), as outlined in Volume 1 Chapter 2 Project description.

Climate change is an emerging issue and the effects are difficult to quantify but reasonable assumptions have been made as set out in this report. The understanding of climate change risks will continue to be refined during the detailed design stage and throughout the life of the NGBR Project.

Climate change projections are based upon assumptions about events and circumstances that have not yet transpired and accordingly, there is no assurance that projections are representative of the situation that will actually occur. Assessment information is provided as general guidance, and as core information that may be used to guide further investigation of impacts and mitigation measures.

## 17.3 Existing environment

### 17.3.1 Existing climate conditions

Rainfall, temperature, and humidity observations were analysed from various BOM climatic stations inland (Clermont and Collinsville Post Offices) and further along the coastal plains (Bowen Airport). The existing climatic conditions were found to differ between station locations. The NGBR Project footprint (defined by the final rail corridor and ancillary infrastructure) west of Moranbah and extending east to Collinsville is persistently dry and characterised by a sub-tropical climate. The final rail corridor to the east of Collinsville is considered sub-tropical to tropical, moving closer towards the coast.

**Temperature and humidity**

The long-term monthly mean temperatures observed at the inland sites show that daytime summer temperatures are mostly in the range of 29 to 38 °C, with winter overnight temperatures dropping to between three and 16 °C with a mean centred near 8 °C. Temperatures in the inland region vary between -3.2 °C and 44.4 °C.

‘Hot days’, those with temperatures exceeding 35 °C, can be expected between 35 to 74 days per year at inland sites where monitoring was conducted. ‘Frost days’, those with screen temperatures below 2 °C are rare at the inland sites with expected return rates of between 2 to 10 days per year.

In contrast, the temperature climatology assessment from the coastal station is more moderate, with the summertime maximum usually varying between 29 and 33 °C, and overnight winter minimum temperatures between 7 and 20 °C. Overall, the temperature varies between 3.2 °C and 39.4 °C during the period of record.

Relative humidity is highest in the mornings and lowest in the afternoons. The highest humidity tends to occur during February in the morning, with the lowest during the afternoon in September and October (inland stations) or July and August (coastal station).

**Rainfall**

Long-term rainfall records obtained from BOM indicate annual rainfall decreases with distance inland from the coast, with potential for short duration flood events from the months September through to May. There are distinct seasonal climatic conditions exhibited between the basins traversed by the NGBR Project. There is a pronounced wet summer and dry winter, with mean annual rainfall in the region ranging seasonally from less than 100 mm in the dry season to over 1,000 mm in the wet season.

The mean annual rainfall at all sites is dominated by the wet season (December to March) producing convectively driven rainfall. The proportion of summertime rainfall (December through

February) declines slightly with distance from the coast (61 per cent at the coastal station, to 50 per cent at the furthest inland station).

**Wind speed and direction**

Assessment of prevailing winds in this location north of the Tropic of Capricorn shows the trade winds out of the south-east sector are dominant, particularly when approaching the coast. The BOM station location closest to the coast has the highest average wind speed reflecting a more open exposure to the trade winds for the coastal region, with lower average wind speeds for inland stations. The strongest winds in all seasons are mostly from the south-east trade direction.

**Regional data**

A summary of the existing climate data for the three BOM weather station locations used to represent different climatic conditions along the NGBR Project is provided in Table 17-4.

