3. Climate, Natural Hazards and Climate Change

This section provides a summary of climatic conditions and natural hazards that may affect management of potential impacts, in regards to the Project (Rail) during construction and operation. The assessment was undertaken in accordance with the requirements of the Terms of Reference (ToR) and a table cross-referencing these requirements is provided in Volume 4 Appendix C ToR Cross Reference Table. Flood plain management in particular is discussed further in Volume 4 Appendix AB Rail Hydrology.

3.1 Introduction

A climate and natural hazards assessment, inclusive of consideration of climate change risk has been undertaken. The assessment describes the climatic conditions experienced in the Project (Rail) area, and identifies the potential vulnerability of the Project (Rail) to these seasonal conditions and potential climatic extremes and natural or induced hazards. Management measures to reduce these potential risks are provided.

3.2 Description of Environmental Values

3.2.1 Overview

The Project (Rail) alignment is located within a 95 m wide corridor that runs from the loading facilities within the boundary of the Mine approximately 189 km eastwards to connect with the Watonga Blair Athol Branch Railway of the existing QR National Goonyella Coal Rail System (Goonyella rail system), south of Moranbah.

3.2.2 Climatic Conditions

3.2.2.1 Temperature and Relative Humidity

The length of the Project (Rail) is 189 km, and stretches over a latitude belt of inland central Queensland. The climate and prevailing meteorology is estimated to show some differences between the east and west of the Project (Rail).

The western end at the Project (Mine) is further inland and more often on the dry side of the inland surface pressure trough often experienced in this region. The available climatic statistics shows that the eastern end of the Project (Rail) is considered as a 'sub-tropical' climate and, due to the inland nature of the region skewing rainfall monthly totals to summer (wet season) rather than winter (dry season), there is a sub-classification of ‘moderately dry winter’. This applies at all of the Bureau of Meteorology (BoM) climatic stations for the length of the rail corridor from Moranbah/Collinsville regions as far west as Twin Hills.

The available climatic statistics also show that while the western end is close to a grassland (hot winter drought) climate, as found at Hughenden, the Carmichael climatic record for monthly rainfall averages (there are no temperature records available) suggest that the western end of the Project (Rail) is still within the ‘sub-tropical’ classification as found to the east.

The above analysis is based on the temperature and rainfall data using the climatic typing scheme of Stern et al. (2000).

The weather station at Moranbah is considered representative to characterise the climatic conditions at the eastern end of the Project. Data taken from the Moranbah Water Treatment Plant (Bureau of Meteorology (BoM)) and presented in Figure 3-1 indicates summer maximums around mid-30 degrees, with occasional extremes of early 40 degrees. Winter months vary historically, with extremes of frost and temperatures below zero degrees recorded on occasion. Relative humidity is highest in the mornings and during the month of March and lowest in the late spring mornings and afternoons as shown in Figure 3-2.

Twin Hills (Site Number 036047) is the BoM climatic station used to characterise the temperature regime at the western end of the Project (Rail). Temperature and humidity monthly statistics for this location are presented in Figure 3-3 and Figure 3-4. Monthly mean temperatures for Twin Hills Post Office show daytime summer temperatures are mostly in the low to mid-30ºC with winter overnight temperatures dropping to between 5 ºC and 10 ºC. The temperature record of approximately 20 years shows values ranging from -3.2 ºC to 43.8 ºC. 'Hot days', with temperatures exceeding 35 ºC can be expected up to 75 days per year. 'Frost days', with screen temperatures below 2 ºC can be expected up to 10 days per year.

