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2.1 INTRODUCTION

The ToR for the EIS requires Waratah Coal (Waratah) to undertake a climate and climate change adaption assessment.

This chapter is divided into two sections. The first section provides existing physical climatic descriptions of the proposed mine site. The second section of this chapter provides Waratah's preliminary risk assessment on climate change. The risk assessment analysed risks and potential impacts relating to the mine associated with climate change. Mitigation measures to minimise risks to the mine from climate change are also discussed.

An assessment of the potential impacts of the construction and operation of the proposed mine on air quality and greenhouse gas emissions is presented in Volume 2, Chapter 10.

2.2 CLIMATE AT THE MINE SITE

The study area has a sub-tropical continental climate and, in general, winter days are warm and sunny and nights are cold (Bureau of Meteorology (BOM), 2010a). Summer days, as with most Australian locations, tend to be hot and nights warm. Summer weather is influenced by a semi-permanent trough that lies roughly north-south through the interior of the state. The trough is normally the boundary between relatively moist air to the east and dry air to the west. It is best developed and generates most weather during spring and summer months. The position of the trough fluctuates diurnally due to vertical mixing and from day to day, due to interaction with broad scale synoptic influences. The trough often triggers convection with showers and thunderstorms to the eastern side.

Meteorological data has been taken from multiple BOM weather stations to provide an indication of regional climate trends. Where possible, data has been taken from the Barcaldine, Emerald, Claremont and Blackall stations, as these are the closest to the location of the mine site. For some parameters, (such as evaporation), data was not available from the preferred stations. Where this occurred data was taken from the next nearest station. The location of each station and selected parameters is shown in Table 1.

2.2.1 TEMPERATURE

The long term monthly average temperatures within the study area display typical ranges for subtropical regions (see Figure 1). Longreach is also close to the study area; however, being further inland, It is generally hotter than the other monitoring stations in the region, although it can be cooler during mid winter. Mean monthly minimum temperatures can be as high as 19°C to 22°C in the summer and drop as low as 7°C in the winter. The mean maximum temperatures can range between 33°C to 36°C in the hottest months and drop to between 22°C and 25°C during the coldest part of the year.

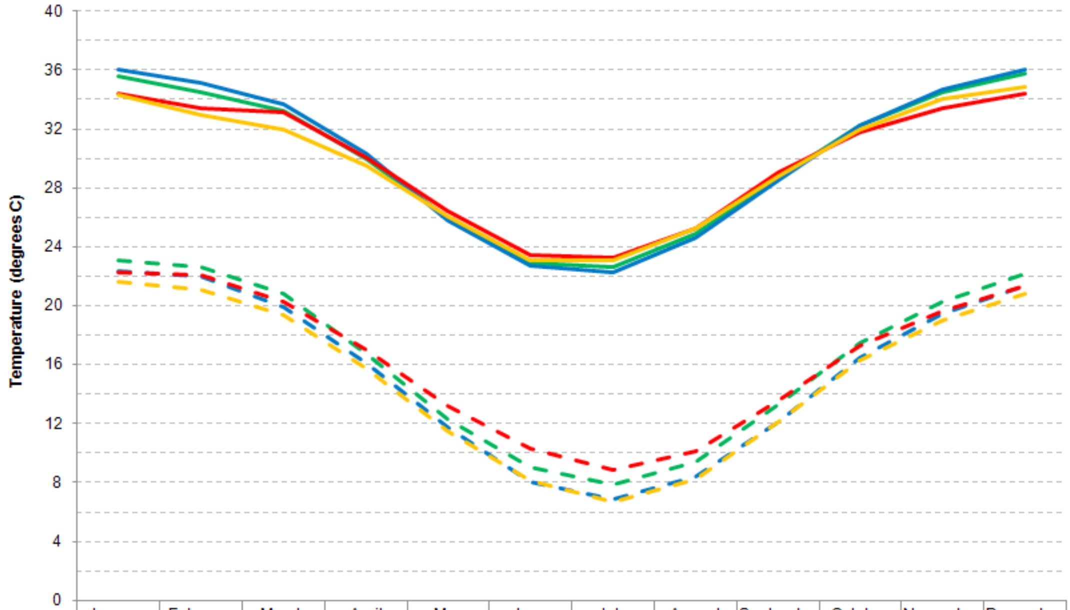
2.2.2 TEMPERATURE INVERSIONS

A temperature inversion refers to a layer of air in the atmosphere in which the temperature increases with height (instead of general profile of decreasing with height). During the night the ground is cooled by radiating heat into space. Air in contact with the ground then becomes cooler than the air above it, forming a typical night-time near-ground inversion layer. Inversions can form from other mechanisms, such as when warm air moves over a cool surface which can also form at high altitudes in the atmosphere.

Table 1. Bureau of Meteorology monitoring site locations and parameters

METEOROLOGY STATION	COORDINATES	DATA RANGE	PARAMETERS
Blackall Township	Latitude: 24.42oS Longitude: 145.47oE	1880-current	Temperature, rainfall, relative humidity
Longreach	Latitude: 23.44oS Longitude: 144.28oE	1949-current	Evaporation
Emerald Airport	Latitude: 23.57oS Longitude: 148.18oE	1981-current	Temperature, rainfall, relative humidity, evaporation, wind speed and direction
Clermont	Latitude: 22.82oS Longitude: 147.64oE	1870-current	Temperature, rainfall, relative humidity, evaporation
Barcaldine Post Office	Latitude: 23.55oS Longitude: 145.29oE	1886-current	Temperature, rainfall, relative humidity, evaporation wind speed and direction

Figure 1. Long term average temperature summaries



	January	February	March	April	May	June	July	August	September	October	November	December
Barcaldine - Mean Max	35.6	34.5	33.2	30	26	22.9	22.6	24.9	28.7	32.2	34.5	35.8
Barcaldine - Mean Min	23.1	22.6	20.8	16.7	12.3	9	7.9	9.4	13.3	17.5	20.3	22.2
Blackall - Mean Max	36	35.1	33.7	30.3	25.8	22.7	22.3	24.6	28.5	32.2	34.7	36
Blackall - Mean Min	22.4	22	19.9	16.1	11.8	8	6.9	8.4	12.1	16.5	19.5	21.4
Emerald - Mean Max	34.4	33.4	33.1	30.1	26.4	23.4	23.3	25.3	29.1	31.8	33.4	34.4
Emerald - Mean Min	22.3	22.1	20.3	17	13.2	10.3	8.9	10.1	13.6	17.3	19.6	21.4
Clermont - Mean Max	34.3	33	32	29.5	26.1	23.1	23.1	25.3	28.8	32	34	34.9
Clermont - Mean Min	21.6	21.1	19.4	15.7	11.5	8.1	6.7	8.2	12.1	16.3	19	20.8

The lack of convective mixing within the lower-level inversion layer means that lower-level pollution can be trapped within the inversion layer, resulting in high pollution levels. This phenomenon is much more pronounced over land than it is over water, as water holds its heat for longer than land does.

The temperature inversion strength and frequency have been estimated based on meteorological modelling output datum for 2008 from a central location within the project area. Analyses of the inversions show that strong inversions occur in 13 % of occasions (Table 2).

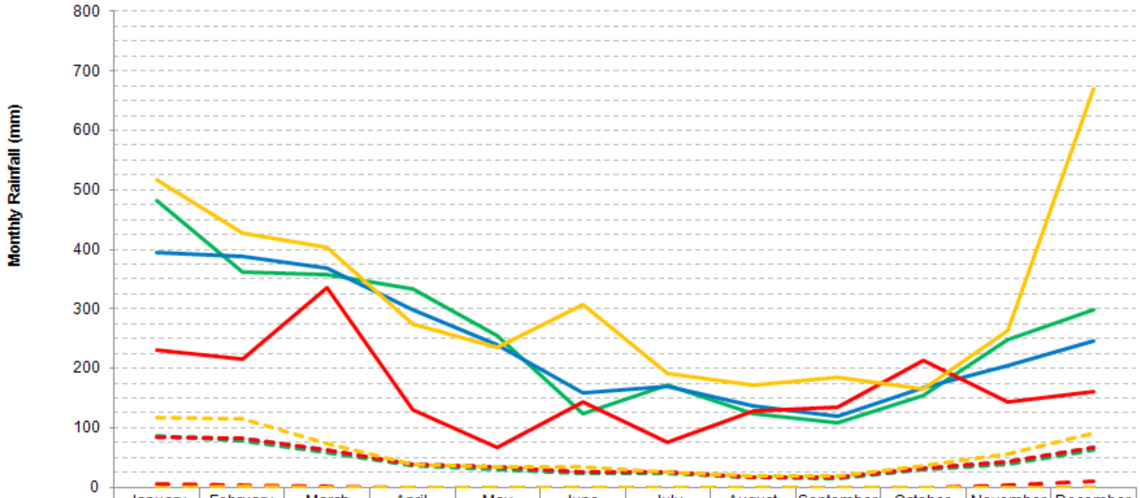
2.2.3 RAINFALL

The long term monthly average of rainfall is presented in Figure 2. This summary shows a consistent pattern across the study region of 80-120 mm of rain per month, on average, during the summer months, dropping to average lows of 15-20 mm during winter.

Table 2. Temperature inversion at night time in the project area

NIGHT TIME INVERSION STRENGTH	PERCENTAGE OF OCCURRENCE (%)	NUMBER OF HOURS
>3°C per 100 m	13	1,169
>2°C per 100 m	20	1,750
>1°C per 100 m	30	2,595
>0°C per 100 m	50	4,410

Figure 2. Long term average rainfall summary



	January	February	March	April	May	June	July	August	September	October	November	December
Barcaldine - Maximum	481.2	362.6	357.1	333.6	255	124.2	171.6	123.4	107.5	154.2	247.9	298.3
Barcaldine - Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Barcaldine - Average	86.1	78.3	59.1	36.7	30.8	24.3	22.9	15.8	15.1	29.1	38.1	63.1
Blackall - Maximum	395.2	389.1	368.5	299.2	240.2	159.9	170.3	136.7	119.4	167.3	203.6	246.8
Blackall - Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Blackall - Average	85.2	81.8	62.8	37.6	33.6	26.2	25.1	16.5	17.4	33.1	42.2	67
Emerald - Maximum	231.6	216.2	335.2	130.1	66.6	143.4	76.4	128.2	135.2	213.4	143.6	162
Emerald - Minimum	6.2	3.7	1.4	0	0	0	0	0	0	0.2	2.8	10.2
Emerald - Average	85.2	81.8	62.8	37.6	33.6	26.2	25.1	16.5	17.4	33.1	42.2	67
Clermont - Maximum	516	428	403.4	274.2	234.4	307.2	192.5	171.2	184.9	165.2	263.9	670.7
Clermont - Minimum	0	1	0	0	0	0	0	0	0	0	0	0
Clermont - Average	117.6	115.7	73.9	38.8	35	34.3	24.9	19	19.3	35.4	57.1	91.8

2.2.4 WIND SPEED AND DIRECTION

Wind roses show the frequency of wind occurrence by direction and strength. The bars correspond to the 16 compass points (N, NNE, NE, etc.). The bar at each wind direction in the wind rose diagram represents winds blowing from that direction. The length of the bar represents the frequency of occurrence of winds from that direction, and the widths of the bar sections correspond to wind speed categories, the narrowest representing the lightest winds. With the resulting figure it is possible to visualise how often winds of a certain direction and strength occur over a long period, either for all hours of the day, or for particular periods during the day.

Long term wind roses from two representative locations in the study area (one from the east and one from the west of the study area) show very different wind strengths although similar wind directions across the study area. Emerald, shown in Figure 3, is located east of the study area and has winds that are frequently from the east with more moderate winds. Barcaldine, to the west of the study area, also shows more winds from the east but has a higher frequency of low wind speeds. Calms form between 3 % and 7 % of monitored 9 am and 3 pm observations (Figure 4).

Figure 3. Long term average 9 am and 3 pm wind roses from Emerald Airport

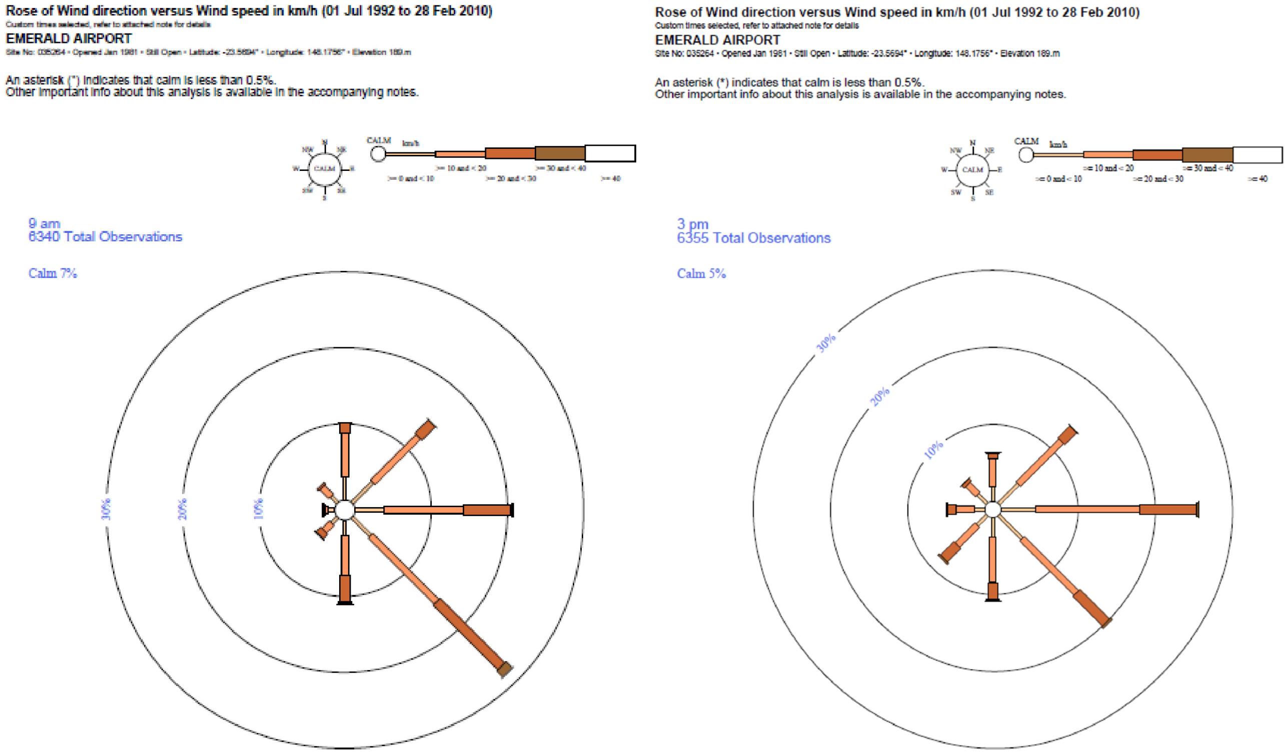
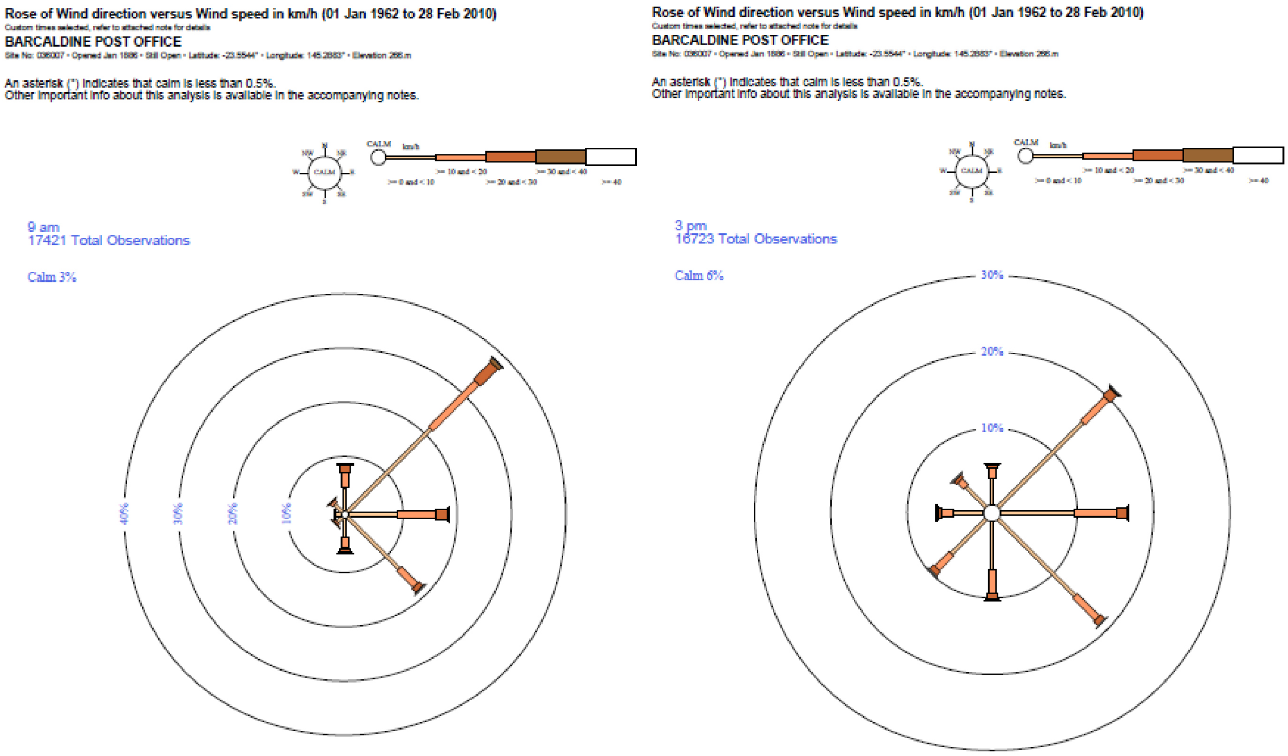


