Central Queensland Coal Project

Chapter 4 – Climate

Supplementary Environmental Impact Statement

CDM Smith

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Central Queensland Coal Project
Chapter 4 – Climate

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4 Climate

This chapter outlines the regional climatic conditions within and surrounding the Central Queensland Coal Project (the Project) area and discusses potential impacts from climatic conditions, natural disasters, natural hazards and climate change on the Project. It also sets out climate change adaptation strategies, which are included as part of the Project design.

This chapter has been updated to reflect matters raised in submissions to the Environmental Impact Statement (EIS) relating to Chapter 4 – Climate in respect of:

- The susceptibility of the Project to increased flooding due to climate change;
- The susceptibility of the Project's water supply to climate change; and
- The susceptibility of the Project to increased drought conditions associated with climate change.

The following chapter has been updated to provide additional information to that already included in the EIS in response to the submissions relating to Chapter 4 – Climate. Appendix A13 includes the full details of all submissions received for the Project.

4.1 Project Overview

Central Queensland Coal Proprietary Limited (Central Queensland Coal) and Fairway Coal Proprietary Limited (Fairway Coal) (the joint Proponents), propose to develop the Central Queensland Coal Mine Project (the Project). As Central Queensland Coal is the senior proponent, Central Queensland Coal is referred to throughout this Supplementary Environmental Impact Statement (SEIS). The Project comprises the Central Queensland Coal Mine where coal mining and processing activities will occur along with a train loadout facility (TLF).

The Project is located 130 km northwest of Rockhampton in the Styx Coal Basin in Central Queensland. The Project is located within the Livingstone Shire Council (LSC) Local Government Area (LGA). The Project is generally located on the "Mamelon" property, described as real property Lot 11 on MC23, Lot 10 on MC493 and Lot 9 on MC496. The TLF is located on the "Strathmuir" property, described as real property Lot 9 on MC230. A small section of the haul road to the TLF is located on the "Brussels" property described as real property Lot 85 on SP164785.

The Project will involve mining a maximum combined tonnage of up to 10 million tonnes per annum (Mtpa) of semi-soft coking coal (SSCC) and high grade thermal coal (HGTC). The Project will be located within Mining Lease (ML) 80187 and ML 700022, which are adjacent to Mineral Development Licence (MDL) 468 and Exploration Permit for Coal (EPC) 1029, both of which are held by the Proponent. It is intended that all aspects of the Project will be authorised by a site specific environmental authority (EA).

Development of the Project is expected to commence in 2019 with initial early construction works and extend operationally for approximately 19 years until the depletion of the current reserve, and rehabilitation and mine closure activities are successfully completed.

The Project consists of two open cut operations that will be mined using a truck and shovel methodology. The run-of-mine (ROM) coal will ramp up to approximately 2 Mtpa during Stage 1 (2019 - 2022), where coal will be crushed, screened and washed to SSCC grade with an estimate 80% yield. Stage 2 of the Project (2023 - 2038) will include further processing of up to an additional 4 Mtpa ROM coal within another coal handling and preparation plant (CHPP) to SSCC and up to 4 Mtpa of HGTC with an estimated 95% yield. At full production two CHPPs, one servicing Open Cut 1 and the other servicing Open Cut 2, will be in operation. Rehabilitation works will occur progressively through mine operation, with final rehabilitation and mine closure activities occurring between 2036 to 2038.

A new train loadout facility (TLF) will be developed to connect into the existing Queensland Rail North Coast Rail Line. This connection will allow the product coal to be transported to the established coal loading infrastructure at the Dalrymple Bay Coal Terminal (DBCT).

Access to the Project will be via the Bruce Highway. The Project will employ a peak workforce of approximately 275 people during construction and between 100 (2019) to 500 (2030) during operation, with the workforce reducing to approximately 20 during decommissioning. Central Queensland Coal will manage the Project construction and ongoing operations with the assistance of contractors.

This SEIS supports the EIS by responding to the submissions that were made during the public notification period regarding the original EIS and identifies the material changes to the Project.

4.2 Relevant Legislation and Guidelines

The following legislation and policies regulate and address impacts relating to climate particularly regarding coal mining in Queensland:

- National Climate Change Adaptation Framework (the NCCAF); and
- *Coal Mining Safety and Health Act 1999* (CMSH Act).

4.2.1 National Climate Change Adaptation Framework

The NCCAF provides targeted strategies for the medium term (five to seven years) with the aim to reduce the climate change vulnerability of key Australian sectors and regions. The NCCAF recognises that risks should be managed by those who best understand the likely consequences of the activities and understand the environmental context. This chapter identifies the existing climate conditions, potential risks associated with current and projected climatic conditions and proposes management measures to reduce the Project's vulnerability to climate change.

4.2.2 Coal Mining Safety and Health Act 199

The CMSH Act places obligations on coal mine operators to ensure that risks to the workers is at an acceptable level. This requires a hazard identification and development of management procedures. Hazards including storms, cyclones, floods and bushfires have the potential to put the health and safety of coal mine workers at risk and thus a risk assessment is required. The CMSH Act is supported by the *Coal Mining Safety and Health Regulation 2001* which addresses management measures for coal related hazards including heat stress.

4.3 Environmental Objectives and Performance Outcomes

4.3.1 Environmental Objectives

Any natural or induced climatic hazards or impacts of climate change in the region do not pose a risk to the safety of Project employees, contractors, visitors or impact the existing the environmental values.

4.3.2 Performance Outcomes

The performance criteria for climate and climate change are:

- Infrastructure and mine design will be resilient to natural or induced hazards and climate change;
- Operations will be conducted safely to protect the health and safety of workers; and
- Current and future controls will reduce the risk of potential impacts to an acceptable level.

4.4 Assessment Method

The methodology involved reviewing relevant climate data to develop an understanding of the existing climatic conditions and natural and induced hazards influencing or having the potential to influence the Project. Following this, natural hazards and climate change impacts were applied to Project components and features to understand potential impacts to the Project.

Information on the existing climatic conditions were obtained from a desktop study of the Bureau of Meteorology's (BoM) online data. The BoM lists several weather stations within 50 km of the Project, these are identified in Table 4-1, and include:

- Strathmuir (BoM Station 033189);
- Tooloombah (BoM Station 033211);
- St Lawrence Post Office site (BoM Station 033065); and
- Rockhampton Aero (BoM Station 03083).