Figure 3-1 Monthly Mean and Decile Maximum and Minimum Temperatures at Moranbah

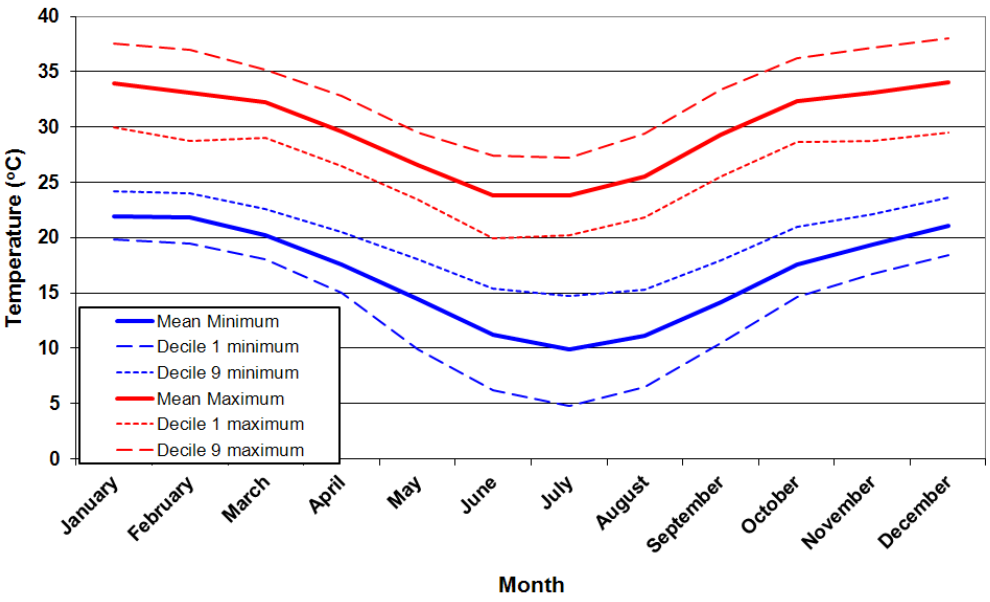


Figure 3-2 Monthly Mean Relative Humidity At Moranbah

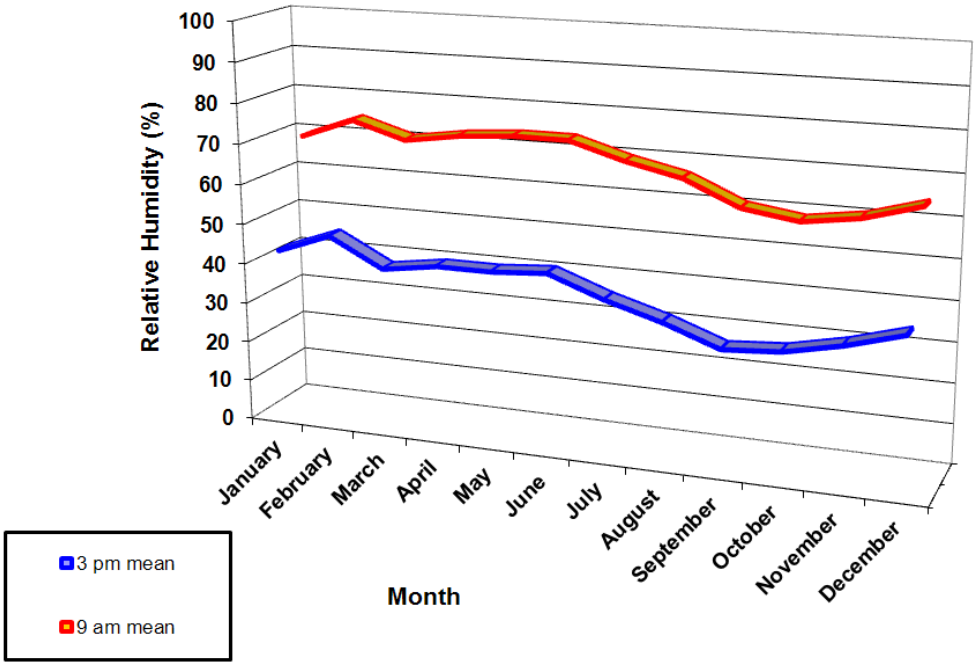


Figure 3-3 Monthly Mean and Decile Maximum and Minimum Temperatures at Twin Hills