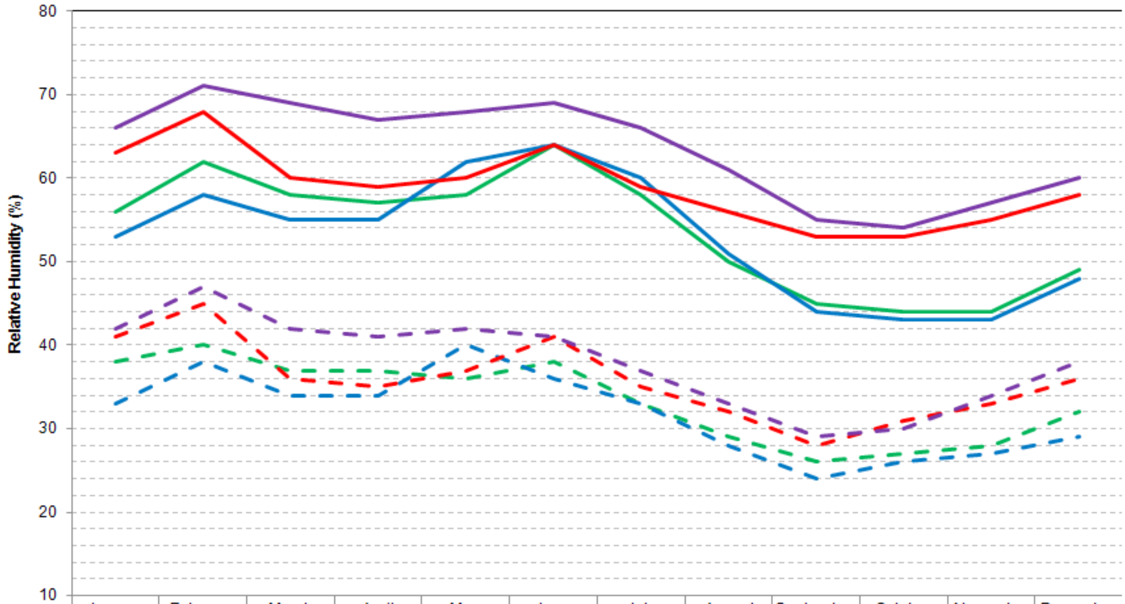
Figure 4. Long term average 9 am and 3 pm wind roses from Barcaldine Airport



2.2.5 RELATIVE HUMIDITY

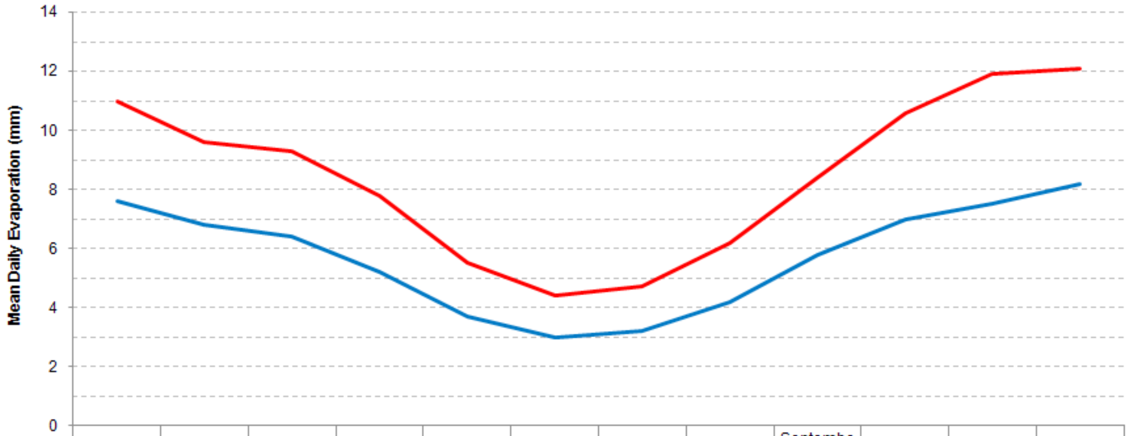
Relative humidity in the study area is typically higher during the summer and autumn months and lower during the spring months. Relative humidity is affected by the distance from the sea with stations further from the ocean having less water vapour available and hence lower relative humidity's (Barcaldine is generally lower than Clermont and Emerald). The long term average relative humidity summaries recorded for the region are shown in Figure 5.

Figure 5. Long term average relative humidity summaries



	January	February	March	April	May	June	July	August	September	October	November	December
Barcaldine - 9AM	56	62	58	57	58	64	58	50	45	44	44	49
Barcaldine - 3PM	38	40	37	37	36	38	33	29	26	27	28	32
Blackall - 9AM	53	58	55	55	62	64	60	51	44	43	43	48
Blackall - 3PM	33	38	34	34	40	36	33	28	24	26	27	29
Emerald - 9AM	63	68	60	59	60	64	59	56	53	53	55	58
Emerald - 3PM	41	45	36	35	37	41	35	32	28	31	33	36
Clermont - 9AM	66	71	69	67	68	69	66	61	55	54	57	60
Clermont - 3PM	42	47	42	41	42	41	37	33	29	30	34	38

Figure 6. Mean daily evaporation



	January	February	March	April	May	June	July	August	September	October	November	December
Longreach	11	9.6	9.3	7.8	5.5	4.4	4.7	6.2	8.4	10.6	11.9	12.1
Clermont	7.6	6.8	6.4	5.2	3.7	3	3.2	4.2	5.8	7	7.5	8.2

2.2.6 EVAPORATION

During the summer months, longer hours of daylight, hotter temperatures and higher solar radiation results in evaporation rates higher than those experienced during the June to August cooler months. As can be seen in Figure 6, solar radiation is generally lower at Clermont than at Longreach.

2.2.7 SURFACE PRESSURE

Hourly and monthly mean minimum, 5th and 95th percentile, median and maximum pressures are presented at Figure 7 and Figure 8, respectively. The hourly graphs show that the median pressure is generally around 1014 hPa and that the pressure generally remains between 1002 and 1025 hectopascals (hPa). There appears to be a diurnal cycle in pressure, with maximums in the mid-morning (7 to 10 am) and minimums during the late afternoon (3 to 5 pm). This is due to a feature often referred to as atmospheric tides. This is where atmospheric solar heating, combined with upward eddy conduction of heat from the ground, generates internal gravity waves in the atmosphere at periods of the integral fractions of a solar day (primarily at the diurnal and semidiurnal periods).

An annual cycle is clearly visible in Figure 8 which reflects the fact that the sub tropic anticyclone belt migrates north during winter resulting in higher pressures.

Figure 7. Hourly averages mean sea level pressure from 2001 to 2010

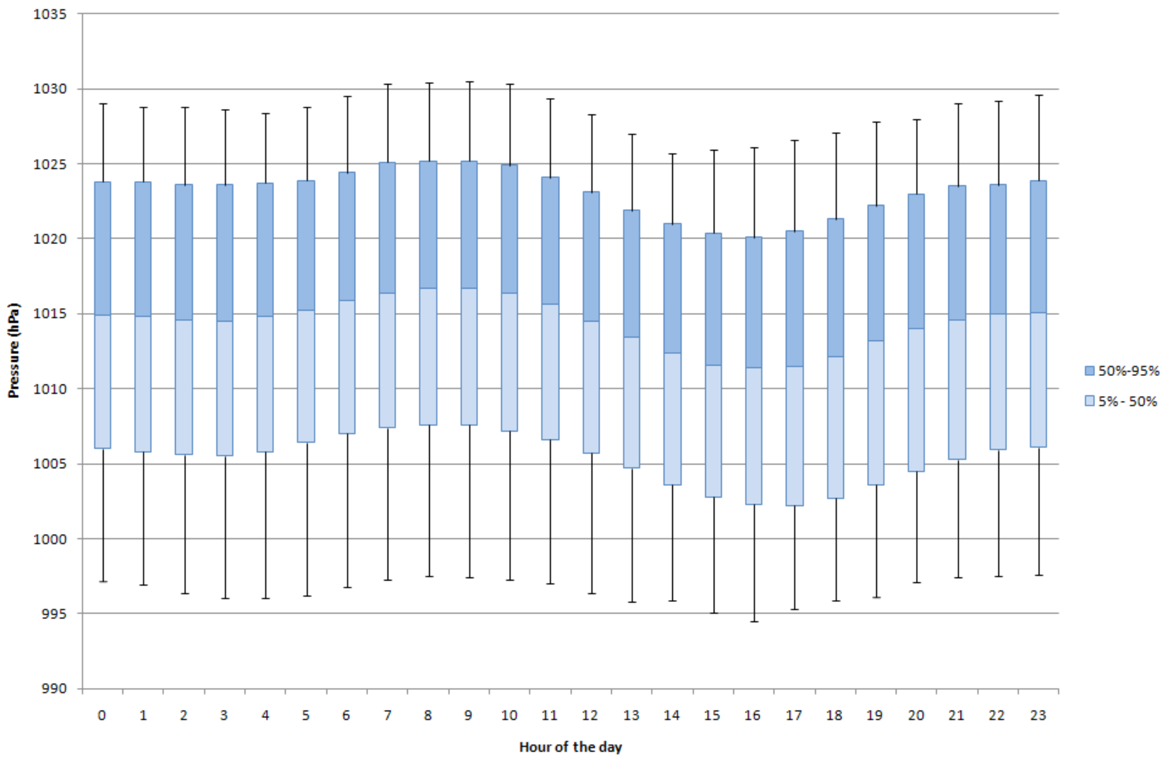
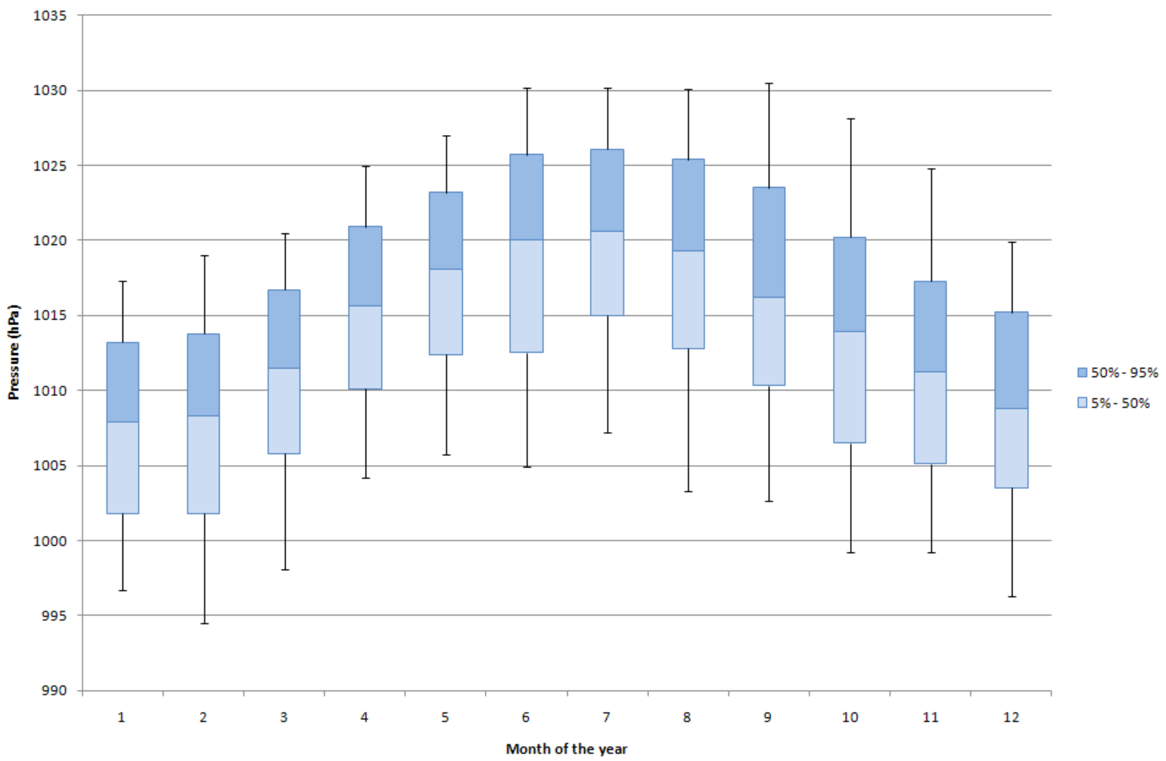


Figure 8. Monthly averages mean sea level pressure from 2001 to 2010



2.2.8 CLIMATE EXTREMES

2.2.8.1 Floods

Northern Queensland has highly variable seasonal and annual rainfall linked to tropical lows / cyclones and monsoonal activity (Lough, 2001). The Belyando catchment (a sub-catchment of the Burdekin), in which the EPC exists is characterised by low relief floodplains (Rogers *et al.*, 1999). The variable rainfall and relatively flat topography can result in localised flooding occurring in sub-catchments during events of 200 mm over a 48 hour period. Flooding generally occurs during summer months as a result of heavy rainfalls caused by tropical lows and rain depressions generated from cyclones crossing the north eastern Queensland coastline.

BOM data indicates that the most recent major flooding occurred in the Burdekin catchment in February 1991. This flood occurred near Ayr, over 300 km downstream of the EPC. Major flooding also occurred in the Fitzroy catchment in and around Emerald, approximately 150 km east of the EPC, as recently as January 2008. This area is not hydraulically linked to the mine site, therefore will have no impact on flooding in this area. Heavy rainfall in the first quarter of 2010 resulted in minor, localised flooding of many of the creeks in and around the EPC.