Information was also obtained using the Air Quality and Greenhouse Gas (GHG) assessment (Vipac 2017). This includes background information on temperature, rainfall, wind speed and direction, atmospheric stability and mixing height. A prognostic air pollution model TAPM (developed by CSIRO, version 4.0.4) and a diagnostic meteorological model CALMET (developed by EarthTec, version 6.327) were used to generate the three-dimensional meteorological dataset for the region. The Air Quality and GHG Technical Report has been included as Appendix A7.

When conducting the desktop climate change impact assessment for the Project, the climate change projections put forward in Section 4.7 are based on the following sources:

- Climate Change in Queensland, What the Science is Telling Us (Queensland Government 2010);
- The Critical Decade: Queensland Climate Impacts and Opportunities (Steffen et al. 2012);
- Climate Change 2014: Impacts, Adaptation and Vulnerability (IPCC 2014);
- Climate Change in Australia: Projections for Australia's NRM Regions (CSIRO 2015); and
- State of the Climate 2016 (CSIRO 2016).

4.5 Existing Climatic Conditions

The closest BoM weather stations with rainfall data are Tooloombah (BoM Station 033211) and Strathmuir stations (BoM Station 033189), located 2 km to the north and 7 km to the east of the Project, respectively. Tooloombah Station has provided rainfall data, albeit not continuously, between 1892 and 2001 and the Strathmuir Station has provided continued rainfall data since 1941 to present. Combined, both stations provide representative rainfall conditions within the Project area. Both stations only produce rainfall data. For a meaningful representation of climatic conditions, data has been obtained from the St Lawrence Post Office (BoM Station 033065) weather station to the north of the Project and the Marlborough Helipad Station (BoM Station 033111) to the south of the Project. These stations are the closest to the Project that provide more complete weather data. By using weather data from the north and south of the Project the overall weather patterns are more easily identified.

Methods of data collection and storage are consistent between stations allowing for direct comparison between multiple stations. Weather station data and recording history is presented in Table 4-1.

Table 4-1 Weather monitoring stations used for climate assessment

Station name	Approximate distance from Project area (km)	Latitude	Longitude	Elevation (m)	Recording period
Strathmuir	7	22.71°	149.73°	40	1941 - present
Tooloombah	2	22.73°	149.54°	80	1890 - 2001
St Lawrence Post Office site	40	22.35°	149.54°	18	1870 - 2015
Rockhampton Aero	112	23.38°	150.48°	10	1939 - present

Data from the BoM weather stations are provided in Table 4-2, Table 4-3 and Table 4-4 (Strathmuir, Tooloombah, St Lawrence Post Office, Rockhampton Aero, respectively). Climate data for St Lawrence Post Office and Rockhampton Aero includes the mean values calculated from the historical data for rainfall, temperature, relative humidity, wind speed and solar exposure. The following subsections discuss these climatic parameters in more detail.

Rainfall and climatic evaporation factors are relevant to water storage design, site water balance, water management and tailings management techniques. These factors are further considered in Chapter 9 – Surface Water.

Table 4-2 Historical rainfall data from the Strathmuir and Tooloombah weather stations

Month	Strathmuir Rainfall [millimetres (mm)] Mean[1]	Tooloombah Rainfall [millimetres (mm)] Mean[2]
January	138.3	171.8
February	144.9	123.5
March	82.0	110.6
April	36.4	53.6
May	38.7	49.8
June	30.7	35.7
July	26.1	26.1
August	19.1	24.1
September	16.2	19.5
October	40.1	45.2
November	63.8	69.6
December	104.1	103.1
Mean Annual	**754.6**	**820.2**

Source: BoM 2017a

1. 1941 – Present
2. 1890 - 2001

Table 4-3 Historical climate data from St Lawrence Post Office weather station

Month	Rainfall (mm)[1]	Temperature (°C)[2]		Relative humidity (%)[3]		Mean wind speed (km/h)[4]		Daily solar exposure (MJ/m²)*[5]	Daily evaporation (mm)[6]
	Mean	Mean min.	Mean max.	9.00am	3.00pm	9.00am	3.00pm	Mean	Mean
January	206.2	22.5	31.7	70	60	9.6	14.6	23.8	5.6
February	198.5	22.5	31.4	74	62	9.4	13.8	21.8	5.1
March	133.8	21.1	30.9	73	59	9.7	13.4	20.7	4.9
April	59.7	18.4	29.3	71	55	10.5	13.6	18.1	4.3
May	47.3	15.1	26.7	71	52	11.1	12.6	15.7	3.4
June	48.8	12.2	24.3	70	51	11.7	12.4	14.1	3.0
July	31.4	10.9	23.8	68	47	11.7	13.6	15.4	3.1
August	23.7	11.8	25.0	66	46	11.3	15.5	18.3	3.7
September	26.2	14.4	27.0	62	48	11.8	17.9	21.8	4.5
October	44.4	17.7	28.9	60	53	12.3	19.0	24.4	5.4
November	71.3	20.2	30.4	62	55	11.7	17.8	25.4	5.9
December	124.7	21.7	31.5	65	58	9.9	15.7	25.0	5.9
Mean Annual	**1018.8**	**17.4**	**28.4**	**68**	**54**	**10.9**	**15.0**	**20.4**	**4.6**

Notes: * MJ/m² is megajoules per square metre

Source: BoM 2017a

1. 1870 - 2015
2. 1938 - 2012
3. 1938 – 2010
4. 1957 – 2010
5. 1990 – 2016
6. 1972 - 2015