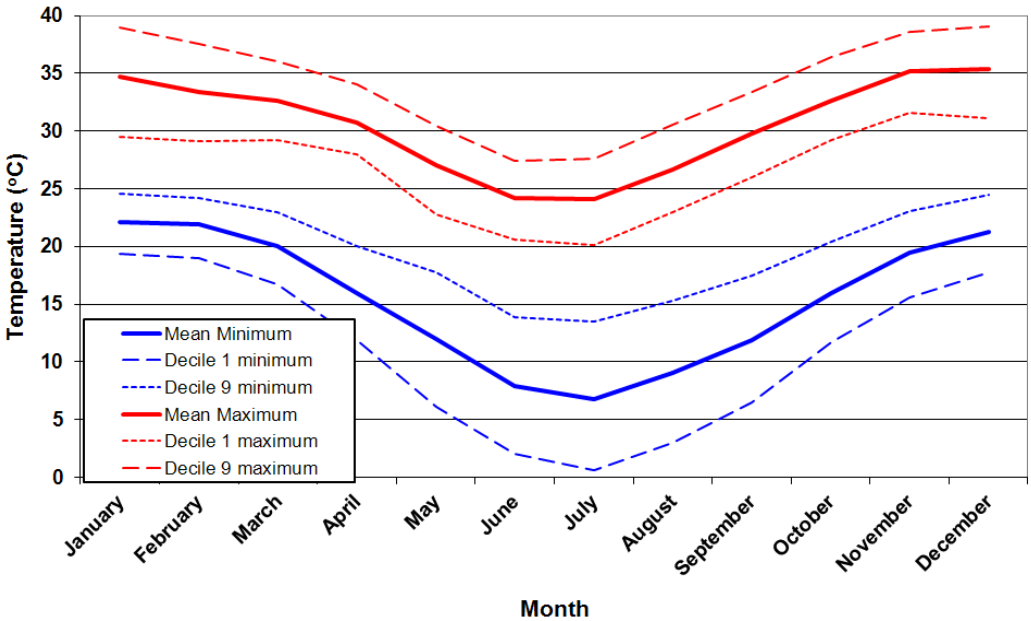
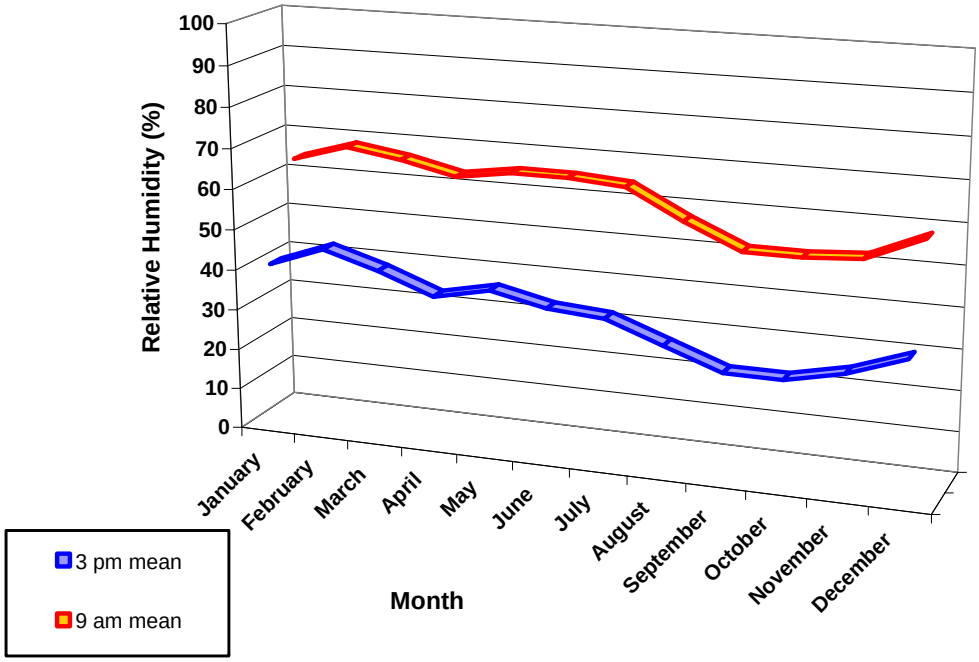


Figure 3-4 Monthly Mean Relative Humidity at Twin Hills Post Office



3.2.2.2 Rainfall

Analysis of rainfall statistics from the Moranbah Water Treatment Plant (Site number 034038), Twin Hills Post Office (Site number 036047) and Carmichael (Site number 036122) (BoM 2011) indicate a clear pattern of decreasing rainfall moving inland.

The annual mean rainfall at all three sites is dominated by the warm months producing convectively driven rainfall as shown in Figure 3-5. December through February, inclusive, accounts for 57 per cent of the annual mean rainfall at Carmichael, 50 per cent at Twin Hills and 51 per cent at Moranbah.

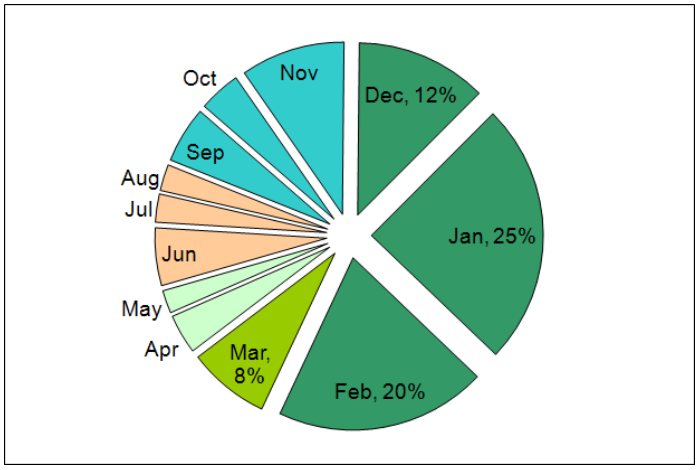
The rain record from the Carmichael site (Moray Downs) is limited, beginning in 2003 with some incomplete monthly records for a number of years to 2010. The annual rainfall at the site ranges from 252 to 700 mm, averaging 457 mm. The annual sum of monthly averages is 524 mm. Even at 500 to 530 mm of annual rain, the western end of the Project (Rail) is drier by at least 20 per cent than experienced at Twin Hills and Moranbah to the east.