Alice Creek, on the south western corner of the EPC, is a tributary of the Copper Creek Catchment. Alice Creek flows into the Barcoo, then the Thomson River system before entering the Cooper Creek System 35 km north west of Windorah. In time of flooding Cooper Creek can spread several kilometres from its banks with the floodwaters draining south west to Lake Eyre in South Australia. No mining is to be undertaken in this part of the EPC thus avoiding any interaction with the Cooper Creek Catchment. Most flooding would occur to the south west of the EPC area therefore the Cooper Creek catchment is unlikely to impact on the proposal.

There are no stream flow or gauging stations within the vicinity of the mine. The closest gauging station is located in Native Companion Creek at Violet Grove. This is in the upper reaches of the Native Companion Creek Catchment which contributes to the upper reaches of the Belyando. Native Companion Creek does not connect hydraulically to the mine area; however, the historic recorded flood levels for this gauging station are provided as a regional guide (see Table 3).

Table 3. Flood levels for Native Companion Creek

120305A – NATIVE COMPANION CREEK	
YEAR	FLOOD LEVEL (M) AHD
1973	29.09
1974	27.66
1977	28.25
1981	27.65
1983	28.56
1984	27.24
1990	33.10
1997	29.56
2003	29.06
2004	27.33

For more information on flooding refer to Volume 2, Chapter 9.

2.2.8.2 Flood event of 2010/2011

The period from late November 2010 to mid January 2011 was recorded as being an extremely wet one throughout eastern Australia. Several major rain events resulted in widespread flooding within rivers and catchments culminating in severe flooding in south-east Queensland. The flooding has been recorded as the most significant in Australia's recorded history in terms of its extent, impact and severity (National Climate Centre, 2011)

December 2010 rainfall levels were the highest on record in Queensland, with total highs of month levels and daily levels, set in 107 locations across the state. The state average level of rainfall of 209.45mm in December 2010 exceeded the previous record of 200.1mm set in December 1975 (BOM, 2011). The December 2010 rainfall totals in Queensland are depicted in Figure 9.

Table 4 demonstrates the monthly record of the December 2010 rainfall levels for the four meteorology stations previously used in Section 2.2 due to their proximity to the mine site. Both Blackall township and Emerald airport experienced their highest total rainfall for December since records have been compiled for each station. All stations surpassed their average rainfall levels for the month of December.

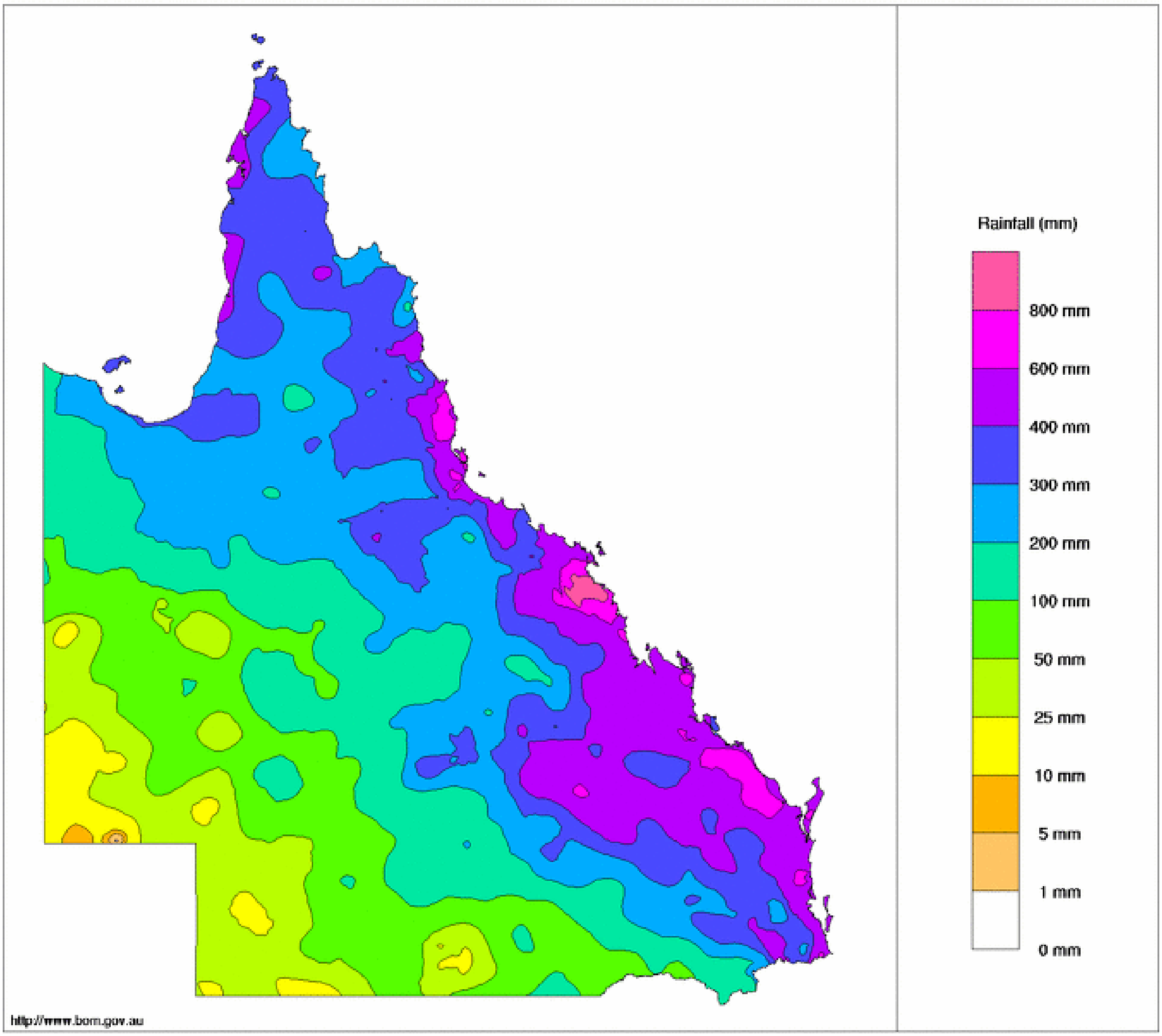
Table 4. Total December 2010 rainfall levels

METEOROLOGY STATION	TOTAL RAINFALL FOR DECEMBER 2010 (MM)	PREVIOUS WETTEST DECEMBER (MM)	YEARS OF RECORD	AVERAGE FOR DECEMBER (MM)
Barcaldine post office	227.7	298.3 in 1907	125	64.4
Blackall township	340.8	246.8 in 1965	130	69.1
Clermont	192.6	670.7 in 1916	141	92.5
Emerald airport	263.8	162 in 1996	18	91.2

Data sourced from BOM website, accessed August 2011

In addition to recording its highest total December rainfall, the weather monitoring site at Blackall Township also recorded its highest December daily rainfall in 124 years of records. The record was set on the 8th December 2010 with a total of 123.6mm rainfall in comparison to the previous record of 96.4mm rainfall set on 31st December 2009.

Figure 9 Queensland rainfall totals in December 2010



Source: BOM website, accessed August 2011

2.2.8.3 Tropical Cyclones

Tropical cyclones in the Queensland region mostly form from lows within the monsoon trough, between November and April. The considerable majority of cyclones are formed in coastal north Queensland; however, occasionally a cyclone tracks to inland and southern parts of the state, where they generally reduce in intensity. In some cases tropical lows do re-intensify and re-establish as a tropical cyclone, particularly where they interact with warmer coastal airflows associated with tropical waters.

Figure 10 shows that from 1906-2006 15 tropical cyclones have passed within 200 km of the mine site, which is approximately 350 km from the Queensland coast. Only two tropical cyclones have tracked within 50 km of the mine site (refer to Figure 11).

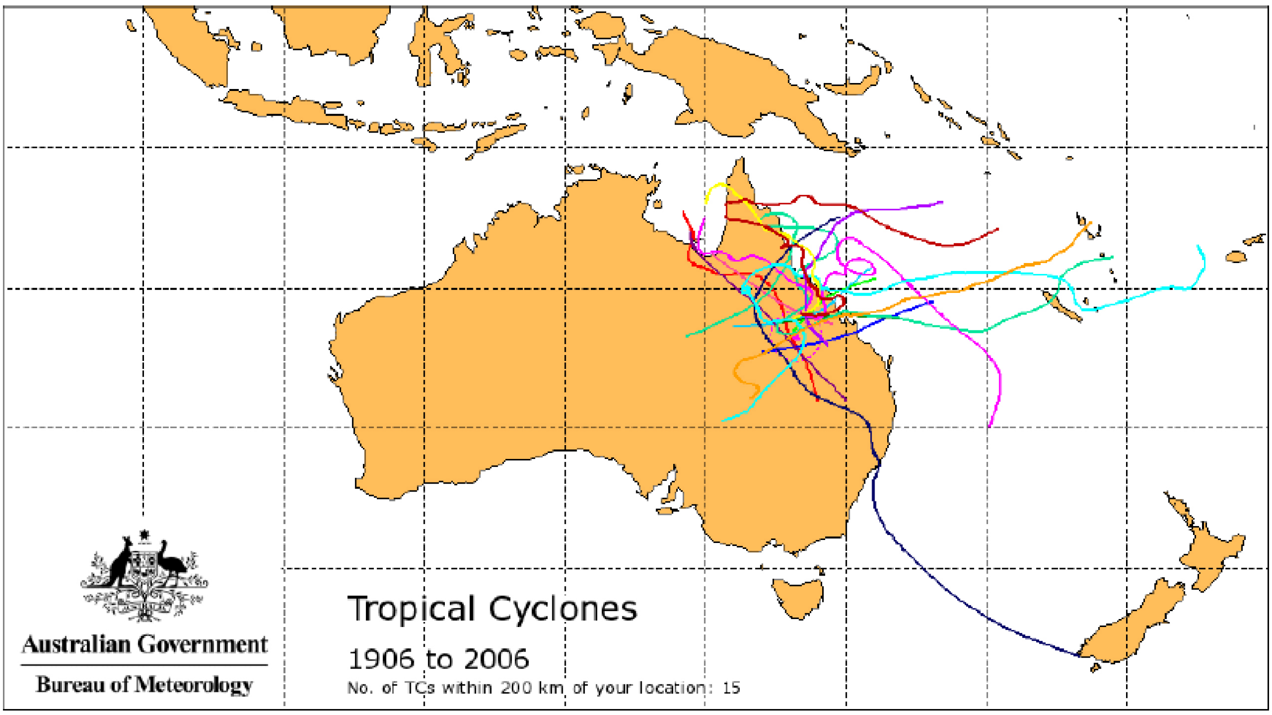
The average number of tropical cyclones at the mine site is <0.1 per year, based on data from the 1975/76 to 2005/06 cyclone seasons (BOM, 2009). This period includes El Niño, La Niña and neutral years; however, tropical cyclones impacts in eastern Australia have been shown to occur almost twice more often during La Niña years than during El Niño years (BOM, 2010b).

Trends in tropical cyclone activity in the Australian region have shown that the number of cyclones has decreased in recent decades, although the number of stronger cyclones (with minimum central pressure <970 hPa) has not declined. These trends may be associated with an observed increase in the frequency of El Niño events. It is difficult to determine if trends in tropical cyclone activity are the result of natural variations in large-scale environment in which tropical cyclones form and evolve, or if they are influenced by anthropologic climate change.

The latest predictions indicate that the number of cyclones in eastern Australia is not expected to increase; however, projections show more long-lived tropical cyclones in eastern Australian (CSIRO and BOM, 2007).

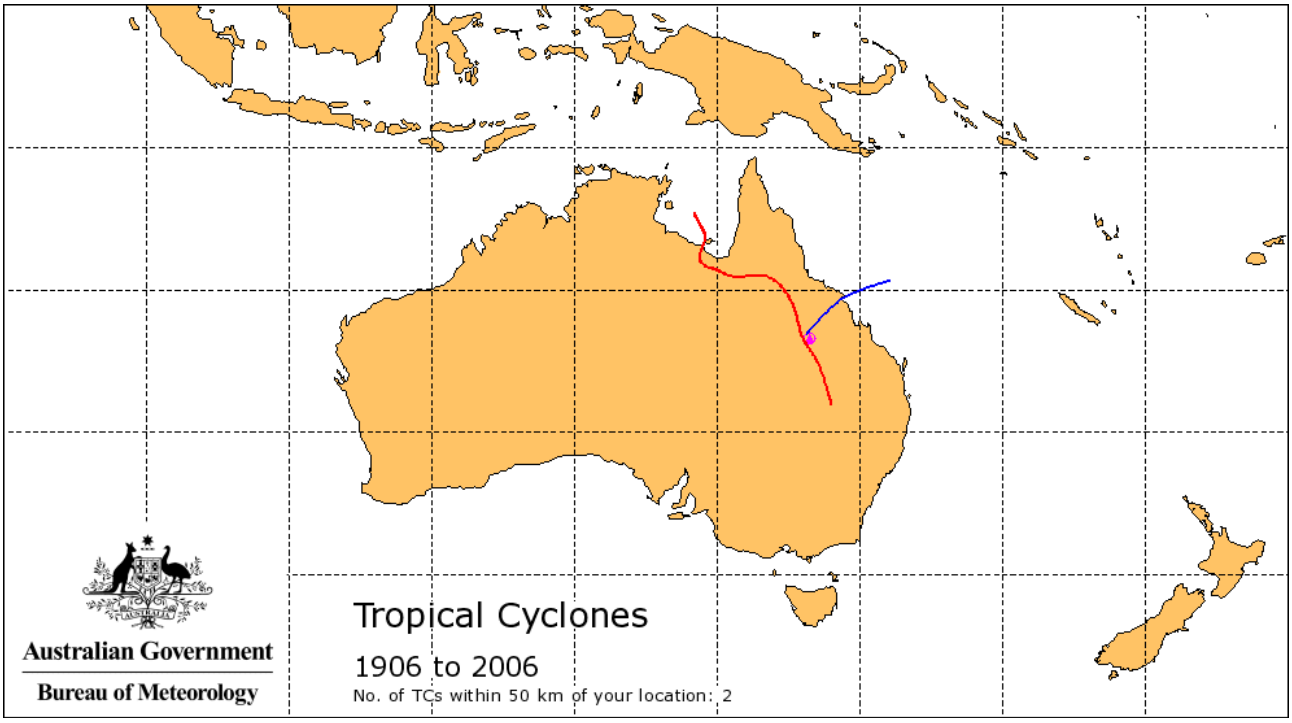
Tropical cyclone Yasi developed as a tropical low northwest of Fiji on 29th January and continued tracking on a general westward track. Yasi maintained a Category 3 intensity in a west-southwestward direction towards the tropical Queensland coast before being upgraded to a marginal Category 5 system. The Category 5 system maintained its intensity and made landfall on the southern tropical coast near Mission Beach between midnight and 1 am on 3rd February. Due to a large, intense system, Yasi maintained a strong core with damaging winds and heavy rain and continued to track westwards across northern Queensland where it finally weakened to a tropical low near Mount Isa almost nine hours later on 3rd February (BOM, 2011a).