Table 17-4 Existing climate conditions

| Station location | Data range (years) | Temperature range (average maximum) | Extreme heat – projected no. days >35 °C | Mean rainfall (mm/ year) | Mean wind speed 3 pm (km/h) | Mean relative humidity 9 am (%) | Solar radiation (MJ/m$^2$) |
|---|---|---|---|---|---|---|---|
| Clermont Post Office | 1962 - 2011 | 29.7 | 57.4 | 664.8 | 10.5 | 64 | 20.6 |
| Collinsville Post Office | 1957 - 2013 | 30.2 | 36.9 | 718.4 | 7.9 | 67 | 20.5 |
| Bowen Post Office & Bowen Airport | 1907 - 2013 | 28.8 | 1.6 | 961.3 | 22.9 | 73 | 21.5 |

### 17.3.2 Natural hazards

Based on the NGBR Project study area and regional geography, there are a number of natural hazards which have the potential to affect construction, operation or maintenance of the NGBR Project. The Queensland Government's State Planning Policy 1/03 states that a natural hazard is a naturally occurring situation or condition with the potential for loss or harm to the community or environment. Tropical cyclones, flooding, bushfires and earthquakes are identified as relevant natural hazards potentially affecting the NGBR Project and are summarised below.

**Tropical cyclone**

Tropical cyclones and associated high winds, high intensity rainfall and storm surges are a recognised natural hazard which have the potential to affect sections of the NGBR Project, particularly in northern areas closer to the coast. Based on historical data, a total of 57 tropical cyclones have passed within 200 km of the NGBR Project study area since 1906 (Bureau of Meteorology, 2013a). These cyclones reached intensities of Category 1 to Category 3, however, most developed into a low by the time they made landfall. One of the most powerful tropical cyclones recorded in Queensland was Yasi, a Category 5 cyclone, which made landfall near

Mission Beach more than 200 km north of Abbot Point. Yasi resulted in gale force (sustained winds of 63 km/h or greater and gusts in excess of 90 km/h) winds at Abbot Point (Bureau of Meteorology, 2013b).

It is considered that cyclones represent an overall low risk to the NGBR Project. The main impacts from cyclone activity in the NGBR Project study area are most likely heavy rainfall resulting in flooding and damage to rail infrastructure.

During detailed design the risk of tropical cyclones will be taken into consideration and appropriate design standards will be adopted to ensure that all structures, including those that contain hazardous materials, are designed to withstand wind and rain associated with cyclonic events.

**Flooding**

Flood plains, particularly those associated with the Elliot River, Bogie River, Bowen River, Suttor River and a number of other creeks, are located along the length of the NGBR Project. A review of published information (Bureau of Meteorology, 2013c) indicates that flooding has historically been reported in these areas, which has been known to include overtopping of rail formations, submergence of access roads and damage to rail infrastructure. Preliminary design of the rail formation is above the one in 50 year flood level while the rail track has been designed above the one in 100 year flood level.

Typical average recurrence interval levels are based on historic records. In terms of climate change, the Queensland Government (2010) recommends flood modelling to consider increase in design rainfall depths by a factor of five per cent per degree of global warming which should be applied to design factors. Note that this is based on a Draft study undertaken for the Queensland Government which only considers a 3 °C increase by the year 2070. This is generally applied as a guide for local governments in town planning and design of new developments.

Preliminary hydrological studies have been undertaken for the NGBR Project and are discussed further in Volume 1 Chapter 9 Water resources. This includes an initial assessment of proposed structures at watercourse crossings and drainage lines to ensure appropriate afflux levels during periods of high rainfall and flooding. Ongoing and more detailed hydrological studies will be undertaken during detailed design to confirm the design and size of structures at watercourse crossings is sufficient for the design flood events.

**Bushfire**

Bushfires have a low to medium risk of occurring along and/or adjacent to the NGBR Project (QFRS 2008a; QFRS 2008b). The NGBR Project will impose restrictions on operational activities at the maintenance yard and construction camps during periods of high risk fire danger. This will include restrictions on mobile flash-butt welding and grinding within the final rail corridor.

**Earthquake**

A review of historical earthquake data for central Queensland found records of 17 earthquakes of magnitude ≥ three on the Richter scale since 1955 (Geoscience Australia 2013). Earthquake risk, as identified by the Commonwealth Government’s Geoscience Australia report on the Mackay area, is assessed as low to moderate. The potential impact of seismic activity on the NGBR Project is therefore considered to be low.