Twin Hills has an annual average of 610 mm over an 80 year record while Moranbah averaged 604 mm over 38 years. The range of annual rainfalls at Twin Hills is 218 mm to 1,477 mm, and at Moranbah is 281 mm to 1,109 mm per year.

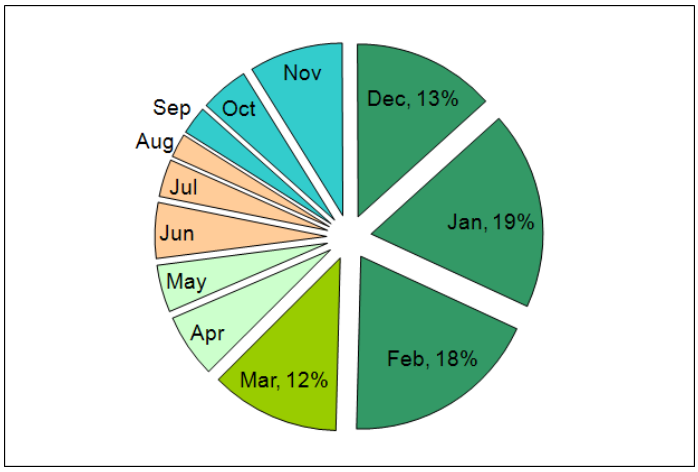
Rainfall patterns, in terms of summer maxima, winter minima and annual totals are broadly similar across this relatively large area. In any month of the year, there can be zero rainfall. There are pronounced annual variations in rainfall, including the persistence of both dry years and wet years.

Figure 3-5 Comparison of Monthly Mean Rainfall (mm) Proportions at Carmichael, Twin Hills and Moranbah

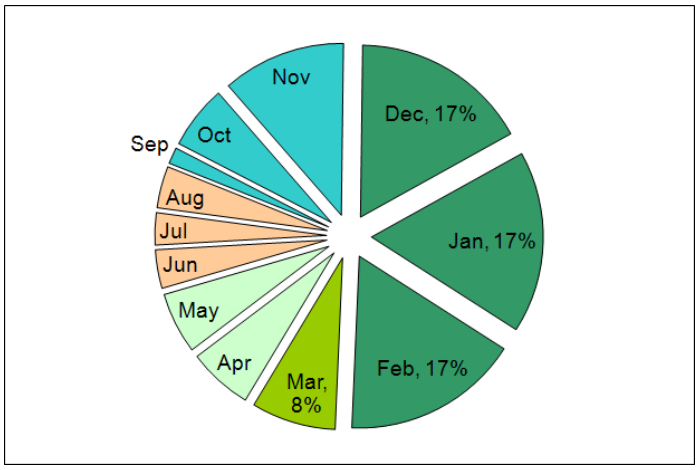
Carmichael - Western



Twin Hills - Central



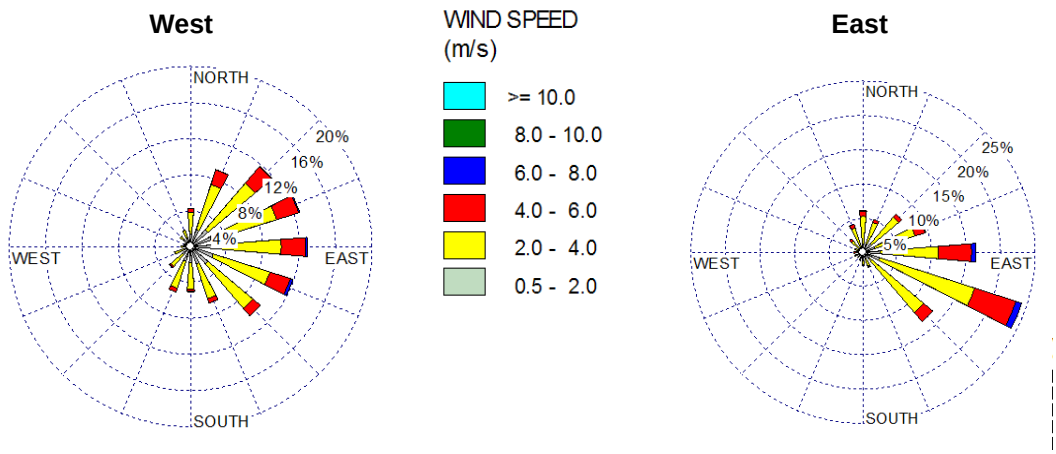
Moranbah - East



3.2.2.3 Wind

Figure 3-6 shows the derived site-representative annual wind roses for the western extent (taken at Cassiopeia) and eastern extent (taken at Moranbah). Note that the east-south-east trade winds have become more evenly spread through the eastern directions as the trade winds move further inland away from the coastal influences. This may also be a reflection of how often the Queensland inland trough is found to influence the more eastern site rather than on the drier inland side of the trough out to the west. The overall pattern is of dominating easterly winds.