Figure 10. Tropical cyclones within 200 km of Alpha (23.41oS 146.41oE) between 1906 – 2006



Source – BOM, 2010 accessed 10 May 2010

Figure 11. Tropical cyclones within 50 km of Alpha (23.41oS 146.41oE) between 1906 – 2006

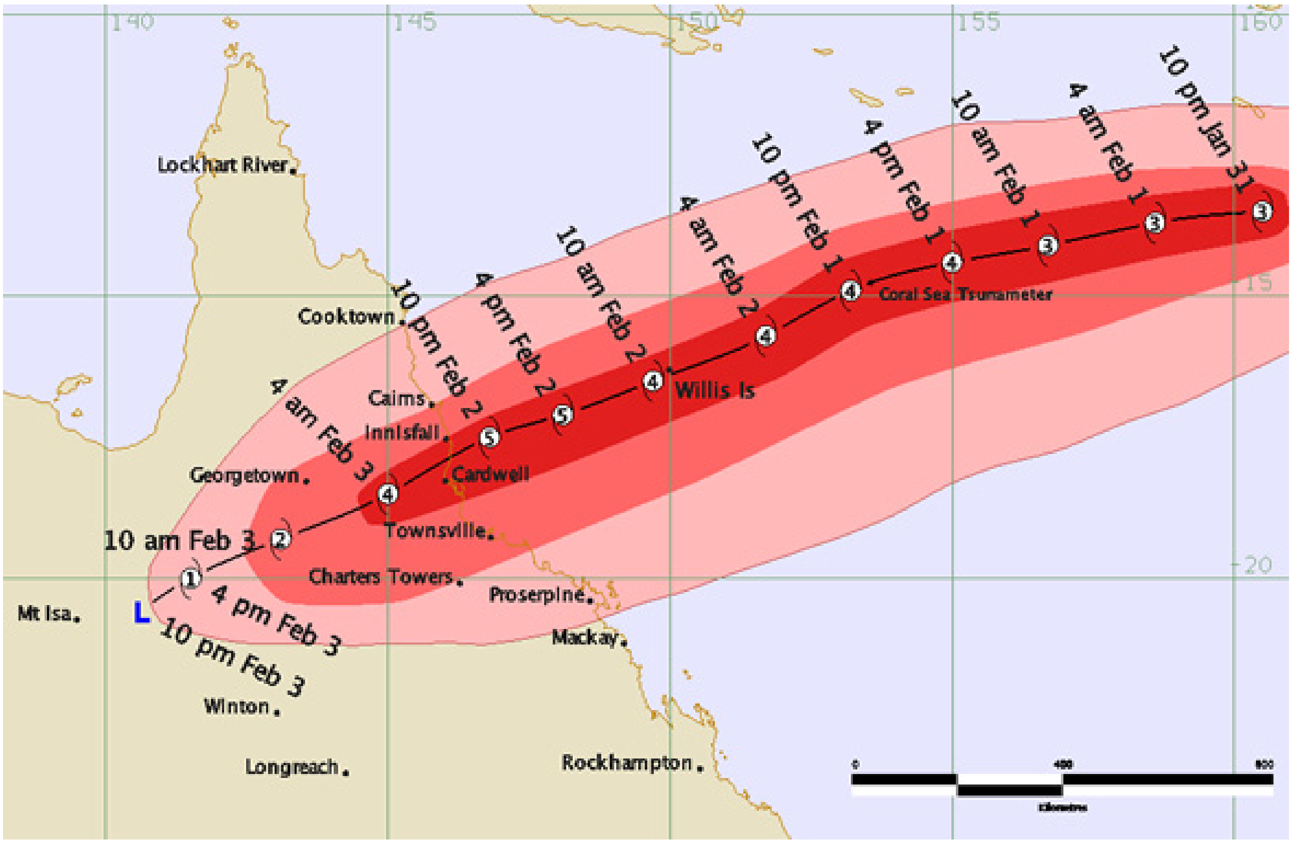


Source – BOM, 2010 accessed 10 May 2010

Yasi was one of the most powerful cyclones to have affected Queensland since records commenced, causing flooding in Cairns and Ayr due to rainfall totals in the order of 200-300 mm in a 24 hour period.

Figure 12 shows the cyclone track for Yasi which tracked almost 300 km away from the mine site.

Figure 12. Cyclone Yasi tracking



Source – BOM, accessed August 2011

2.2.8.4 Droughts

Dry periods, or droughts are a natural part of life in Australia, particularly in the marginal areas away from the coast and ranges. A drought is generally considered to be an acute shortage of water resulting from a longer than usual period of time in which the water available from rainfall and water in storage is not enough to meet demand. Drought in Australia can typically be categorised into three general themes:

- a meteorological drought – where an area receives an extended period of below-average precipitation;
- a hydrological drought – where water under storage fall below a pre-determined capacity versus usage threshold; and
- an agricultural drought where there is insufficient moisture for average stock carrying capacity and / or crop production.

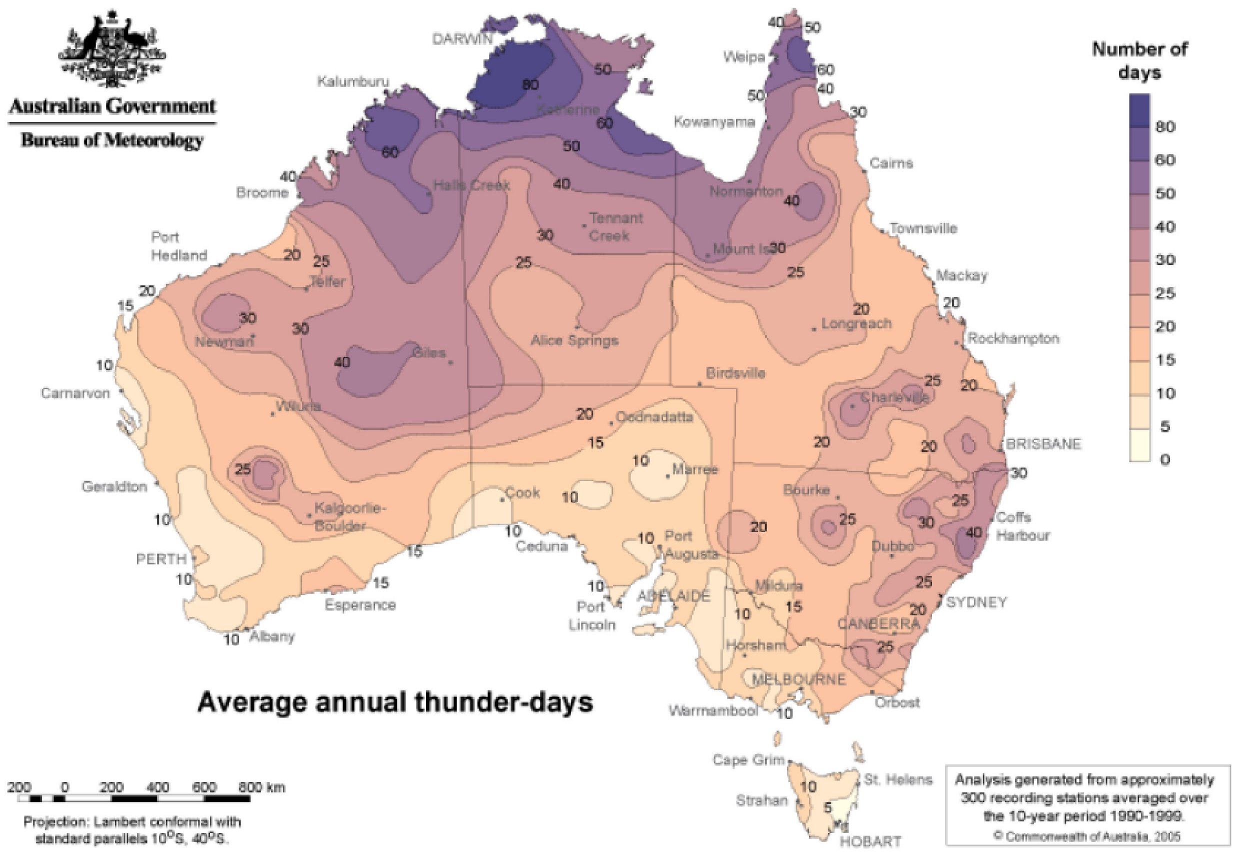
Research indicates that severe drought affects some part of Australia about once every 18 years. This does not indicate that severe drought regularly and predictably recurs every 18 years; intervals between severe droughts have varied from four to 38 years (BOM, 2010c). Severe droughts spanning several years have affected the east coast of Australia in each decade since the 1960s (BOM, 2010c).

Large areas of the region surrounding the mine site have been drought declared for most of the last decade. Whilst surrounded by drought declared areas, the previous Jericho Shire (now part of Barcaldine Regional Council) has not been drought declared since 15 March 2005 (Department of Primary Industries and Fisheries, 2010). Prior to that the area surrounding the mine had been drought declared since January 2003.

2.2.8.5 Thunderstorms and Lightning Strikes

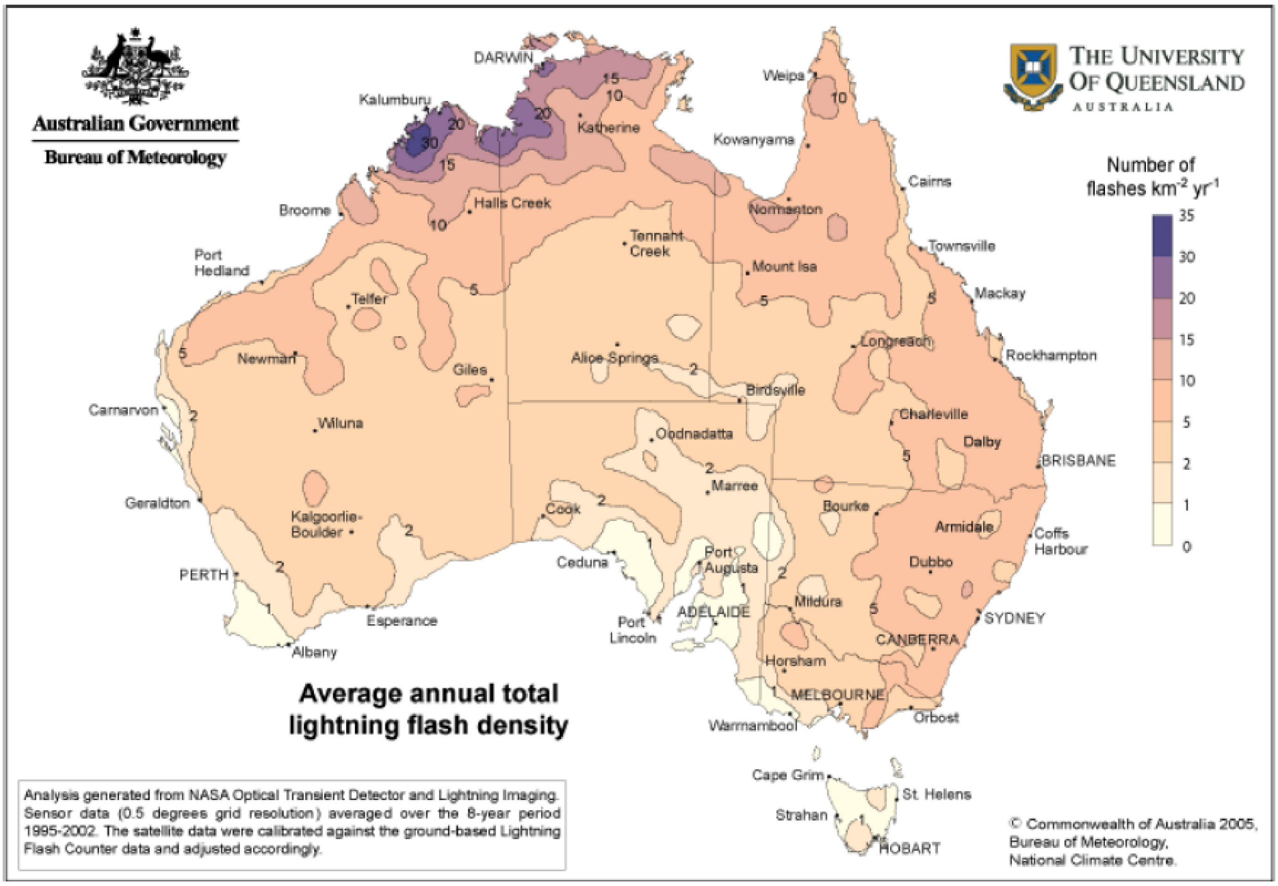
The BOM has estimated that the study area experiences 15 to 25 thunder days per year (see Figure 13), some of which can result in destructive winds, intense rainfall and flash flooding. Since the 1995 BOM has also been monitoring lightning flashes as both total lightning flash density (including intracloud flashes) and cloud to ground flash density per km^2 per year. Figure 14 and Figure 15 present long term (1995 - 2002) averages of expected annual lightning counts. These show that on average the study area might expect between 5 and 10 total flashes/km^2/year and 1 to 3 ground flashes/km^2/year.

Figure 13. Average annual thunder days between 1990 – 1999



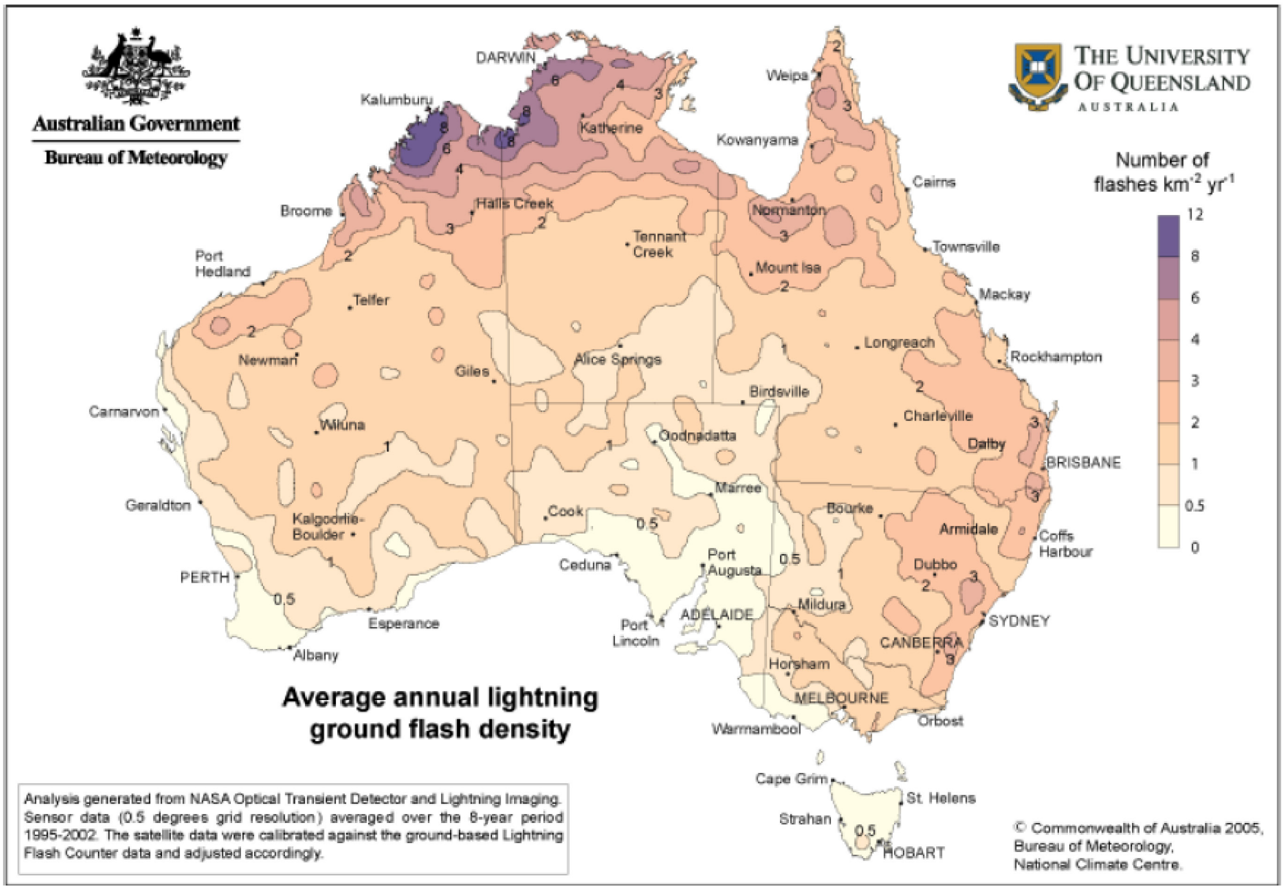
Source – BOM, 2010 accessed 10 May 2010

Figure 14. Average annual total lightning flash density between 1906 – 2006



Source – BOM, 2010 accessed 10 May 2010

Figure 15. Average annual total lightning flash density between 1906 – 2006



Source – BOM, 2010 accessed 10 May 2010

2.3 CLIMATE CHANGE IMPACT ASSESSMENT

2.3.1 ASSESSMENT METHOD

A desktop assessment was undertaken to establish a baseline context to climate change impacts at the Galilee Basin. Using projection scenarios developed by the Garnaut Review (2008), the United Nations Intergovernmental Panel on Climate Change (IPCC) and CSIRO, a climate change risk assessment process was undertaken by Waratah Coal. Projections from Garnaut, IPCC and CSIRO scenarios were utilised in assessing the Project's vulnerability to climate change, and in particular where there may be a significant impact to human safety or property.