Table 4-4 Historical climate data from Rockhampton Aero weather station

Month	Rainfall (mm)[1]	Temperature (°C)[2]		Relative humidity (%)[3]		Mean wind speed (km/h)[4]		Daily solar exposure (MJ/m²)*	Daily evaporation (mm)
	Mean	Mean min.	Mean max.	9.00am	3.00pm	9.00am	3.00pm	Mean	Mean
January	131.8	22.2	32.0	70	53	13.2	16.5	24.3	7.3
February	147.4	22.1	31.3	73	57	13.5	16.1	22.2	6.6
March	102.6	20.9	30.5	72	54	14.2	16.2	20.9	6.2
April	44.0	17.9	28.8	71	49	12.9	14.9	18.2	5.3
May	46.3	14.2	26.0	71	47	10.3	13.5	15.5	4.1
June	38.6	11.0	23.5	72	46	8.4	13.0	13.7	3.5
July	32.0	9.6	23.2	72	42	7.8	12.7	14.8	3.6
August	28.0	10.7	24.8	68	40	9.6	13.6	17.7	4.4
September	25.0	13.7	27.4	65	40	11.8	15.3	21.1	5.8
October	47.7	17.0	29.7	62	42	12.7	16.4	23.6	6.8
November	67.2	19.6	31.3	62	46	12.2	16.4	24.9	7.6
December	106.2	21.2	32.1	66	49	12.1	16.0	24.8	7.7
Mean Annual	**812.9**	**16.7**	**28.4**	**69**	**47**	**11.6**	**15.0**	**20.1**	**5.7**

Notes: * MJ/m² is megajoules per square metre

Source: BoM 2017a

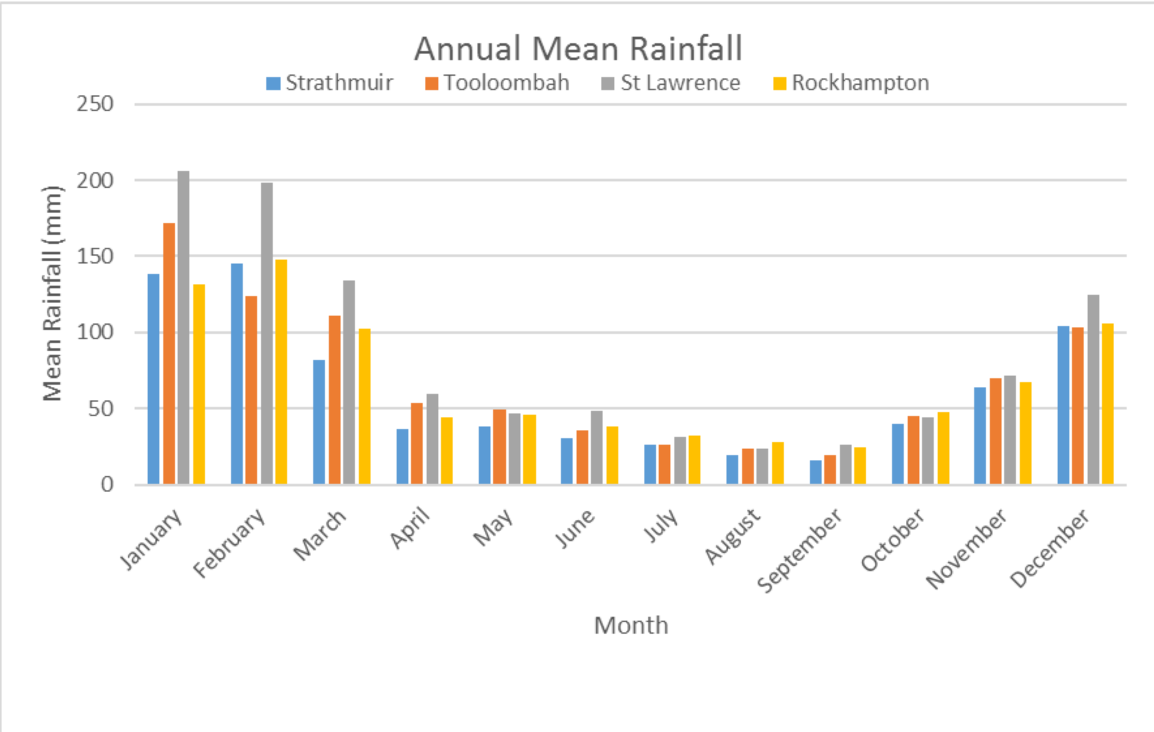
1. 1939 - present
2. 1939 - present
3. 1939 – 2010
4. 1939 – 2010
5. 1990 – 2016
6. 1951 - 2016

4.5.1 Rainfall

Historical climate data from the four weather stations (see Table 4-2, Table 4-3 and Table 4-4) show a distinct wet season with the highest rainfall occurring during the summer months (December to March) with more rainfall in January and February and drier periods predominating in the winter and early spring months (June to September). BoM climate statistics show that the wet season is characterised by an increased number of storm events leading to heavy rainfall over relatively short time periods (see Section 4.6.1).

The average monthly rainfall for Strathmuir ranges from lows of 16.2 mm in spring and 19.1 mm in winter to a high of 144.9 mm in summer. For Tooloombah, the average monthly rainfall ranges from 19.5 mm in spring and 24.1 mm in winter to a high of 171.8 mm in summer. The pattern of rainfall is similar between the two locations (see Figure 4-1). For St Lawrence, monthly rainfall ranges from lows of 23.7 mm in winter and 26.2 mm in spring to a high of 206.2 mm in summer. Rockhampton's monthly rainfall ranges from lows of 25 mm in spring and 28 mm in winter to a high of 147.4 mm in summer.

The mean average rainfall data of Tooloombah is 65.6 mm and 7.3 mm more than Strathmuir and Rockhampton, respectively. The mean average rainfall data of St Lawrence is approximately 200 mm more than Tooloombah.



Source: BoM 2017a

Figure 4-1 Annual rainfall at Strathmuir, Tooloombah, St Lawrence & Rockhampton weather stations

The average annual rainfall for the studied weather stations are:

- 820.2 mm for Tooloombah;
- 754.6 mm for Strathmuir;
- 1,018.8 mm for St Lawrence; and
- 812.9 mm for Rockhampton.

Cumulative deviation from mean rainfall is the accumulated difference between actual rainfall (e.g. in a month or a year) and the long-term mean, providing an indication of the general climatic trend over time as well as general water availability (soil water, surface water and groundwater). A cumulative deviation from mean plot of monthly rainfall at Strathmuir (BoM Station 033189) from January 1941 to February 2018 is presented in Figure 4-2.

The plot indicates that climate (rainfall) variability is typical of the Project area, with periods of:

- Above average rainfall occurring from 1950 to 1955 and from 1973 to around 1980;
- Below average rainfall occurring from approximately 1957 to 1971 and from 1992 to 2013; and
- Around average rainfall occurring from 1940 to 1950, from 1978 to 1991 and from 2012 to present.