### 17.3.3 Climate change

In 2007, the Intergovernmental Panel on Climate Change (IPCC) in its Fourth Assessment Report concluded that it is “very likely” (more than 90 per cent probability) that most of the warming in the past 50 years is due to the observed increase in greenhouse gas (GHG) concentrations, which has amplified the greenhouse effect.

The greenhouse effect is ordinarily a natural process that traps heat in the atmosphere to create climatic conditions in which humans, plants and animals live. Evidence has shown that human activities, such as the burning of fossil fuels, increase the concentration of GHGs including carbon dioxide, methane and nitrous oxide in the atmosphere. This is known as the 'enhanced greenhouse effect', which causes more heat to be trapped in the atmosphere, resulting in global temperature rises, a rise in sea-level and melting of mountain glaciers and sea-ice.

There is a wide body of evidence available to suggest that Australia’s climate has already changed significantly, particularly over the last 50 years. Queensland has one of the most naturally variable climates in the world and its climate is projected to become more variable and extreme in the future. Some of the key changes currently observed (CSIRO & BOM, 2007), at a national scale, are listed below:

- Oceans
  - Australian sea levels rose on average, by 10 cm between 1920-2000
  - Substantial warming (on average around 0.15 °C per year) has occurred in the three oceans surrounding Australia, particularly off the south-east coast (Tasman Sea) and in the Indian Ocean.
- Temperature
  - Average Australian temperatures have increased 0.9 °C since 1950
  - There are now more heatwaves (defined where daily maximum temperature of more than five consecutive days exceeds average maximum temperature by 5 °C) and fewer frosts.
- Rainfall
  - Rainfall has, on average, declined substantially (between 30 to 50 mm per decade) across most of eastern and south-western Australia since 1950
  - Patterns of rainfall intensity and frequency have changed in the south-east, the south-west and along the central east coast of Australia.

Scientific evidence predicts a number of changes to climatic events, including an increase in severity of rainfall events, increased flooding and an increased occurrence of extreme bushfire events. Future climate change projections for the study area have been estimated under two emissions scenarios according to ClimSystems data (refer Section 17.2.4). These predictions have been identified according to each climatic variable assessed and considered in the development of mitigation and management measures in relation to natural hazards.

## 17.4 Potential impacts and mitigation measures

### 17.4.1 Climate, natural hazards and climate change risk assessment

A high level risk assessment was undertaken for natural hazard and climate change events, with each identified risk analysed by estimating its likelihood and consequence of occurrence. Potential adaptation or mitigation measures were recommended and residual risks evaluated based on identified management measures. Scenario modelling has indicated increase in temperature projections by up to 9 °C and increased average annual rainfall projections by up to 163 per cent (location dependent) by 2070. This is based on the GCMs modelled for the specific locations, taking into consideration historic climate conditions at the sites and a future that remains largely fossil fuel intensive. This represents a long-term extreme or near worst-case scenario but is useful to identify potential long-term challenges (whether amplified or not). Results of this high level risk assessment are provided in Table 17-5.