The risk assessment identified and analysed mitigation measures associated with potential risks from climate change. The risk assessment is consistent with ToR's requirements and AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines.

This section of the chapter details the results of the climate change risk assessment and in particular, this section links to Sustainability Outcomes desired by Waratah Coal. These outcomes are identified as adaptation opportunities and will be incorporated into the mine Environmental Management Plan (EMP).

2.3.1.1 Projections Background

2.3.1.1.1 United Nations Intergovernmental Panel on Climate Change (IPCC)

The United Nations IPCC Special Report on Emissions Scenarios developed a range of scenarios as part of modeling global climate change projections. The IPCC prepared 40 greenhouse gas and sulfate aerosol emission scenarios for the 21st century that combine a variety of assumptions about demographic, economic and technological factors likely to influence future emissions. A full list and description of each scenario can be found at IPCC (2000). For the purpose of this assessment only scenarios A1B, B1 and A1FI have been selected for use.

A definition of each scenario, as taken from IPCC (2000) follows:

- the A1 storyline describes a future world of very rapid economic growth, a global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 storyline develops into three scenario groups that describe alternative directions of technological change in the energy system. They are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources and technologies (A1T), or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies); and
- the B1 storyline describes a convergent world with the same global population as in the A1 storyline (one that peaks in midcentury and declines thereafter) but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

Discussion regarding the three projections models considered is provided in the following sections.

2.3.1.1.2 National Garnaut Review Predictions

The most recent and authoritative work in predicting the future impacts that global Greenhouse Gas (GHG) emissions will have on Australian climate patterns and the Australian economy is the Garnaut Climate Change Review (Garnaut, 2008). The Garnaut review builds on previous attempts to quantify the social and economic impacts of climate change; in particular, the Stern Review on the Economics of Climate Change, which was prepared for the British Government and released in October 2006 (Stern, 2006).

The Garnaut review found that actual emissions between 2000 and 2005 were higher than those projected by the IPCC's emissions scenarios. An updated emissions scenario was developed based on the most recent projections of the International Energy Agency.

Predicted climate change impacts and emission trajectories identified by the Garnaut Review are divided into three global emission scenarios, no mitigation, 550 parts per million (ppm) stabilisation and 450 ppm stabilisation with overshoot.

No mitigation

- no action to mitigate climate change. Emissions continue to increase throughout the 21st century, leading to an accelerating rate of increase in atmospheric concentrations of greenhouse gases. Greenhouse gas concentrations reach 1,565 ppm equivalent carbon dioxide (CO_2-e), more than 3.5 times higher than pre-industrial concentrations by 2100.

550 ppm stabilisation

- emissions peak and decline steadily, so that atmospheric concentrations stop rising in 2060 and stabilise around 550 ppm CO_2-e (one third the concentration reached in the no mitigation scenario).

450 ppm stabilisation with overshoot

- emissions are reduced immediately and decline more sharply than in the 550 ppm case. Atmospheric concentrations overshoot to 530 ppm CO2-e mid-century and decline toward stabilisation at 450 ppm CO2-e early in the 22nd century.

The Garnaut review details Australian emission trajectories for each of the three global emission scenarios, in the context of Australia playing a fair and proportionate part in an effective global agreement to constrain greenhouse emissions. The trajectories give an indication of the greenhouse emission cuts required to achieve the 550 ppm and 450 ppm CO_2-e stabilisation goals, so they can be related to potential impacts predicted by the Garnaut review.

Annual GHG emissions associated with the Project, as a proportion of emissions trajectories detailed by the Garnaut Review are shown in Table 4.

Forecasted climate change impacts identified by Garnaut Review for the global emission scenarios are summarised in Table 5. It is problematic to predict how emissions from a specific source will impact future climate change, as changes in the global concentration of greenhouse gases are unknown and factors other than greenhouse gas concentrations affect global climatic systems.

Australia's commitment to the Kyoto Protocol effectively limits Australia's total greenhouse emissions, in the short term. Post-Kyoto, the GHG emissions from the Project would be regulated by the proposed Carbon Pollution Reduction Scheme CPRS under a cap and trade scheme, which outlines a reduction target between 5-25 %, with the upper target subject to global agreement stabilising greenhouse gas levels at 450 (ppm) or lower. It is unclear how or if Australia's emissions would be regulated if the CPRS is not adopted. However, currently Australia has a long-term greenhouse emission goal of a reduction of 60 % from 2000 levels by 2050.

Table 4. Garnaut target emissions for 2020 and 2050 for Australia and portion of 2020 target associated with the Project

GLOBAL AGREEMENT	AUSTRALIAN TARGET			
	2020	CHINA FIRST PROJECT % OF 2020 TARGET	2050	CHINA FIRST PROJECT % OF 2050 TARGET
450 ppm stabilisation with overshoot	405.8 Mt CO_2-e/a 32% reduction from current Kyoto commitment target 2008-2012	0.58%	59.7 Mt CO_2-e/a 90% reduction from current Kyoto commitment target 2008-2012	3.95%
550 ppm stabilisation	495.3 Mt CO_2-e/a 17% reduction from current Kyoto commitment target 2008-2012	0.48%	107.4 Mt CO_2-e/a 82% reduction from current Kyoto commitment target 2008-2012	2.19%
No global agreement	519.2 Mt CO_2-e/a 13% reduction from current Kyoto commitment target 2008-2012	0.45%	220.8 Mt CO_2-e/a 63% reduction from current Kyoto commitment target 2008-2012	1.08%

Source: Fraction of Australia's target emissions in 2020 and 2050 includes scope 1 and 2 emissions based on annual emissions forecast associated with Galilee Coal Project (Northern Export Facility) of 2.326 Mt/a. (Target values adapted from Garnaut Climate Change Review, 2008).

Table 5. Summary of forecast impacts from the Garnaut Climate Change Review, 2008

ASPECT	LOCATION	YEAR	PREDICTED IMPACT			NOTES	REFERENCE
			NO MITIGATION	450 PPM	550 PPM		
Temperature	Global	2030	Predicted increase in average temperature 1.3°C	Predicted increase in average temperature 1.2°C	Predicted increase in average temperature 1.2°C	Approximates estimated from Figure 4.5 Garnaut Climate Change review, best estimate median probability, increases over 1990 levels	Chapter 4 Figure 4 p88
		2070	Predicted increase in average temperature 3.5°C	Predicted increase in average temperature 2°C	Predicted increase in average temperature 2°C		
		2100	Predicted increase in average temperature 4.5°C	Predicted increase in average temperature 1.5 °C	Predicted increase in average temperature 2°C		
Sea level rise	Global	2100	29 to 59 cm rapid changes in ice flow could add another 10 to 20cm to the upper range	Not specifically determined	Not specifically determined	Based on IPCC estimations for SRES scenario A1F1 similar to no mitigation case	Chapter 4 p93
Ocean acidity	Global	NA	Increasing ocean acidity proportionate to increased atmospheric carbon dioxide concentrations, consequences for aquatic life, increased impact in colder waters			This is directly related to CO_2 concentration in atmosphere	Chapter 4 p80
Precipitation	Queensland	2030	Decrease from 1990 level -2.4%	Not specifically determined	Not specifically determined	Based on median annual average	Chapter 5 Table 5.1 p115
		2070	Decrease from 1990 level -8.6%	Not specifically determined	Not specifically determined	Based on median annual average	
		2100	Decrease from 1990 level -12.7%	Not specifically determined	Not specifically determined	Based on median annual average	
Cyclones and storms	Global	NA	Increased intensity			Not based on a specific scenario	Chapter 5 p117
		NA	Frequency same or decreased			Not based on a specific scenario	

ASPECT	LOCATION	YEAR	PREDICTED IMPACT			NOTES	REFERENCE
			NO MITIGATION	450 PPM	550 PPM		
Bushfires	Australia	2013	5 to 25% increase in number of days with extreme fire weather	Not specifically determined	Not specifically determined	Based on 0.4°C increase	Chapter 5 Table 5.4 p118
		2034	15 to 65% increase in number of days with extreme fire weather	Not specifically determined	Not specifically determined	Based on 1°C increase	
		2067	100 to 300% increase in number of days with extreme fire weather	Not specifically determined	Not specifically determined	Based on 2.9°C increase	
Heatwaves	Brisbane	2008	0.9 days over 35°C	Not specifically determined	Not specifically determined	Increase over 1990 baseline	Chapter 5 Table 5.3 p117
		2030	1.7 days over 35°C	Not specifically determined	Not specifically determined		
		2070	8 days over 35°C	Not specifically determined	Not specifically determined		
		2100	21 days over 35°C	Not specifically determined	Not specifically determined		
Agriculture	Australia	NA	Crop production affected by changes in average rainfall and temperature. Livestock affected by quantity and quality of pastures. Severe weather events (bushfire, flooding) reduce production. Increased temperature alters occurrence of pests and disease. Potential for carbon fertilisation if not crop growth is not restricted by temperature and rainfall.			Not based on specific scenario	Chapter 6 p129

ASPECT	LOCATION	YEAR	PREDICTED IMPACT			NOTES	REFERENCE
			NO MITIGATION	450 PPM	550 PPM		
Dryland cropping - wheat	Dalby, Queensland	2030	8.2% cumulative yield change	1.6% cumulative yield change	4.8% cumulative yield change	Percentage cumulative yield change from 1990	Chapter 6 Table 6.5 p132
		2100	-18.5% cumulative yield change	-3.7% cumulative yield change	-1.0% cumulative yield change	Based on median probability of rainfall, relative humidity, temperature	
Dryland cropping - wheat	Emerald, Queensland	2030	7.2% cumulative yield change	1.8% cumulative yield change	4.4% cumulative yield change	Percentage cumulative yield change from 1990	Chapter 6 Table 6.5 p132
		2100	-10.1% cumulative yield change	-2.5% cumulative yield change	0% cumulative yield change	Based on median probability of rainfall, relative humidity, temperature	
Irrigated agriculture	Murray Darling	2030	12% decline in economic value of production	3% decline in economic value of production	3% decline in economic value of production	Based on median probability of rainfall, relative humidity, temperature	Chapter 6 Table 6.4 p130
		2050	49% decline in economic value of production	6% decline in economic value of production	6% decline in economic value of production	Based on median probability of rainfall, relative humidity, temperature	
		2100	92% decline in economic value of production	6% decline in economic value of production	20% decline in economic value of production	Based on median probability of rainfall, relative humidity, temperature	
Water supply infrastructure	Australia	2100	34% increase in cost of supplying water	4% increase in cost of supplying water	5% increase in cost of supplying water	Based on median probability	Chapter 6 Table 6.3
Coastal buildings	Queensland	2030	Medium magnitude of net impact	Medium magnitude of net impact	Medium magnitude of net impact	Based on median probability of rainfall, relative humidity, temperature	Chapter 6 Table 6.8
	Queensland	2100	Extreme magnitude of net impact	Medium magnitude of net impact	Medium magnitude of net impact		
Temperature related deaths	Queensland	2100	Over 4000 additional heat-related deaths relative to no climate change	Fewer deaths relative to no climate change	Fewer than 80 additional heat-related deaths relative to no climate change	Based on median probability	Chapter 6 Table 6.3 p128

ASPECT	LOCATION	YEAR	PREDICTED IMPACT			NOTES	REFERENCE
			NO MITIGATION	450 PPM	550 PPM		
Geopolitical stability in Asia-Pacific	Asia Pacific	2100	Displacement of people from South East Asian cities (sea rise)	Less displacement (lower sea rise)	Less displacement (lower sea rise)	Based on median probability	Chapter 6 Table 6.3 p128
Ecosystems	Global	NA	Loss of biodiversity in high altitudes, wet tropics, coastal freshwater wetlands, coral reefs increasing with higher impact scenarios			Impact is specific to each ecosystem	Chapter 6 p142
International trade	Global	NA	Affected economies (China, India, Indonesia) reducing demand for Australian goods			not based on a specific scenario	Chapter 6 p145

2.3.1.2 CSIRO Climate Change Scenarios

Climate change projections relevant to Australia have been developed by CSIRO and BOM (2007) for years 2030, 2050 and 2070. These projections were extrapolated as background data for the climate change risk assessment.

The mine has an expected 30 year life commencing with the construction period starting in 2014 and as such the projections for 2030 and 2050 are considered to be the most relevant. The projections for 2070 were considered; however, they are not seen as relevant as the other projections. Data input from 2070 projections were included for completeness.

CSIRO and BOM (2007) have developed climate change prediction summaries for Brisbane, Cairns and St George in Queensland. Whilst not individually relevant to the mine area, collectively the three data sets provide an indication of what is projected for Queensland. As such, where an increase is predicted for a certain parameter for each of the three sites in Queensland, it was assumed for the risk assessment that an increase would be projected for the mine site. .

The data presented in the Queensland Government (2009) Climate Change Predictions were incorporated into the risk assessment as additional data to the IPCC projections, noting though, that those data do not provide results for the adopted project life. Where IPCC did not project changes in climate for a number of parameters, projected changes from the Garnaut (2008) review were used (i.e. bushfire days, cyclones and sea level rise). An interpretation of the climate change models used in the risk assessment is provided below.

2.3.1.2.1 Interpretation to CSIRO Climate Change Projections

Background

In *Climate Change in Australia* (CSIRO and BOM,2007), annual or seasonal average changes in temperature, mean precipitation, humidity, radiation, wind speed, potential evaporation and sea surface temperature are provided in a probabilistic form, with 10th, 50th, and 90th percentiles provided. It is important to note that the site-specific probability distribution represents the range of model results. It is still a leap of faith to assume that the range of model results gives a representation of the expected change of the real world to a specific emission scenario. The real world may end up with different climate changes than any of these models have predicted, or the future climate changes may truly be within the bounds of these models' predictions.

Uncertainties in model predictions lie in how the models simulate the complicated physical and chemical processes of earth systems. Some of the processes are straight forward, but others may be complex systems with potential feedback mechanisms; some changes may be gradual and some others may be abrupt changes (such as the possible route changes of ocean currents). Processes may be known to scientists and hence incorporated into the existing climate models and others may remain unidentified by scientific communities. Because of the complexity of earth systems in response to increases in greenhouse gases contents in atmosphere and the uncertainties of model predictions, it is important to treat the predictions with caution.

Climate

Climate change models generally predict mean temperature changes in the most consistent way, in other words, the range of model predictions are narrow. For most other climate variables such as rainfall, relative humidity, solar radiation, the predicted changes vary significantly among models. For example, in *Climate Change in Australia*, predicted mean temperature changes for 2030 A1B are all positive, with less than one degree of uncertainties; in comparison, the predicted changes for rainfall, relative humidity, and solar radiation range from positive to negative, with mean model predictions near zero for the 2030 A1B scenario. Due to the large variations in the model predictions in these climate variables, the best estimate of the change is the ensemble average or multi-model mean. The upper and lower bounds of model predictions should not be taken as the bounds of climate changes in the future real world.