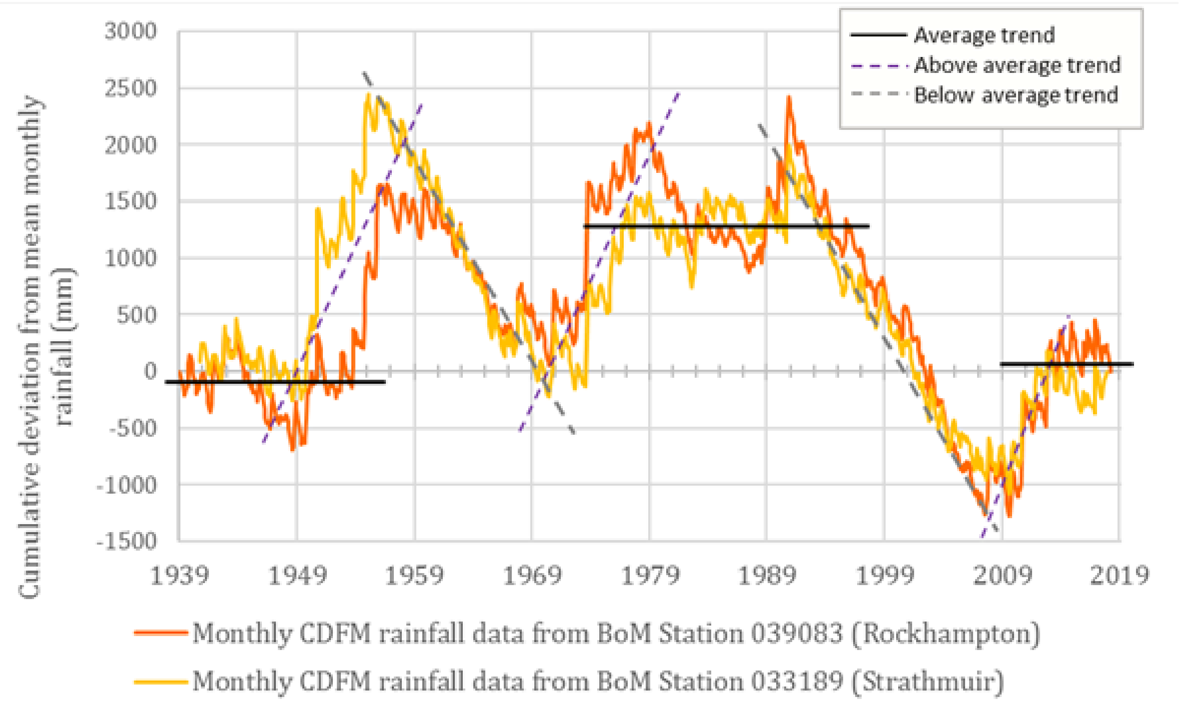


Figure 4-2 Cumulative deviation from mean monthly rainfall from BoM Station 033189 (Strathmuir) and 039083 (Rockhampton Aero)

SILO Data

Long-term rainfall and evaporation data were collected from the Scientific Information for Land Owners (SILO) Climate Data website (Department of Science, Information Technology, Innovation and the Arts (DSITI 2017b)) at the following coordinate location:

- Latitude: 22.70 degrees south; and
- Longitude: 149.65 degrees east.

These coordinates represent the approximate location of the Project.

SILO represents a gridded dataset based on records provided by the Bureau of Meteorology (BoM). The data is then processed to fill gaps in data and produce a spatially complete dataset. Table 4-5 and Figure 4-3 summarise monthly averages of the SILO long-term data.

Table 4-5 Data drill average monthly rainfall and evaporation

Month	Rainfall (mm)	Evaporation (mm)
January	159.7	199.6
February	140.0	165.9
March	91.3	177.7
April	36.8	141.0
May	33.5	115.1
June	38.1	96.6
July	25.2	103.3
August	20.0	125.9
September	18.3	156.1
October	46.2	205.2
November	62.7	217.5
December	108.0	223.3
Annual Average Total	779.8	1927.2

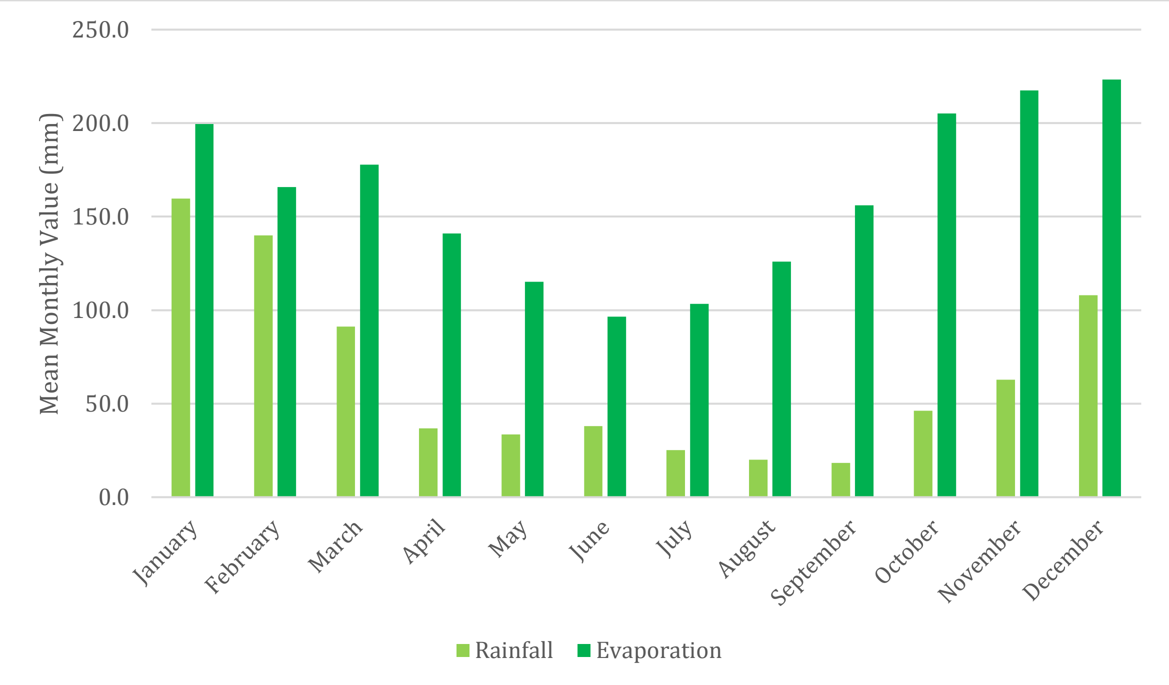


Figure 4-3 Graph of average monthly rainfall and evaporation from SILO

Some general trends can be observed from the SILO data, such as:

- A distinct wet season during the months of December, January and February, with monthly rainfall averages greater than 100 mm;
- A distinct dry season between the months April through October with less than 50 mm mean monthly rainfall between these months; and
- Evaporation rates that are highest during the summer months, and lowest mid-year. In any given month, the average evaporation is greater than the average rainfall.