Figure 3-6 Comparison Annual Wind Roses for Representative Sites



3.2.2.4 Solar Radiation

Global solar exposure is the total amount of solar energy falling on a horizontal surface. The daily global solar exposure is the total solar energy for a day. Typical values for daily global solar exposure range from 1 to 35 MJ/m^2 (megajoules per square metre). The values are usually highest in clear sun conditions during the summer and lowest during winter or very cloudy days.

The average daily solar exposure is consistent across the Project (Rail) and is in the order of between 21 and 24 MJ/m^2. The Project (rail) area experiences average daily sunshine hours (annually) of between 8 and 9 hours.

3.2.3 Natural or Induced Hazards

3.2.3.1 Flooding

The landscape of the rail corridor is characterised by flat floodplains dominated by a number of rivers and creeks which have reasonably well defined channels but with wide floodplains that are inundated during flood events. The railway alignment is located predominantly within the Belyando River / Suttor River sub-catchments of the Burdekin River Catchment. The first 40 km of the railway alignment (from the eastern extent) is located within the Grosvenor Creek sub-catchment of the Isaac River, which is a tributary of the Fitzroy River.

A hydrology assessment has been prepared for the site (see Volume 4 Appendix AB Rail Hydrology) which outlines surface water conditions in and around the Project (Rail) alignment and potential impacts of the Project (Rail) on these characteristics.

Flood data obtained from the BoM indicates at least one flood event per year (average) since 1949, with the frequency of flooding corresponding with the frequency of summer monsoonal and cyclonic rain events. The severity of each flood event is likely to be influenced by the rainfall amount and the preceding conditions such as the degree of soil cracking.

Almost all of the waterways within the Project (Rail) area are ephemeral. Under normal conditions the main stem of the Belyando River maintains a small base flow during the dry season. Once storm flow reaches the rivers and creeks, they rapidly fill and overflow into floodplains where flooding can persist for several days and sometimes weeks at a time.

The frequency of flooding as shown in Figure 3-7 for the available record (no data from 1972 to 1976 or from 2006 to 2010) from the Gregory Developmental Road gauge on the Belyando River mirrors the frequency of summer monsoonal and cyclonic rain events. Although the severity (as demonstrated by the annual maximum flood plotted in Figure 3-8) is likely to depend upon the level to which antecedent wetness has closed up the soil cracking as much as it does the amount of rainfall.

Figure 3-7 Flood Frequency on the Belyando River at Gregory Developmental Road Gauge (1949-2006)

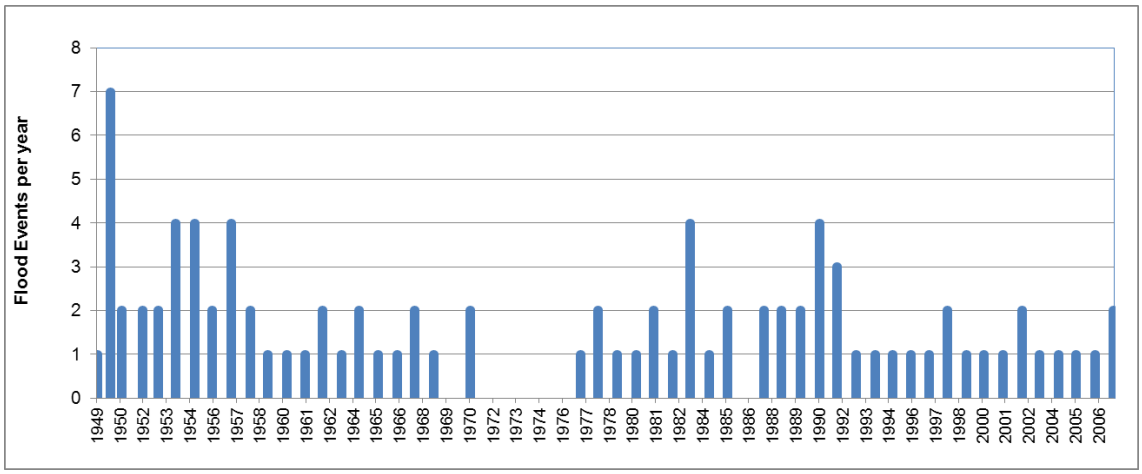
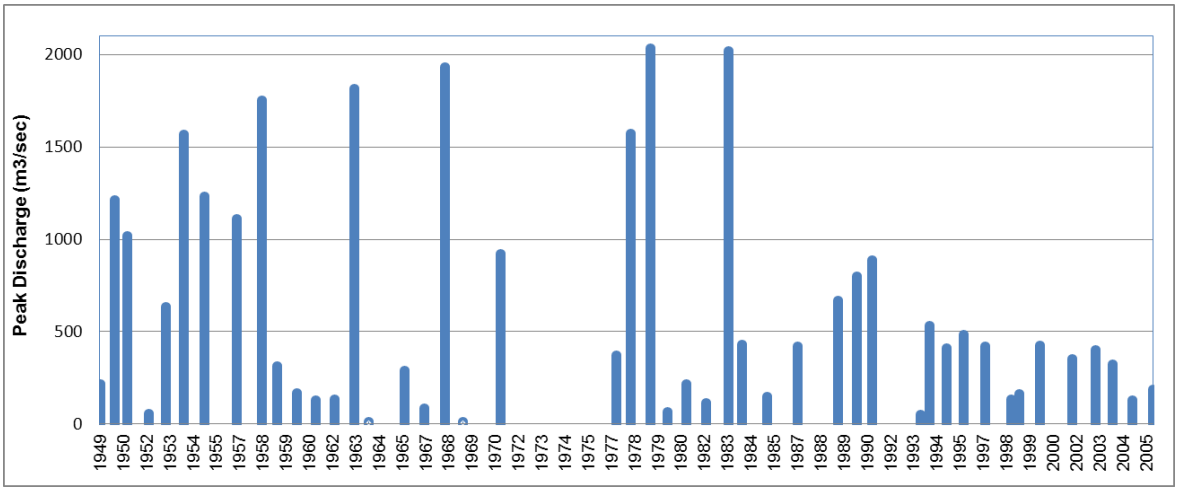