Table 17-5 Climate and natural hazard risk assessment

| Hazard | Present Climate | 2030 A1B Scenario | 2070 A1FI Scenario | Likelihood of Occurrence | Potential Impacts (Consequence) | Overall Risk | Adaptation Measures | Responsive Measures | Residual Risk |
|---|---|---|---|---|---|---|---|---|---|
| Temperature change (°C) (average annual temperature) | Clermont: 29.7 °C<br>Collinsville: 30.2 °C<br>Bowen: 28.8 °C | + 24% (36.8 °C)<br>+ 28% (38.6 °C)<br>+ 28% (36.9 °C) | + 12% (33.3 °C)<br>+ 30% (39.3 °C)<br>+ 32% (38.0 °C) | Risk is ongoing throughout the life of the NGBR Project and not subject to a singular event.<br>Potential impacts of average temperature increase are unlikely to cause any major impact on track or track infrastructure and components, and thus unlikely to affect the NGBR Project. | Increases in average temperature will likely increase the probability (and therefore expected frequency) of extreme temperature events. | Low | No adaptation actions required. | | Low |
| Extreme heat significantly above stress free temperature, over a prolonged period, causing track buckling | Clermont: 57.4 days<br>Collinsville: 36.9 days<br>Bowen: 1.6 days | 74[1] days<br>74 days<br>4[2] days | 136 days<br>136 days<br>12 days | Unlikely to cause track buckling following standard installation procedures that consider temperature changes and construct to stress-free thresholds. | Track buckling would cause damage to rail infrastructure and lead to potential incident if carriages cross over. | Medium | With appropriate maintenance (potentially including periodic track de-stressing) and ensuring the track has been installed to stress free temperatures, increase in number of extreme heat days is unlikely to have significant effect on the track. | | Medium |
| Extreme heat causing malfunction in communication and signalling equipment | | | | Unlikely to be significantly affected by temperature extremes where signalling and communication equipment is installed with appropriate design in line with standards and guidelines. | Malfunction or failure of power supply or communication and signalling equipment could cause delays in operation or lead to rail incidents and potential collisions. | Medium | Appropriate design for temperature extremes in line with relevant rail authority standards or approved guidelines.<br>Where applicable, housing structures for signalling equipment to be designed for adequate natural ventilation. Consider shade structures for signalling cases and bungalows, if necessary.<br>Undertake adequate preventative maintenance of the track and infrastructure as part of standard procedures. | Implement an emergency stop work procedure in the event of equipment failure or malfunction. | Low |
| Extreme heat conditions causing worker discomfort and potential illness and heat stress | | | | Temperature extremes are unlikely to cause significant impact on worker discomfort as preventative measures will be employed and designed in line with Australian Standards. | Worker discomfort has the potential to cause lapse in concentration, dehydration and illness due to heat stress during construction, rail maintenance activities and operations. | Medium | Rail cabins designed in line with Australian Standards.<br>Where appropriate, limit outdoor works during periods of extreme temperature.<br>Adhere to health and safety policies and procedures for the safety and wellbeing of workers conducting work outdoors or in warm environments. | Ensure adequate number of first aid officers on site to manage health and safety incidents. | Low |
| Extreme precipitation causing flooding | Clermont:<br>664.8 mm/yr<br>Collinsville:<br>718.4 mm/yr<br>Bowen:<br>961.3 mm/yr | + 67%<br>(1,110.2 mm/yr)<br>+ 61%<br>(1,156.6 mm/yr)<br>+ 61%<br>(1,547.7 mm/yr) | + 163%<br>(1,748.4 mm/yr)<br>+ 100%<br>(1,436.8 mm/yr)<br>+ 145%<br>(2,355.2 mm/yr) | The construction of temporary and permanent constructed drainage features and platforms could potentially alter existing drainage patterns and create a barrier to waterway flows and overland flow paths. | Flooding could lead to scour and flooding of bridges, embankment scour, culvert washout, flooding of track and equipment failure. | High | Ensure track drainage meets expected conditions.<br>Rail bridges will be designed for a 100 year ARI discharge plus 300 mm freeboard. The Queensland Government recommends flood modelling to consider increase in design rainfall depths by a factor of 5% per degree of global warming.<br>Formation level designed for 50 year ARI and rail level designed for 100 year ARI.<br>Implement abutment and embankment scour protection.<br>Investigate potential to maintain stockpiles of suitable formation and culvert reconstruction material in areas prone to high risk of washout from flooding during operation. | | Medium |