Comparison Between Data Sources

Due to the gridded and somewhat synthetic nature of the long-term SILO data, a comparison with rainfall station data gathered from the nearby Strathmuir rainfall gauge was prepared to assess the validity of long-term SILO climatic data. The Strathmuir rain gauge (33189) was selected due to its 76-year data record and proximity (within 8 km) to the Project site. A comparison of mean monthly rainfall values between the Strathmuir rain gauge and SILO data is presented in Figure 4-4. The graph indicates good agreement between gauge records and data acquired through SILO.

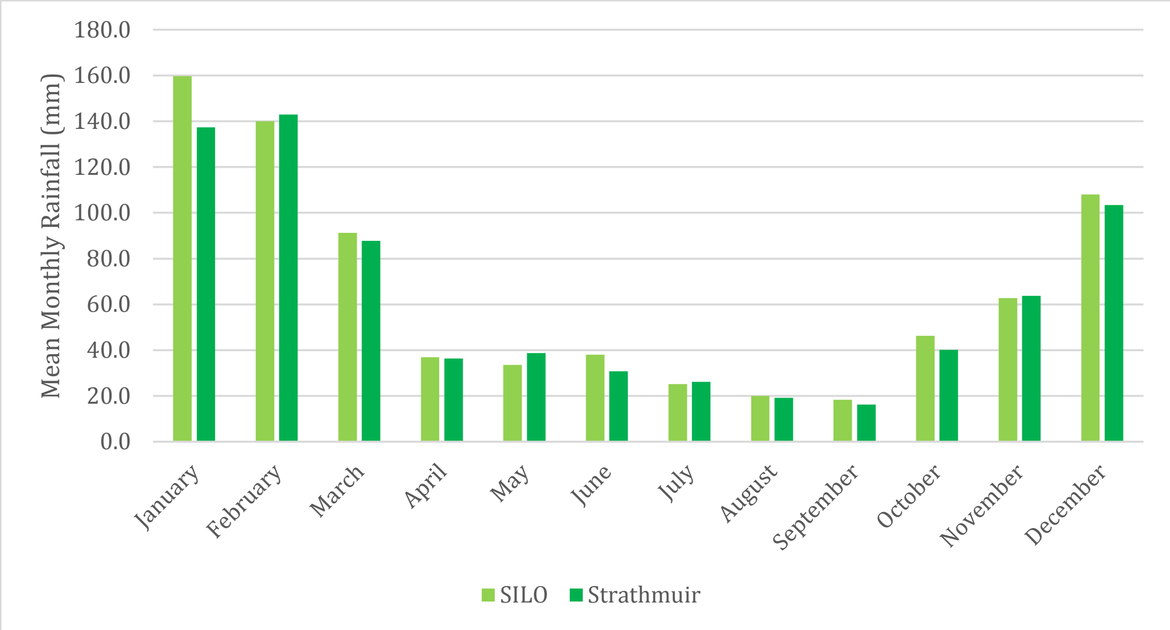
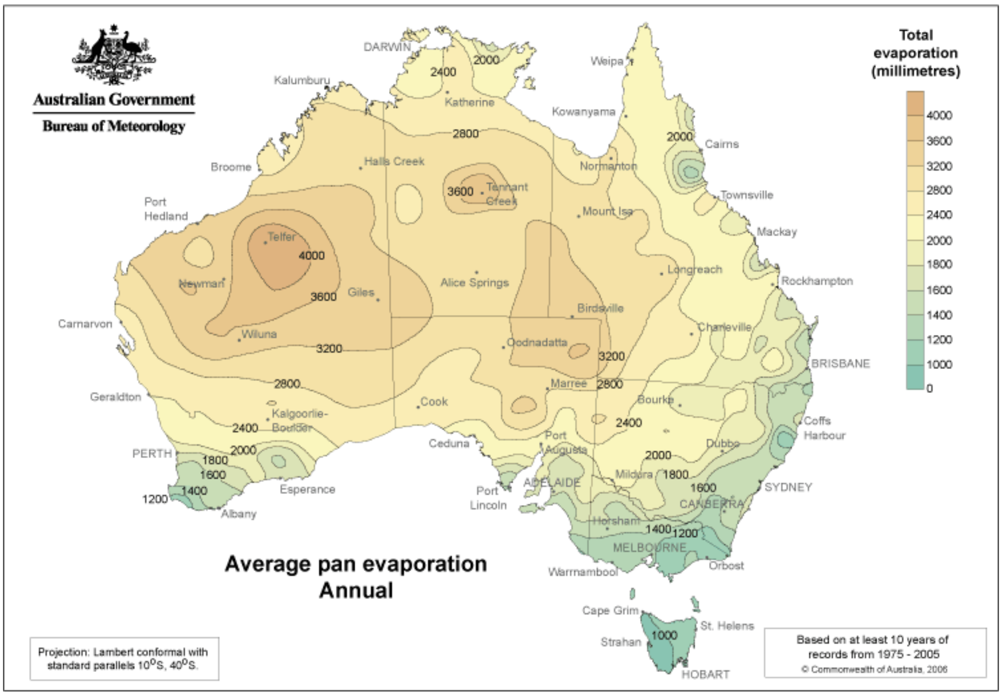


Figure 4-4 Comparison of SILO data to gauge data

4.5.2 Evaporation

The average annual evaporation rate is described as moderate at 2,000 mm to 2,400 mm per year (see Figure 4-5). This is based on at least 10 years of BoM records from 1975 to 2005. Total evaporation is considerably higher than average annual rainfall for all four weather station locations.