Figure 3-8 Annual Maximum Flood recorded on the Belyando River at the Gregory Developmental Road Gauge

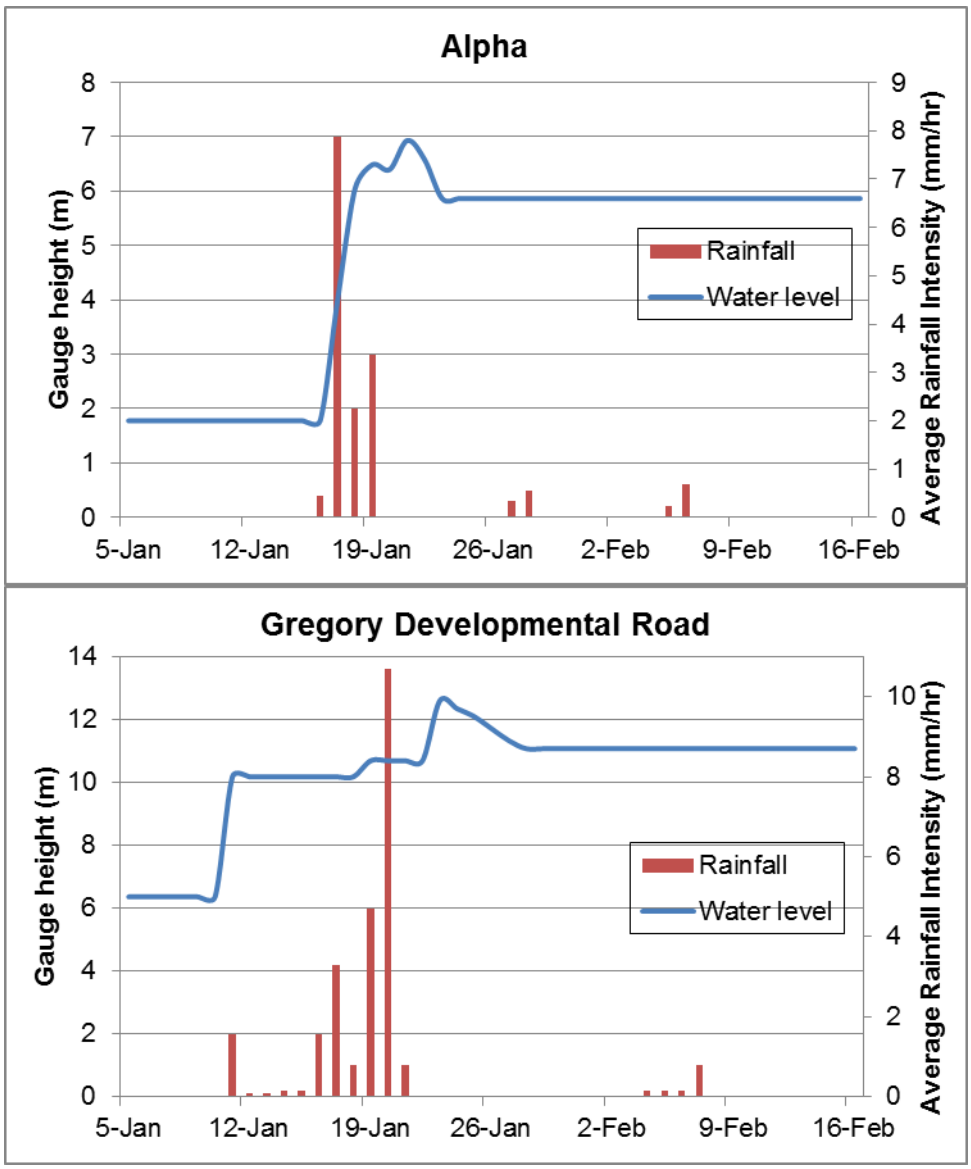


3.2.3.2 Tropical cyclones

There have been two recent cyclones which have affected the Project area, Cyclone Yasi in December 2010 and Cyclone Helen in January 2008. Although the bulk of rainfall during cyclone Yasi fell to the north of the Belyando River catchment, river levels still reached a peak of 3.2 m on 27 December 2010 at the Gregory Developmental Road gauge.

The best documented flood of recent times in the Belyando River is associated with tropical cyclone Helen in January 2008. The 162 mm rain depth recorded at the Alpha rain gauge on 17 January 2008 is the highest recorded, and occurred within a six day total of 225 mm. This is illustrated by the concurrent hydrographs/rainfall plots from the Alpha and Gregory Developmental Road gauges shown in Figure 3-9 and the peak flood heights in Figure 3-8. Cyclones and associated heavy rainfalls and potential flooding have the potential to directly affect the Project towards the eastern portion of the rail line.

Figure 3-9 Cyclone Helen (January 2008) - Water Level and Rainfall Intensity in the Belyando River Catchment



3.2.3.3 Land Use

Cattle grazing dominates the land use of the Project (Rail) route. Historical forest clearance for cattle grazing has resulted in altered hydrological regimes and resultant negative impacts on the morphological character of a number of waterways crossed by the Project. Changes in the morphological character from land clearance results in increased runoff, increased erosion and sediment within the catchment.

3.2.3.4 Bushfires

According to the Bushfire Risk Analysis map prepared for Isaac Regional Council (Qld Fire and Rescue Service, June 2008), bushfires have a low to medium risk of occurring on and/or adjacent to the rail corridor.

3.3 Potential Impacts and Mitigation Measures

3.3.1 Overview

Provided in Table 3-1 is a summary of potential climate risks to the Project and potential impacts and mitigation measures.

Table 3-1 Summary of potential climate risks to the Project (Rail)

Climate Parameter	Project Components Most Likely Affected	Potential Impacts	Potential Adaptation Options
Increase in temperature	Rail line and tracks	Increased potential of track buckling resulting in derailment and delays	Undertake adequate preventative maintenance of the track and infrastructure as part of standard procedures Monitor track conditions on days of extreme temperature Appropriate design to account for temperature ranges, inclusive of potential temperature extremes
	Communications equipment	Possible malfunctioning of communication and signalling equipment resulting in train stoppages and delays	Use appropriate housing for signalling equipment