[1] Note as no site specific data was available for Clermont and Collinsville, data from the Charter Towers site was used to represent the projected regional increase in days greater than 35 °C.
[2] Queensland Government – Climate change in the Whitsunday, Hinterland and Mackay Region *ClimateQ: toward a greener Queensland* (Department of Environment and Heritage Protection 2013)

| Hazard | Present Climate | 2030 A1B Scenario | 2070 A1FI Scenario | Likelihood of Occurrence | Potential Impacts (Consequence) | Overall Risk | Adaptation Measures | Responsive Measures | Residual Risk |
|---|---|---|---|---|---|---|---|---|---|
| Extreme precipitation causing inundation of signalling equipment or bungalows | | | | Unlikely to be heavily affected by precipitation events should appropriate design options be implemented. | Malfunction or failure of communication and signalling equipment could cause delays in operation or lead to rail incidents and potential collisions. | Medium | Appropriate design options to ensure signalling boxes will be above the projected relevant flood level (based on the future climate scenario). | Implement an emergency stop work procedure in the event of equipment failure or malfunction. | Low |
| Extreme precipitation causing inundation or damage to critical infrastructure | | | | Possible for major rain event to inundate or cause damage to infrastructure. | Possible disruption of safe track conditions or derailment impacting operations. | High | Formation level designed for 50 year ARI and rail level designed for 100 year ARI plus 300 mm freeboard. The Queensland Government recommends flood modelling to consider increase in design rainfall depths by a factor of 5% per degree of global warming.<br>Rail bridges will be designed for a 100 year ARI discharge plus 300 mm freeboard.<br>Monitor for extreme weather events through Bureau of Meteorology.<br>Investigate potential to maintain stockpiles of suitable formation and culvert reconstruction material in areas prone to high risk of washout from flooding during operation. | | Medium |
| Changes to wind speed causing vegetation to fall and restrict road access | Clermont: 10.5 km/h<br>Collinsville: 7.9 km/h<br>Bowen: 22.9 km/h | + 74% (18.3 km/h)<br>+ 69% (13.4 km/h)<br>+ 56% (35.7 km/h) | + 106% (21.3 km/h)<br>+ 59% (12.6 km/h)<br>+ 28% (29.3 km/h) | Unlikely to occur given the vegetation clearing is to occur within the final rail corridor. | Potential to restrict road access causing delays and possible vehicle incidents when vehicles collide with falling or obstructing vegetation. | Medium | Appropriate maintenance of track corridor to minimise risk of falling vegetation.<br>Appropriate vegetation buffer along rail corridor to prevent risk of falling vegetation. | | Low |
| Changes to mean relative humidity causing increased bushfire risk | Clermont: 64%<br>Collinsville: 67%<br>Bowen: 73% | - 2%<br>Little change expected along coastal areas | | Impacts of evaporation and humidity changes are unlikely to have any significant impact on the NGBR Project. | Risk of increased likelihood or intensity of bushfires. | Low | Ensure appropriate buffers along rail corridor to reduce risk of impact from possible bushfire. | | Low |
| Sea level rise | Clermont: N/A<br>Collinsville: N/A<br>Bowen: 0 m | Not applicable<br>Not applicable<br>0.18 m | Not applicable<br>Not applicable<br>0.59 m | Unlikely to be issue for NGBR Project as lowest point along the route is approximately 5 to 8 m AHD which is above the projected sea rise levels.<br>Potential impacts of sea level rise are unlikely to cause any major impact on track or track infrastructure and components, and thus unlikely to affect the NGBR Project. | Potential for storm surge events. | Low | No adaptation actions required. | | Low |