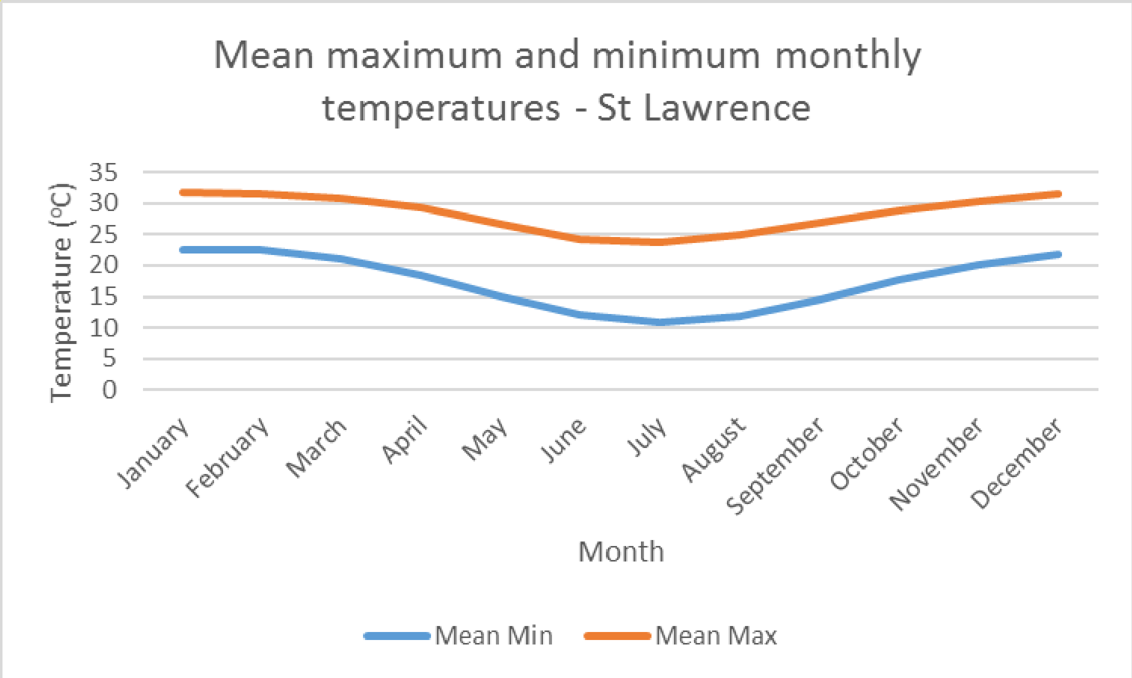
Source: BoM 2017b

Figure 4-5 Average annual evaporation for Australia

4.5.3 Air Temperature

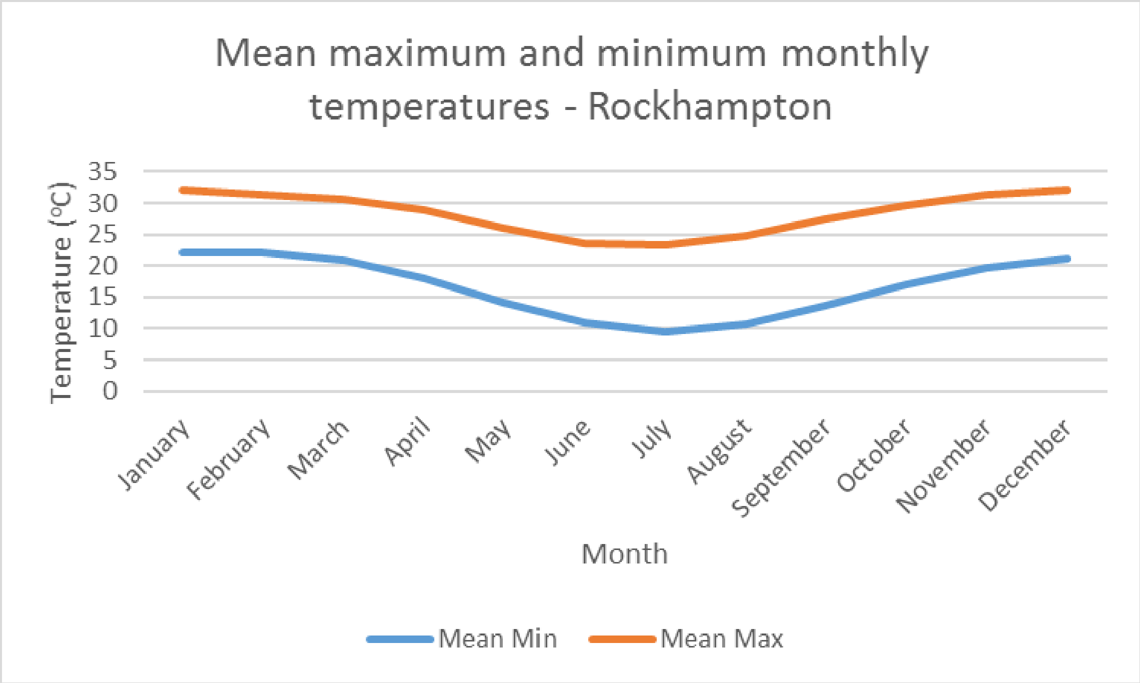
Temperatures in the Project region are characteristic of a sub-tropical climate, with cool winters and hot summers. Data from St Lawrence and Rockhampton is consistent with this trend with air temperatures low in the winter months and progressively increasing into spring (Table 4-3 and Table 4-4). No temperature data is available at the Tooloombah or Strathmuir weather stations.

The coolest temperatures are typically recorded in July and the warmest in December and January for both St Lawrence and Rockhampton. Mean minimum and maximum temperatures range from lows in winter of 9°C to 11°C and 10.9°C to 12 °C at Rockhampton and St Lawrence, respectively and highs in summer 31.4°C to 31.7°C to 31.3°C to 32.1°C at St Lawrence and Rockhampton, respectively (see Figure 4-6 and Figure 4-7).