Intense rainfall events	Rail line Associated supporting infrastructure including bridges, road crossing, drainage structure	Potential increased risk of flooding or inundation of rail line during summer resulting in train derailment, train stoppage and train delays Potential increased risk of flooding or inundation of infrastructure A major rain event may mobilise ballast or rail material, resulting in contamination or blockage of waterways and/or drainage structures and blockage of access across the corridor Swelling of clay soils supporting rail line or associated infrastructure during ponding of water in periods of flood Prolonged flooding and wet weather may prevent access for maintenance	Embankments shall be designed above floodplain levels and with sufficient drainage structures, with consideration of 100 year ARI events (i.e. probability of a 1 in 100 year flood event) Drainage areas are designed to increase the operational resilience of the railway during flood conditions Drainage structures are designed with sufficient hydraulic capacity to accommodate high flows Drainage diversions and lines to direct and accommodate flows to be considered in design Consider provision of all weather (4WD) access at key locations
Evaporation	Any on-site water or fuel stores	Unlikely to be any considerable impacts as no significant water uses are required during operations	Not likely to be a significant issue which requires management

Climate Parameter	Project Components Most Likely Affected	Potential Impacts	Potential Adaptation Options
Humidity	Signalling and communications equipment	Increase in humidity may affect signalling equipment. Extremes in humidity may affect communications and services supply	Continued monitoring and maintenance of signalling equipment
Bushfire	Infrastructure, rail line, crossings	Prolonged dry periods may increase likelihood of bushfires. Bushfires may result in impaired visibility resulting in reduced speeds and subsequent delays Damage to rail infrastructure, trains or signalling equipment resulting in train delays	Rail corridor provides an adequate fire break in terms of clearing and maintenance Land management practices to be negotiated with adjacent landholders to maintain and manage firebreaks Maintenance personnel to refrain from smoking in undesignated areas

3.3.2 Flood Plain Management

3.3.2.1 Construction

The construction of temporary bridge/causeways over the channel as a construction platform, or for vehicular access, is a potential barrier to waterway flows. This could potentially cause additional flooding if there is insufficient hydraulic capacity to convey the flood flows, or the waterway becomes blocked by debris. It is likely that any construction phase causeways are built to a low flood immunity standard. Temporary works in the waterways have the potential to raise flood levels in a flood. To mitigate this potential impact several control measures have been identified to avoid and/or reduce the potential adverse impacts.