Rainfall

Rainfall is one of the most important climate variables for the Project. But, it is hard for climate models to predict it with any certainty. Cumulative rainfall is influenced by many different scales of weather systems, from the small-scale systems such localised thunderstorms, tropical cyclones, to large-scale frontal systems. Global climate change models (general circulation models – GCM) are mostly run at a coarse resolution, say 250 km, and this resolution is not fine enough to resolve small scale rainfall systems such as thunderstorms and tropical cyclones. Rainfall tends to vary locally, and is impacted by local terrains, distance to the coastal, etc. Current global climate change models cannot resolve such fine geographic changes. Many other climate variables suffer similar constraints. For example, solar radiation is associated with cloud cover, which is related to predicted rainfall and other climate variables such as relative humidity.

Many climate variables, such as climate extremes, have not been presented in *Climate Change in Australia* in a probabilistic manner; the uncertainties in predicting them are even greater. For these climate variables, the scientific understanding of the topic may be such that a qualitative assessment was all that was warranted.

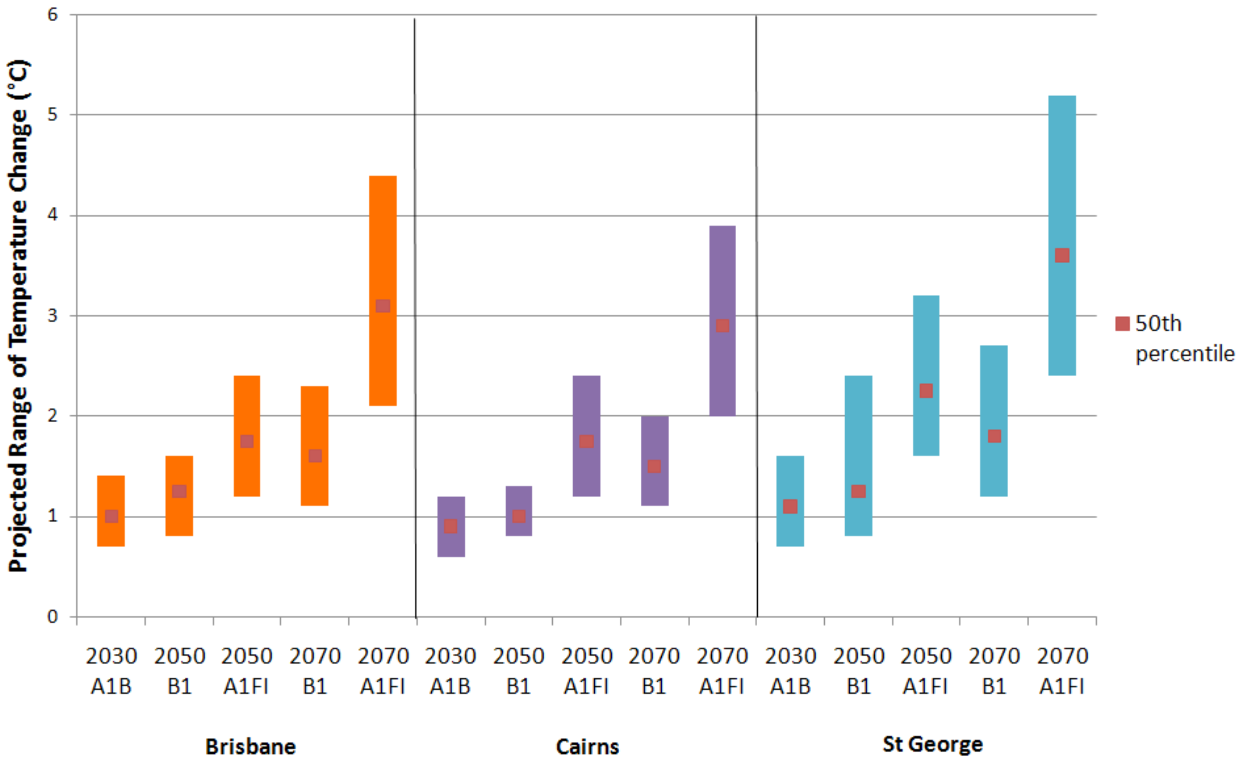
Trends and ranges of climate change projections are location specific. Hence, predictions for the three locations in Queensland, Brisbane, Cairns, and St George may not be applicable to the project region for all climatic parameters. Brisbane and Cairns are both coastal areas, while the mine and part of the rail component are located approximately 500 km inland. St George is inland Australia, but it is far south of the project area. Climate change projections by the Queensland Government, derived from downscaled runs of the CSIRO's climate change modeling, provide more region-specific predictions for temperature, rainfall and evaporation; however, the projections for 2070 fall outside of the life of the Project.

Temperature

Increased concentrations of GHGs in the earth's atmosphere directly impact temperature change. Therefore projected temperature change is the climatic parameter that can be most accurately modelled.

Projected annual average temperature changes for Brisbane, Cairns and St George show similar upward trends for low, medium and high emissions scenarios (Figure 16). It is reasonable to suggest annual average temperatures for the project region will follow similar upward trends.

Figure 16. Projected annual average temperature change for Brisbane, Cairns and St George relative to 1990 baseline



Source: Values adapted from Climate Change in Australia – Technical Report 2007.
Bars represent range from 10th percentile to 90th percentile

Number of Days above 35°C

The projected number of days greater than 35°C gives an indication of future climate extremes. Figure 17 shows the number of days greater than 35°C is expected to increase in Brisbane, Cairns and St George; however, the absolute number of days and the projected range varies significantly between cities. It can be assumed that under the various emissions scenarios, the future number of days greater than 35°C will increase in the project region. Further detail for the project region is provided in Table 6, sourced from the Queensland Government; however, the projections are for 2070 and therefore fall outside the adopted context of the assessment in terms of risk to safety and health of personnel and protection of infrastructure.

Rainfall

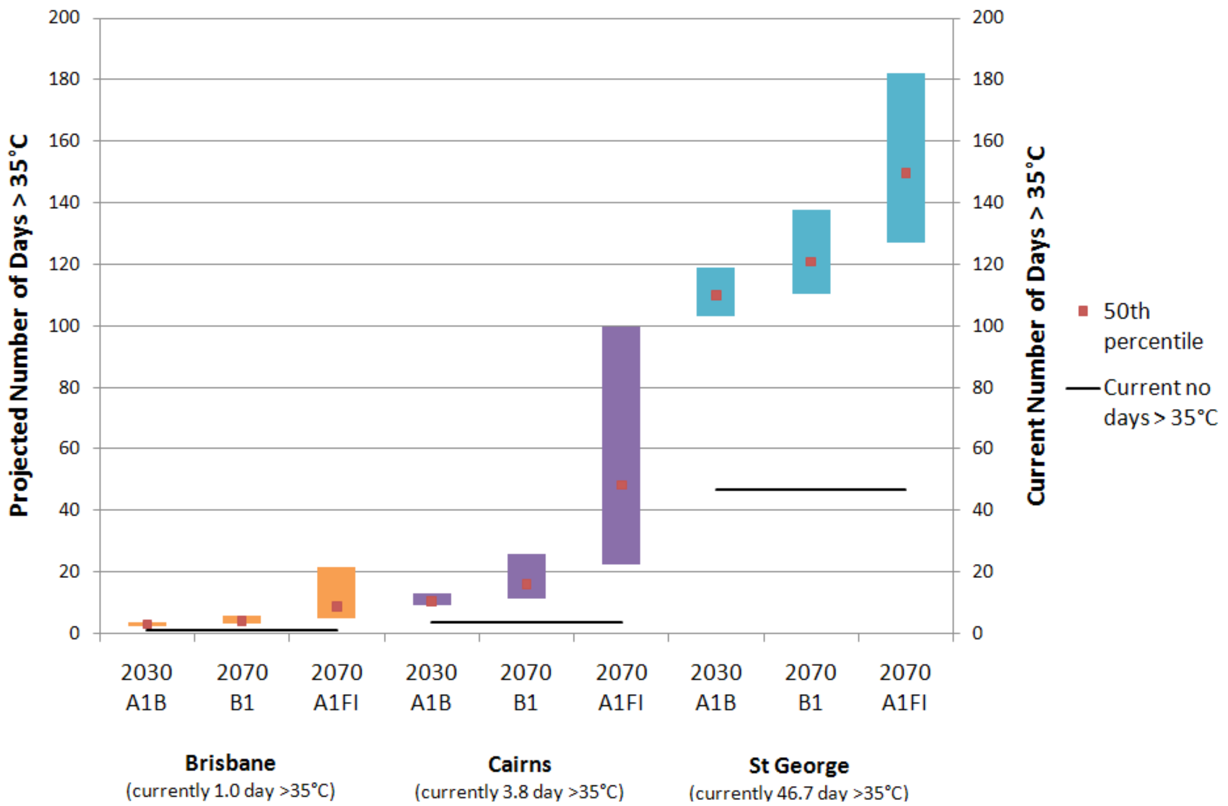
Best estimate (50th percentile) model projections indicate that rainfall is expected to decrease at Brisbane, Cairns and St George; however, the range of uncertainty is great for all model scenarios at all cities, and shows that rainfall could either increase or decrease. Figure 18 shows the projected rainfall changes for Brisbane, Cairns and St George.

Rainfall predictions are location specific, and therefore using the trends for Brisbane, Cairns and St George to predict rainfall for the project region are not ideal. More regional specific rainfall predictions, sourced from the Queensland Government, are shown in Table 6; however, the projections are for 2070 and therefore fall outside the adopted context of the assessment.

Potential Evaporation

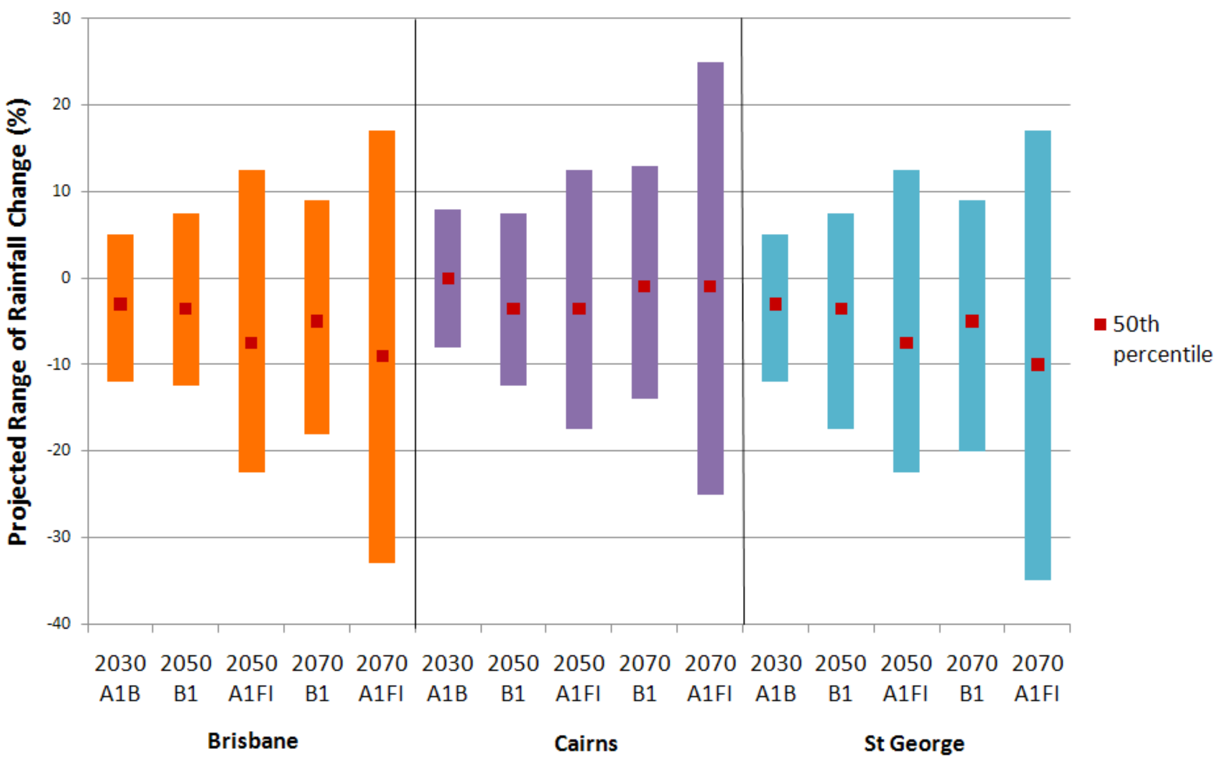
Potential evaporation for Brisbane, Cairns and St George is projected to increase under all emissions scenarios; however, the range of uncertainty is large, especially for a high emissions scenario (A1FI) at 2070. Figure 19 shows the projected potential evaporation changes for Brisbane, Cairns and St George.

Figure 17. Projected annual average number of days > 35°c for Brisbane, Cairns and St George relative to 1990 baseline



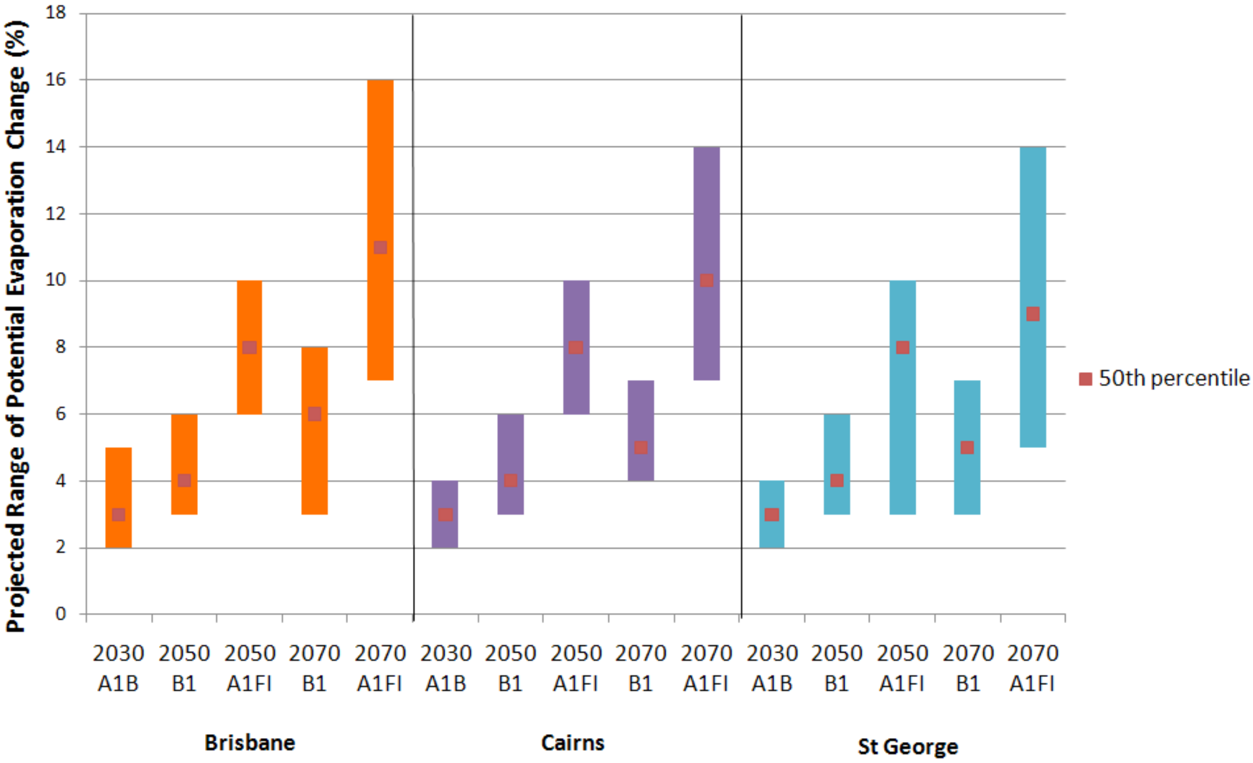
Source: Values adapted from Climate Change in Australia – Technical Report 2007.
Bars represent range from 10th percentile to 90th percentile. Values for 2050 not available

Figure 18. Projected annual average rainfall change for Brisbane, Cairns and St George relative to 1990 baseline



Source: Values adapted from Climate Change in Australia – Technical Report 2007
Bars represent range from 10th percentile to 90th percentile

Figure 19. Projected annual average evaporation change for Brisbane, Cairns and St George relative to 1990 Baseline



Source: Values adapted from Climate Change in Australia – Technical Report 2007
Bars represent range from 10th percentile to 90th percentile

Wind-Speed

Best estimate (50th percentile) model projections indicate that wind-speed is expected to increase at Brisbane, Cairns and St George **(Figure 20)**. The range of uncertainty is great for all model scenarios at all cities; however, the probability of increasing wind-speed is greater than decreasing wind-speed. It is reasonable to assume that annual average wind-speed at the project region will increase. However, as wind-speed is location specific, the projected changes should be used as a guide showing potential trends rather than absolute projections for the project area.