Source: BoM 2017a

Figure 4-6 Mean maximum and minimum annual temperatures at St Lawrence weather station



Source: BoM 2017a

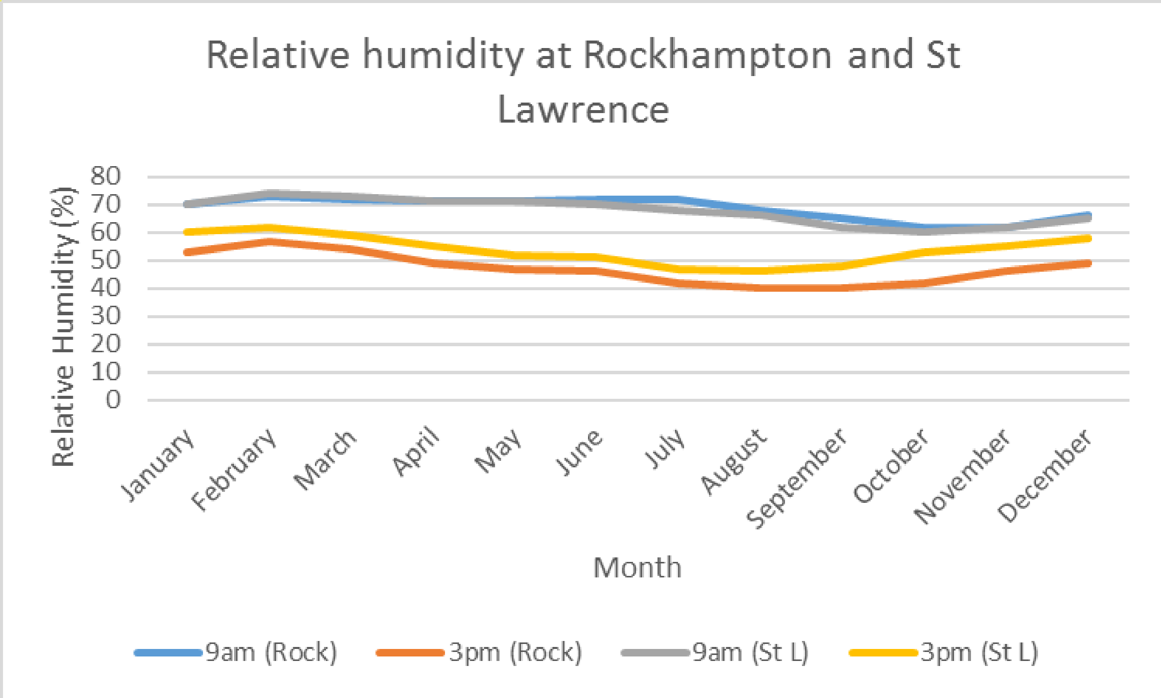
Figure 4-7 Mean maximum and minimum annual temperatures at Rockhampton weather station

The Project processes and structures can be influenced by weather conditions such as extreme high or low temperatures. With maximum temperatures likely to exceed 32°C in the summer months, potential impacts associated with heat will be considered in the design of the Project and management of the workforce (see Section 4.6.8 for further details on heatwaves).

4.5.4 Humidity

Relative humidity patterns were similar for both Rockhampton and St Lawrence. A comparison between 9am and 3pm humidity levels indicates mornings were typically more humid than afternoons (see Table 4-3, Table 4-4 and Figure 4-8). Both locations demonstrated a similar 9am value with Rockhampton presenting a 1% greater mean value (69% to 68%). The 3pm average annual humidity values were noticeably different with St Lawrence recording a 14% greater value (54%) to that at Rockhampton (47%).

Relative humidity was highest in late summer (February) and lowest mid spring (September and October) for both Rockhampton and St Lawrence. Whilst St Lawrence has a greater relative humidity range (60-74% for 9am) when compared to Rockhampton (62-73%), Rockhampton's mean annual value of 69 indicates Rockhampton is generally more humid in the morning than St Lawrence. Conversely, Rockhampton has a greater 3pm relative humidity range (40-57%) compared to St Lawrence (46-62%) yet St Lawrence's mean annual value of 54% compared to 47% at Rockhampton indicates that St Lawrence is more humid in the afternoon than Rockhampton.



Source: BoM 2017a

Figure 4-8 Mean 9am and 3pm relative humidity at Rockhampton and St Lawrence

High humidity, such as that experienced in the region, has the potential to increase corrosion of plant and equipment and interfere with electronics. It can also result in a less efficient workforce because of human discomfort. Mould and mildew may also develop because of high humid conditions over a prolonged period.