Construction phase activities within major watercourses are as far as is possible, likely to be limited to the drier periods and the risk of additional flooding of the floodplains is considered low. However, the following specific mitigation measures are proposed:

- If causeways are constructed, provide sufficient hydraulic capacity to allow the conveyance of natural flows with minimal increase in velocity or afflux
- Keep low flow channels and any culverts through site clear of debris
- Conduct a detailed scour assessment to determine the appropriate depth of cover or scour protection measures to be adopted at each crossing. The detail design of the creek crossings will incorporate works and measures to minimise the following:
  - The risk of damage to the creek banks during construction
  - Change in the sediment transport regime at the crossing
  - The risk of creek bank collapse or erosion during flood events

3.3.2.2 Operations

Design flows and flood modelling have been carried out for major waterway crossings. The construction and operation of rail bridge crossings over waterways is considered the most significant infrastructure likely to change the flow of waterways and overland flow paths, in particular the rise in flood levels (afflux).

Hydraulic modelling of the 100 year ARI storm event has been conducted for pre- and post-development conditions at the Belyando River and Mistake Creek crossings to determine the afflux (the rise in flood level above normal) of three potential (preliminary) opening sizes. Preliminary modelling indicated the extent of the inundation in the Belyando River and Mistake Creek compared with the 2008 Cyclone Helen inundation which was a 100 year ARI storm event.

Preliminary modelling indicates that construction of rail bridges and/or culverts across water courses traversed by the Project (Rail) may impact on afflux levels.

The principal effect of the operating railway crossings is likely to be changes to the flows of waterways and overland flow paths, and particularly the rise in flood levels (afflux). Current hydrology and hydraulic modelling is being undertaken with base afflux limits being used as a basis for determining an acceptable afflux and to refine the assessment of potential impacts on infrastructure, landholdings and ecosystems.

However, the following potential impacts may arise as a result of afflux:

- Graziers currently lose the use of grazing land for the duration of flooding. An increased afflux has the potential to lead to greater areas of lost grazing land being inundated during floods. Inundation may also be present for longer. According to DEEDI (2010), five days of inundation is sufficient to kill the exotic buffel grass. Buffel grass is a common species of grazing land pasture in the Dry Tropics. The estimated average flood duration only exceeds five days for the Belyando River so incremental loss of buffel grass is unlikely to be of concern.
- Widespread grass death caused by weeks of flooding of the Belyando River associated with Cyclone Helen in 2008 (an estimated 100 ARI event) resulted in a proliferation of the toxic pest herb *Parthenium hysterophorus* (parthenium). An increase in flood extent and duration will potentially increase the area at risk of invasion by parthenium.
- Infrastructure assets in the floodplain, such as roads and farm tracks, will most likely be affected by the increased depth and duration of flooding.
- In areas where land values are lower, and where the flood affected assets are sparse and of lower value (e.g. broad acre dry land farming, limited unsealed roads that are lightly trafficked), and where the lateral gradients are generally steeper (implying modest additional flooding for a given rise in flood level) higher values of afflux may be acceptable.
- For a given floodplain “value”, where the duration of flooding is moderately long (say 12 hours to 3 days), and where the lateral slope of the floodplain is generally flatter, acceptable afflux values will be generally smaller, and vice versa.

Mitigation measures associated with potential impacts to the floodplain as a result of the operation of the Project will consider the following:

- Continued and iterative flood modelling through detailed design will determine afflux values in association with refinement in bridge and culvert crossing design
- Further work will be undertaken to catalogue the impacts of afflux on the floodplain, properties, assets and infrastructure
- Ongoing consultation with affected landowners and asset owners to assist in further refinement of project design and ongoing flood modelling
- Selectively raising farm roads by placing fill material, will reduce the impact on farm roads subject to negotiations and agreements with landholders and asset owners
- Consideration of compensation to flood affected land and asset owners in relation to excessive afflux

A full description and detail of the modelling assumptions, modelled conditions, results and scope for future modelling are presented in the Hydrology report (See Volume 4 Appendix AB).

3.4 Summary

Climatic parameters such as an increase in temperate extremes, extreme precipitation/flooding, evaporation, wind speed and humidity all have the potential to impact on the Project (Rail) structures and processes. At the current time (concept design) the Project (Rail) has lengths. specified three indicative bridge spans for the major waterway crossings. As such, the magnitude of afflux, and its impacts on farm roads and other floodplain assets, is defined across a range.

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