Relative Humidity

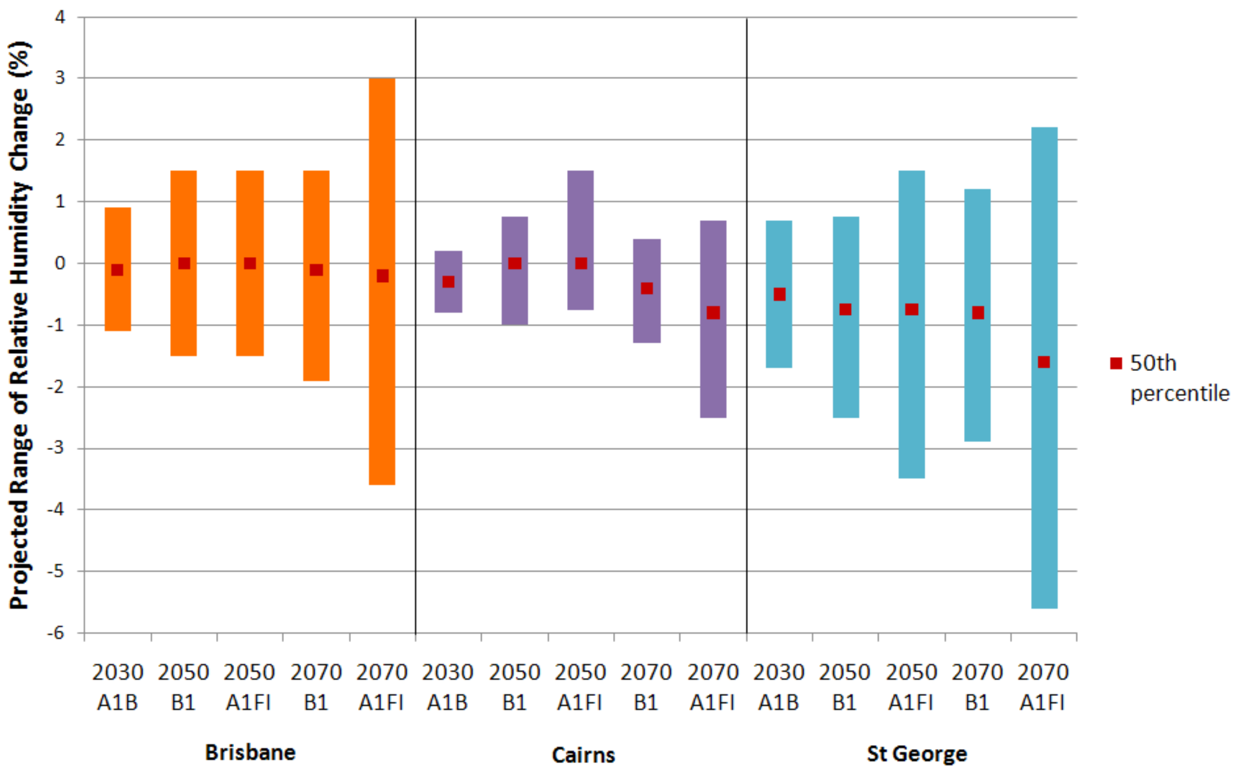
Best estimate (50th percentile) model projections indicate that relative humidity is expected to slightly decrease at Brisbane, Cairns and St George; however, the range of uncertainty at all cities shows that the relative humidity could either increase or decrease. Figure 21 shows the projected relative humidity changes for Brisbane, Cairns and St George.

As relative humidity is location specific, the projected changes should be used as a guide showing potential trends rather than absolute projections for the Project area.

Figure 20. Projected annual average wind-speed change for Brisbane, Cairns and St George relative to 1990 baseline

Source: Values adapted from Climate Change in Australia – Technical Report 2007
Bars represent range from 10th percentile to 90th percentile

Figure 21. Projected annual average relative humidity change for Brisbane, Cairns and St George relative to 1990 baseline



Source: Values adapted from Climate Change in Australia – Technical Report 2007
Bars represent range from 10th percentile to 90th percentile

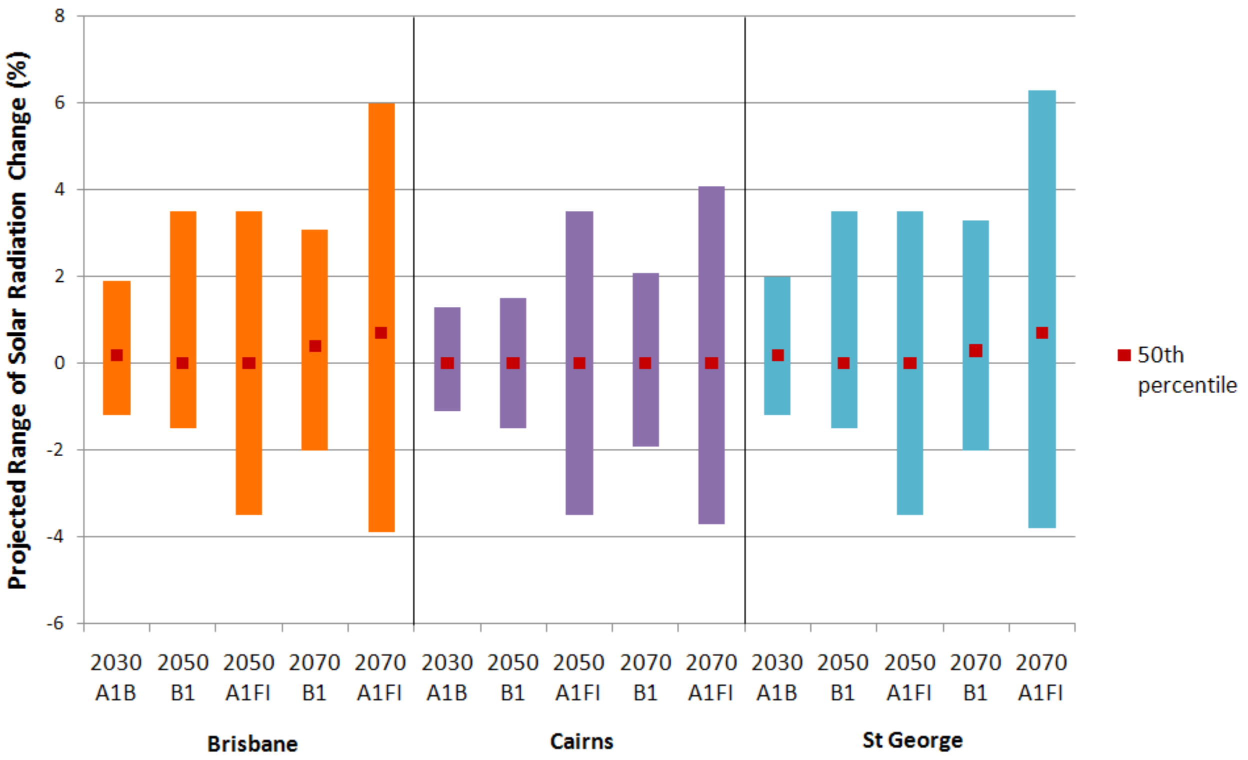
Solar Radiation

Best estimate (50th percentile) model projections indicate that solar radiation is expected to slightly increase or remain the same at Brisbane, Cairns and St George. The ranges of uncertainty for the model scenarios show solar radiation at all cities could either increase or decrease with almost equal probability. Figure 22 shows the projected changes in solar radiation for Brisbane, Cairns and St George.

As solar radiation is location specific, the projected changes should be used as a guide showing potential trends rather than absolute projections for the project area.

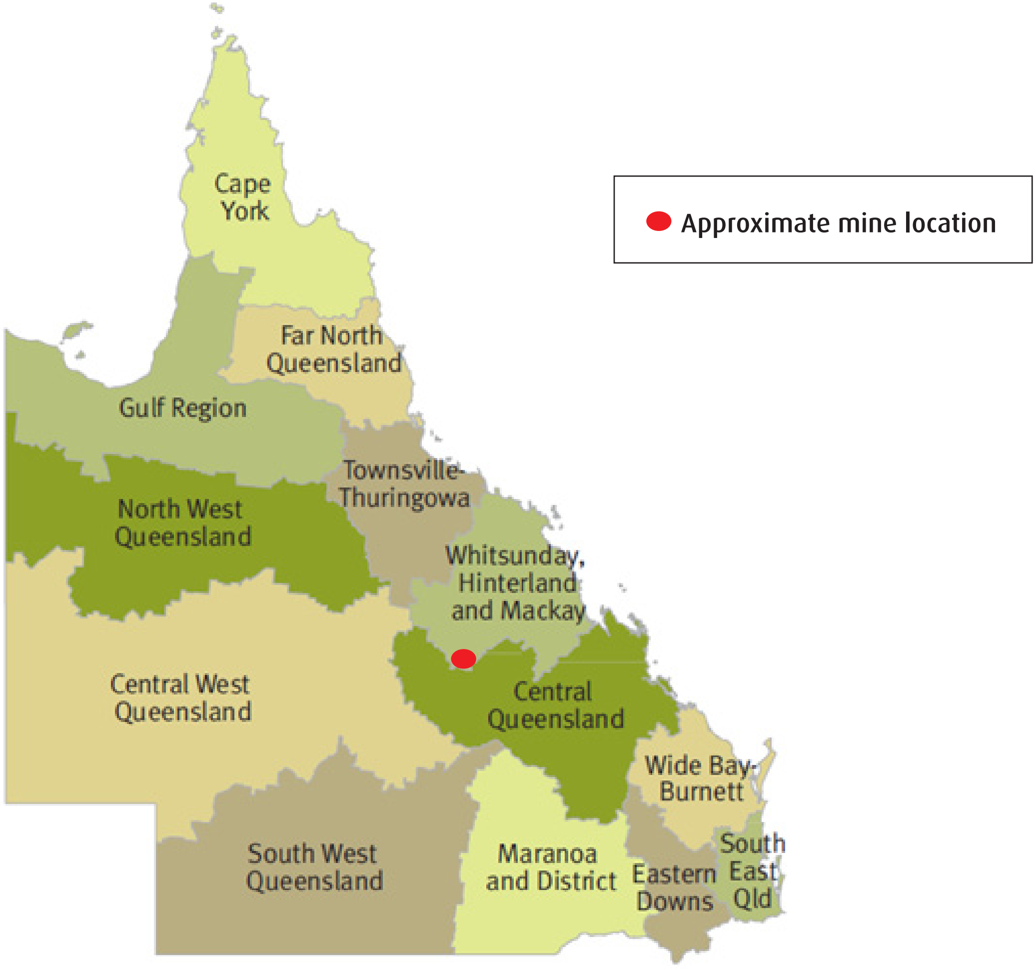
After 2030, climate change projections are increasingly dependent on the level of emissions, so both low and high emissions scenarios are used for 2050 and 2070.

Figure 22. Projected annual average solar radiation change for Brisbane, Cairns and St George relative to 1990 baseline



Source: Values adapted from Climate Change in Australia – Technical Report 2007
Bars represent range from 10th percentile to 90th percentile

Figure 23. Regions used for Queensland climate change projections and the approximate location of the Project



Source: Figure taken from Qld Government, 2009, ClimateQ: Towards a Greener Queensland (Chapter 5: Climate Change Impacts on Queensland's Regions)

2.3.1.2.2 Queensland Government Predictions

The Queensland Government has built on the modelling conducted for the Climate Change in Australia report, providing climate change projections for Queensland regions.

Table 6 presents a summary of the predicted impacts of climate change by 2070, under a high emissions scenario (A1FI) best estimate (50th percentile) projection, sourced from *ClimateQ: Towards a Greener Queensland*. The shaded data reflect the area identified as most representative of the project area. Figure 23 shows the regions used for Queensland climate change projections and the approximate location of the Project.

Table 6. Queensland Government's climate change predictions

PARAMETERS	QUEENSLAND AVERAGE	WHITSUNDAY, HINTERLAND AND MACKAY	CENTRAL QUEENSLAND
Temperature			
Change previous decade	0.4 °C	0.3 °C	0.5 °C
Predicted change by 2070	4.4 °C	4.2 °C	4.5 °C
Predicted no. days above 35°C (% change)	437 %	1,200 %	400 %
Rainfall			
Change in last decade in comparison with previous 30 years[a]	-8 %	-14 %	-14 %
Predicted change (% change)[b]	-4.3 %	-35 to 17 %	-35 to 17 %
Evaporation			
Predicted change (% change)	10.5 %	7-15 %	7-15 %

[a] This is generally consistent with natural variability experienced over the last 110 years, which makes it difficult to detect any influence of climate change at this stage

[b] The 'best estimate' of projected rainfall change shows a decrease under all emissions scenarios

Source: Qld Government, 2009, *ClimateQ: Towards a Greener Queensland* (Chapter 5: Climate Change Impacts on Queensland's Regions)

2.3.1.3 Climate Change Risk Assessment

The climate change risk assessment included each parameter being assessed in the identification of the potential impacts associated with the Galilee Basin for each climate change variable. Where a projected change in the climate parameter will potentially have a high or extreme impact on the mine site, the details were recorded for further analysis and a risk was assigned to each of the identified *"potential risks"* requiring further consideration. This assessment was undertaken using the Australian Government (AGO) Risk Likelihood Ratings (Table 7) and Risk Consequence Scales (Table 8).

Table 7. Risk likelihood ratings

RATING	RECURRENT RISKS	SINGLE EVENTS
Almost Certain	Could occur several times per year	More likely than not – Probability greater than 50%
Likely	May arise about once per year	As likely as not – 50/50 chance
Possible	Mar arise once in ten 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 to occur during the next 25 years	Negligible – Probability very small, close to zero

Source: AGO 2006

Table 8. Consequence ratings (adapted from AGO, 2006)

CONSEQUENCE RATING	SUCCESS CRITERIA				
	WORKPLACE SAFETY	ENVIRONMENT AND SUSTAINABILITY	SHAREHOLDER VALUE	GROWTH	COMPLIANCE
CATASTROPHIC	Large numbers of serious injuries or loss of lives	Major widespread loss of environmental amenity and progressive irrecoverable environmental damage	The business would have to be wound up	The business would contract markedly placing its long term viability in question	Obvious and proven breaches of legal and regulatory requirements with the prospect of corporate or individual penalties
MAJOR	Isolated instances of serious injuries or loss of lives	Severe loss of environmental amenity and danger of continuing environmental damage	Shareholder value would decline markedly and necessitate significant remedial action	The business would contract and require significant remedial action	Significant amounts of management and adviser's effort would be required to answer charges of compliance failures
MODERATE	Small number of injuries	Isolated but significant instances of environmental damage that might be reversed with intensive efforts	Shareholder value would stagnate	There would be no growth	Formal action would be required to answer perceived breaches or charges of compliance failure
MINOR	Serious near misses	Minor instances of environmental damage that could be reversed	Shareholder value would increase but fail to meet expectations	Growth would be achieved but it would fail to meet expectations	Minor perceived or actual breaches of compliance would be resolved
INSIGNIFICANT	Appearance of threat but no actual harm	No environmental damage	There would be a minor shortfall in meeting expectations for shareholder value but they would pass unnoticed	There would be a minor shortfall in growth but this would not attract much attention	Concerns about compliance would be resolved without special action

2.3.1.4 Climate Change Risk Evaluation

Those risks with rankings of high and extreme were revisited and potential adaptation strategies and / or management control process changes were recorded and the mitigated risk was assigned. The method used for the identification and assessment of risk is consistent with the risk management process as outlined in *AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines and the Australian Greenhouse Office Climate Change Impacts and Risk Management Guide for Business and Government*.