| Hazard | Likelihood of Occurrence | Potential Impacts (Consequence) | Overall Risk | Preventative Measures | Responsive Measures | Residual | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | L | C | Risk |
| Natural hazards | | | | | | | | |
| Severe wet weather event resulting in significant stormwater runoffs/ flows. | Likely.<br>Based on historical data, the area has potential for flooding. | Moderate. The embankment has the potential to be damaged by water flowing over the embankment.<br>Blocked relief drainage due to debris.<br>A major rain event could flood and washout the rail infrastructure resulting in disruption to transport of coal. | High | Safety in design. The formation level will be designed for 50 year ARI, while the rail track level will be designed for the 100 year ARI. Rail bridges will be designed for a 100 year ARI.<br>Ensure track and infrastructure/component drainage is adequate and improved if needed.<br>Adopt appropriate design standards to ensure all structures and components (including any overhead wires or exposed communications wiring) are designed to withstand wind and rain associated with cyclonic events in line with relevant Australian Standards.<br>As deemed appropriate, secure and evacuate site if significant flood events predicted.<br>If feasible stop rail traffic in the event of flooding. | Communicate with Queensland Police Services in relation to evacuation of workers.<br>Emergency response plan to include evacuation of workers and storage of rolling stock at the rolling stock maintenance facility. | Rare | Minor | Low |
| Bushfire at laydown yard, temporary construction camp or flash welding yard. | Possible. Current grazing land use on the rail corridor and adjacent properties.<br>Regional bushfire mapping (refer section 17.3.2) identifies the rail corridor as low to medium risk for bushfires. | Moderate. Loss of vegetation, including vegetation outside project areas that would otherwise be undisturbed.<br>Loss of property including stoppages to construction activities or movement of trains during operational phase, potential ignition of flammable fuel or chemical storage areas. | Medium | Clear vegetation in all work areas and manage growth in other areas to prevent excessive fuel load accumulation.<br>Maintain fire breaks around areas identified as being potential sources of bushfire risk.<br>Minimise storage of flammable fuels of chemicals and provide appropriate bunding and buffers in storage design.<br>Incorporate bushfire response in the NGBR Project Environmental Management Plan and maintain fire fighting capability at site.<br>Educate staff in relation to bushfire prevention, including management of cigarettes and other sources of ignition. | Implement bushfire response procedures as per emergency response plan.<br>Should bushfire threaten areas outside the NGBR Project, provide warnings. Communicate with Queensland Police in relation to need for road closure. | Unlikely | Minor | Low |
| Landslides along the railway line due to extreme wet weather or land slips. | Rare. Potential for landslides especially during and after heavy rain, particular around large cuttings. High fills and deep cuts are required across the Leichhardt and Clarke Ranges. | Minor. Temporary stoppage to movement of coal trains depending on the severity of the incident resulting in loss of revenue for the NGBR Project.<br>Potential for injuries to workforce. | Low | Conduct geotechnical investigation. Design to address issues around landslides.<br>Regular track inspection.<br>Installation of adequate scour protection. | Emergency response plans will be developed.<br>Workers will be trained to respond during emergencies. | Rare | Minor | Low |

## 17.5 Susceptibility of ecological communities and species

Impacts from the NGBR Project that will increase the susceptibility of ecological communities and species to the impacts of climate change are anticipated to be negligible. However, the final rail corridor is likely to act as a barrier to bushfire risk given its nature as a fire-break.

## 17.6 Conclusion

The assessment of climate and natural hazards includes potential impacts to infrastructure, equipment and personnel, and the environment associated with the NGBR Project. As climate change predictions and potential impacts typically relate to an increase in the severity or frequency of natural hazards, the assessment is considered to incorporate existing natural hazards as well as those under a climate change scenario.

A Risk Management Plan will be developed and implemented for the NGBR Project and include preventative and responsive mitigation measures to reduce the overall risk of potential hazards identified as high risk (refer Volume 2 Appendix P Environmental management plan framework). Following the implementation of proposed mitigation measures, three hazards remain ranked with a medium residual risk given the measure of consequence, namely the risk of extreme heat and extreme precipitation causing flooding or inundation of critical infrastructure.

The various management plans incorporated into the Environmental Management Plan for the NGBR Project (refer Volume 2 Appendix P Environmental management plan framework) will serve to significantly reduce the likelihood of potential impacts occurring during natural hazard events. Management plans will be periodically updated and expanded as required throughout the life of the NGBR Project as design progresses, and as risks and climate predictions are further refined.