For each identified risk ranked as high or extreme:

- any existing controls (features of the environment, natural or made structures, mechanisms, procedures and other factors) that are already in place to mitigate the risk were identified;
- the consequences of the risk, if it were to arise, given the controls, in each of the scenarios under consideration was described;
- the likelihood of that level of consequence, given the controls, in each of the scenarios under consideration, were also described; and
- an initial priority was assigned in each scenario (2030 and 2070) based on the likelihood and consequence of the risk.

At the completion of the risk analysis and evaluation, the risk assessment matrix in Table 9 was used to identify the mitigated potential risk for each scenario. The raw risk and mitigated risk differ as the risk profile changes through the included mitigation or management controls influencing the likelihood of the event occurring and / or reduces the predicted intensity of the consequence. The descriptors applied to the risk rankings in the Rask Ranking Matrix are provided in Table 10.

Table 9. Risk ranking matrix

DEFINITIONS		CONSEQUENCE				
		Insignificant	Minor	Moderate	Major	Catastrophic
LIKELIHOOD	Almost Certain	Medium	Medium	High	Extreme	Extreme
	Likely	Low	Medium	High	High	Extreme
	Possible	Low	Medium	Medium	High	High
	Unlikely	Low	Low	Medium	Medium	Medium
	Rare	Low	Low	Low	Low	Medium

(Source: AGO 2006)

Table 10. Risk ranking descriptors

RANKING	DESCRIPTION
Extreme	Risks demand urgent attention at the most senior level and cannot be simply accepted as part of routine operations without executive sanction.
High	Risks are the most severe that can be accepted as part of routine operations without executive sanction but they will be the responsibility of the most senor operational management and reported upon at the executive level.
Medium	Risks can be expected to form part of routine operations but the will be explicitly assigned to relevant managers for action, maintained under review and reported upon at senior management level.
Low	Risks will be maintained under review but it is expected that existing controls will be sufficient and no further action will be required to treat them unless they become more severe.

(Source: AGO 2006)

2.3.1.5 Potential Impacts

2.3.1.5.1 Mine Site

The risk assessment identified that increased average wind speed associated with climate change posed a potential high risk to environment and sustainability resulting in potential minor breaches in compliance. It was also considered that increased wind speed could impact upon the success of rehabilitation programs leading to potential sheet and / or gully erosion problems; however, this risk was considered as a medium risk.

Impacts associated with the projected increase in the number of days reaching 35ºC or > 35 ºC were assessed as a medium risk due to the potential of a small number of injuries occurring each year as a result of fatigue from extreme heat.

In regard to the site water balance and potential implications associated with the projected decrease in precipitation, it was acknowledged that there may be a decrease in water resources available for production resulting in a subsequent increase in demand from local storages. This was not considered a significant risk given the option to use raw water from the Sunwater owned and operated pipeline from the Connors River Dam as a back-up secure water supply to augment dewatering of the coal seams and on site water catchment yields. The potential to impact offsite water quality due to reduced precipitation was considered as representing a low risk due to controls established to manage discharge water in accordance with operating license conditions.

The risk assessment identified an increase on average wind speed associated with climate change that posed a potential high risk to environment and sustainability resulting in potential minor breaches in compliance. It was also considered that increased wind speed could impact upon the success of rehabilitation programs leading to potential sheet and / or gully erosion problems; however, this risk was considered as a medium risk.

Whilst it is projected that there will be a potential decrease in rainfall, it is projected that rainfall intensity will increase, resulting in more frequent storm events. It was agreed that increases in the potential for 1 in 100 year flood events posed a medium risk due to potential flooding impacts to the operation of the open cut and underground mines, failure of the tails storage dam, potential increases in erosion to exposed surfaces and recently rehabilitated areas, in addition to potential impacts to offsite water quality associated due sediments leaving the site. It was agreed that a major compliance issue could potentially result if the above situations arose, notwithstanding it was assessed that these potential impacts would be isolated and able to be reversed with significant effort.

Risks associated with increased extreme fire risk days were assessed as posing a medium risk. Extreme fire risk days already pose a risk to the site due to the number of extreme temperature days that already occur and that the increase was not significant enough to warrant a higher risk ranking.

Risks associated with increased storms were ranked as medium given the potential for risks to human health and minor isolated instance of environmental damage.

In terms of workplace health and safety, the environment and sustainability matters associated with projected changes in rainfall, humidity and solar radiation these were ranked as being medium to low risks. Shareholder value and growth were ranked against the same parameters as being a low risk. The results of the climate change risk assessment for the mine site are presented in Table 11.

Table 11. Initial climate change risk assessment results – mine site

PARAMETER	PROJECTIONS	VARIATION RANGE	WORKPLACE SAFETY	ENVIRONMENT AND SUSTAINABILITY	COMPLIANCE	SHAREHOLDER VALUE	GROWTH	HIGHEST RISK RANKING
Temperature (°C)	2030	0.7 - 1.6 (m=1.1)	Medium	Medium	Medium	Low	Low	Medium
	2050	1.6 – 3.2 (m=2.25)	Medium	Medium	Medium	Low	Low	Medium
Extreme Heat Days (>35oC)	2030	56.3 - 72.3 (m=63.1)	Medium	Medium	Medium	Low	Low	Medium
	2050	N/A	Medium	Medium	Medium	Low	Low	Medium
Annual Rainfall (%)	2030	-12.0 – 5.0 (m=-3.0)	Low	Medium	Medium	Low	Low	Medium
	2050	-22.5 – 12.5 (m=-7.5)	Low	Medium	Medium	Low	Low	Medium
Potential Evaporation (%)	2030	2.0 – 4.0 (m=3.0)	Medium	Medium	Medium	Low	Low	Medium
	2050	3.0 – 10.0 (m=6.0)	Medium	Medium	Medium	Low	Low	Medium
Wind Speed (%)	2030	-2.0 – 6.0 (m=2.0)	Medium	Medium	High	Low	Low	High
	2050	0.0 – 12.5 (m=3.5)	Medium	Medium	High	Low	Low	High
Relative Humidity (%)	2030	-1.7 – 0.7 (m=-0.5)	Low	Low	Low	Low	Low	Low
	2050	-3.5 – 1.5 (m=-0.75)	Low	Low	Low	Low	Low	Low
Solar Radiation (%)	2030	-1.2 – 2.0 (m=0.2)	Medium	Medium	Medium	Low	Low	Medium
	2050	-3.5 – 3.5 (m=0.0)	Medium	Medium	Medium	Low	Low	Medium
Extreme Rainfall Events 1 in 40 year event	Assumed 10% increase in events annually		Medium	Medium	Medium	Low	Low	Medium
Extreme Rainfall Events 1 in 100 year event	Assumed 5% increase in events annually		Medium	Medium	Medium	Low	Low	Medium
Increase in Fire Risk days	Assumed 20% increase in extreme fire days		Medium	Medium	Medium	Low	Low	Medium
Cyclones and Storms	Increased intensity but fewer storms		Medium	Medium	Medium	Medium	Medium	Medium

Note: A1B data is presented for 2030 projections and A1FI data is presented for 2050

2.3.1.6 Climate Change Adaption Summary

The risk assessment identified that there were no potential extreme risks as a result of projected climate change to the project or to employees of the Project. Risks ranked as high are considered to be risks that are most severe. A high risk can be accepted as part of routine operations without executive sanction.

At the mine site increased average wind speed was ranked as a potential high risk. The risks were related to increases in dust generation resulting in potential exceedances in air quality leaving the site and affecting off-site receptors. Prolonged occurrences of dust leaving the site would potentially result in non compliance with operational approval conditions.

The remainder of the risks, those ranked as medium and low, are not discussed in detail as those risks can be expected to form part of routine operations. Medium risks will be explicitly assigned to relevant managers for action, maintained under review and reported upon at senior management level. Low risks will be maintained under review, but it is expected that existing controls will be sufficient and no further action will be required to treat them unless they become more severe.

To address potential high risks associated with climatic changes, the EMP will include a specific section on Climate Change Adaption. The EMP will include review steps to continually assess a range of climatic variables, and how these relate to the identified potential high risk variables.

In regard to addressing potential high risks associated with the mine, it is expected that rather than having to implement new measures to address potential high risks, for example existing measures will be adopted in accordance with variable change and the extant operating licenses. Such as assuming the average projected wind speed increases occur, it would simply be the case that dust suppression activities will be reviewed and amended as appropriate at the mine site. This would include increased water treatment of roads and stockpiles (using recycled water) and minimising the amount of exposed surfaces through increasing the rate of rehabilitation. It is also likely that engineering / design solutions would be investigated, particularly around stockpiles and crushing / sizing infrastructure.

In addition to specific measures to address high risks, a range of measures will be imbedded into the design phase and routine operating procedures to take into account potential climate change. The following provides an indication of the type of measures that will be considered to take into account climate change.

The infrastructure for the Project will be designed for tropical conditions. As such the projected increases in ambient temperature will be within designed operating ranges. Therefore it is unlikely that there will be material changes to the infrastructure or its operation as a result of climate change. Increases in extreme heat days and how this may impact the workforce will be addressed through the ongoing review of workplace operating procedures and the health and safety system. Again, given the proximity of the Project to areas that are already subjected to a significant number of high weather days annually, it is not expected that the projected increases will have a detrimental impact on the operational or safe working environment an any of the project sites.

The water management system will be designed to include tolerances to cater for changes in annual rainfall averages and potential evaporation. As such it is not expected that increases or decreases in either variable will have a significant effect on the water management system for the mine. Erosion which may result from changes in annual rainfall will be managed as part of routine site maintenance.

It is possible that either increases or decreases in the amount of precipitation could result in erosion occurring onsite and / or the failure of rehabilitation activities. It is expected that the operating license conditions will establish criteria for managing erosion and rehabilitation and these will be implemented through routine maintenance activities. Where erosion control and rehabilitation activities do not achieve the desired outcomes, procedures will be adapted to achieve compliance. The process of adapting management and control measures to meet license requirements will occur as a routine part of managing the site. It is therefore considered that the adaptive management approach will adequately address variations associated with climate change.

Projected changes in average wind speed will potentially result in increased dust dispersal at the mine. Routine air quality monitoring will be established from the commencement of the Project in accordance with operating license conditions. Where emission trends occur, onsite management procedures will be established to review the existing operational activities and associated mitigation strategies and adaptations will be implemented to cater for variances in emissions. In terms of impacts to operational capacity, it is expected that the Project increases will be within design tolerances and will not pose a significant risk to operations or workplace safety. For example, infrastructure such as communication towers, the CHPP and conveyor structures will all be designed with inbuilt tolerances to accommodate projected increases in wind loadings.

Changes in relative humidity levels are considered to be within the design tolerances of the infrastructure and are not expected to have a material impact on the Project.

It is projected that there will be a decrease in the number of storms; however, storm intensity is projected to increase. Changes in the frequency and intensity of 1 in 40 and 1 in 100 year events will be addressed as part of the flood immunity design for the infrastructure. This will take into consideration the protection of assets, in particular underground mines and water storages, and the maintenance of the overall safe working conditions on each site.

It is expected that that the operating license conditions will establish criteria for managing flood runoff and protecting offsite water quality and these will be implemented through routine monitoring and maintenance activities. Where these activities do not achieve the license conditions, procedures will be adapted to achieve compliance. The process of adapting management and control measures to meet license requirements will be similar to that for managing dust and erosion in that it will occur as a routine part of managing the site. As such, it is considered that the adaptive management approach will adequately address variations associated with climate change.

The projected increase in temperatures and evaporation, together with a potential decrease in annual rainfall will add to the number of fire risk days in the project area. A Bushfire Management Plan (BMP) will be prepared that provides a strategic approach to the management of bushfires in the project area, and follows on from previous research and strategies prepared by CSIRO in Northern Australia. This document will provide plans and processes based on contemporary best-practice for managing fires in tropical Savannah systems that best mitigate wild fire risks. The BMP will be focused on preservation of life and infrastructure in a context that adheres to ecological needs wherever possible. Moreover, the CSIRO strategy also aims to implement measures that minimise the risk of fires leaving the project area.

In addition to the BMP the infrastructure will have bushfire protection embedded into the design in order to protect workers and equipment. The maintenance of the fire protection equipment will be carried out as part of routine site management. It is therefore expected that the bushfire risk to the project will largely be managed through routine maintenance, albeit with review and revision of the procedures if the projected changes occur.

2.3.2 CONCLUSION

A climate change risk assessment was undertaken for the proposed mine site. The approach adopted for the risk assessment was consistent with AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines. The methodology used in the risk assessment was adapted from *Climate Change Impacts and Risk Management - A Guide for Business and Government* (AGO, 2007). Emission scenarios were adopted from the IPCC's *Special Report on Emissions Scenarios* (2001) and these were considered against climate change projection data sets derived from CSIRO and BOM (2007), Garnaut (2008) and the Queensland Government (2009).

The risk assessment identified that impact from the project associated with increases in average wind speed as a result of climate change may pose a potential high risk to environment and sustainability. This in turn could potentially result in minor breaches in compliance. The assessment further considered that the projected increase in the number of extreme fire risk days posed a potential high risk to the environment and sustainability. The remainder and by far the majority of the risks to the project and workforce associated with climate change were assessed as being medium to low.

The risks ranked as high during the assessment are considered as the most severe risks that can be accepted as part of routine operations without executive sanction. To ensure that appropriate action is taken to address these risks they will be managed by the senior management team, and monitoring and reporting will be undertaken at the executive level. The risks ranked as medium to low will be managed as part of routine operations and they will be maintained under review and reported upon at senior management level.

The Project is located predominantly in a hot, arid environment that is subjected to high volume flooding and intense storms and as such the design tolerances will already largely be addressed at the initial design stage. Therefore, designing the project infrastructure to ensure operating tolerances include climate change projections or are able to be adapted to meet changing conditions is a key mitigating factor. It is expected that any areas requiring adaption to take into consideration changes associated with climate change will be identified as part of routine operational monitoring and performance reporting.

Implementing appropriate workplace health and safety procedures is the other key mitigating factor to address potential impacts associated with climate change. The procedures established to address the existing conditions are expected to adequately mitigate the projected changes to the climate. Similarly it is expected that any areas requiring adaption to take into consideration changes associated with climate change will be picked up as part of routine operational monitoring and performance reporting.

To summarise, potential impacts to the project and Waratah's workforce associated with climate change will be adequately managed through appropriate design of infrastructure and the implementation of a sound workplace health and safety system. It is expected that these two factors, combined with the standard monitor, review and adapt continuous improvement management system will adequately mitigate climate change risk.

2.3.3 COMMITMENTS

In order to manage potential impacts of climate and climate change associated with the mine (and associated infrastructure), Waratah will:

- incorporate adaptive management approach to climate change throughout the life of the mine;
- incorporate climate change adaption strategies into each relevant major design element of the mine; and
- co-operate with government, other industry and other sectors to address adaptation to climate change.