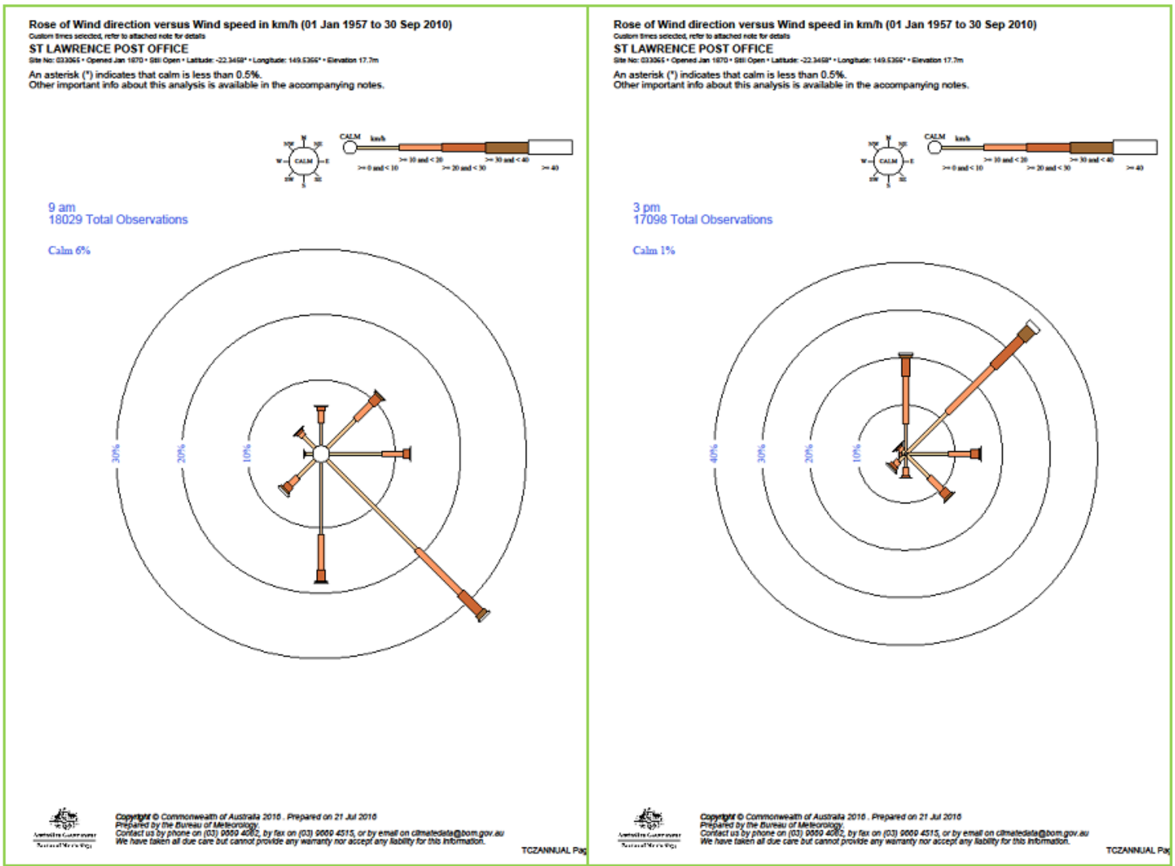
4.5.5 Wind Conditions

Annual, seasonal and diurnal distributions of winds were predicted at the Project using the TAPM/CALMET meteorological modelling system for 2014.

The annual wind rose (Figure 4-9) shows the predominant wind directions at 9 am are from the southeast, and east to north east at 3 pm.

The seasonal wind rose (Figure 4-10) shows that the predominant wind directions are from the north northeast during spring, north northeast and southeast during summer. In autumn, the winds are primarily from the south easterly directions, southerly and south-southeast winds are more frequent during the winter season.

The diurnal wind rose (Figure 4-11) shows the wind roses for the time of day during the year of 2014. The wind roses show that there are more frequent and stronger winds from the north-northeast during the afternoon and evening periods.



Location: St Lawrence	**Data Period:** 1957 to 2010	**Data Type:** Measured Data

Figure 4-9 Annual wind rose

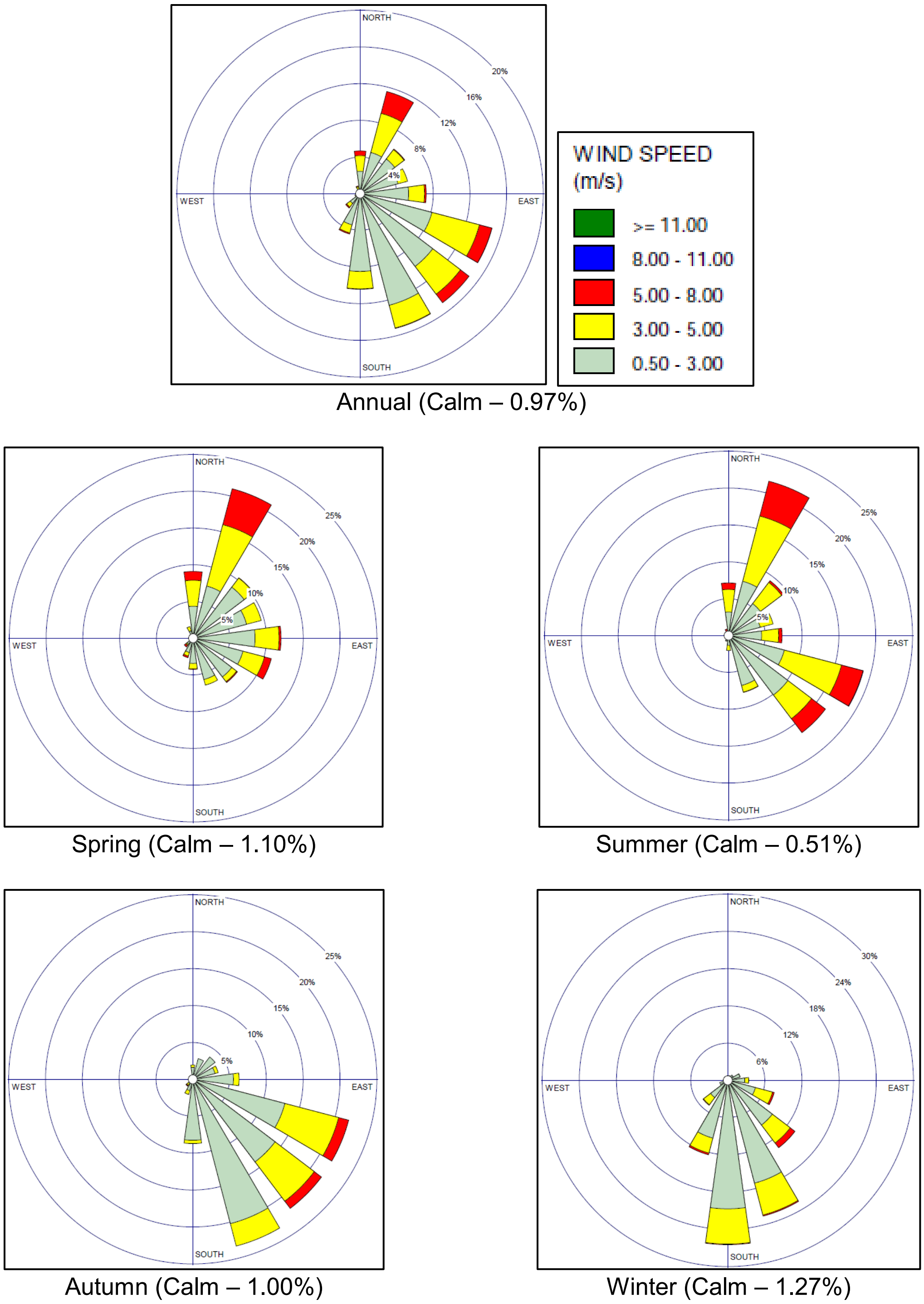


Figure 4-10 Seasonal wind rose

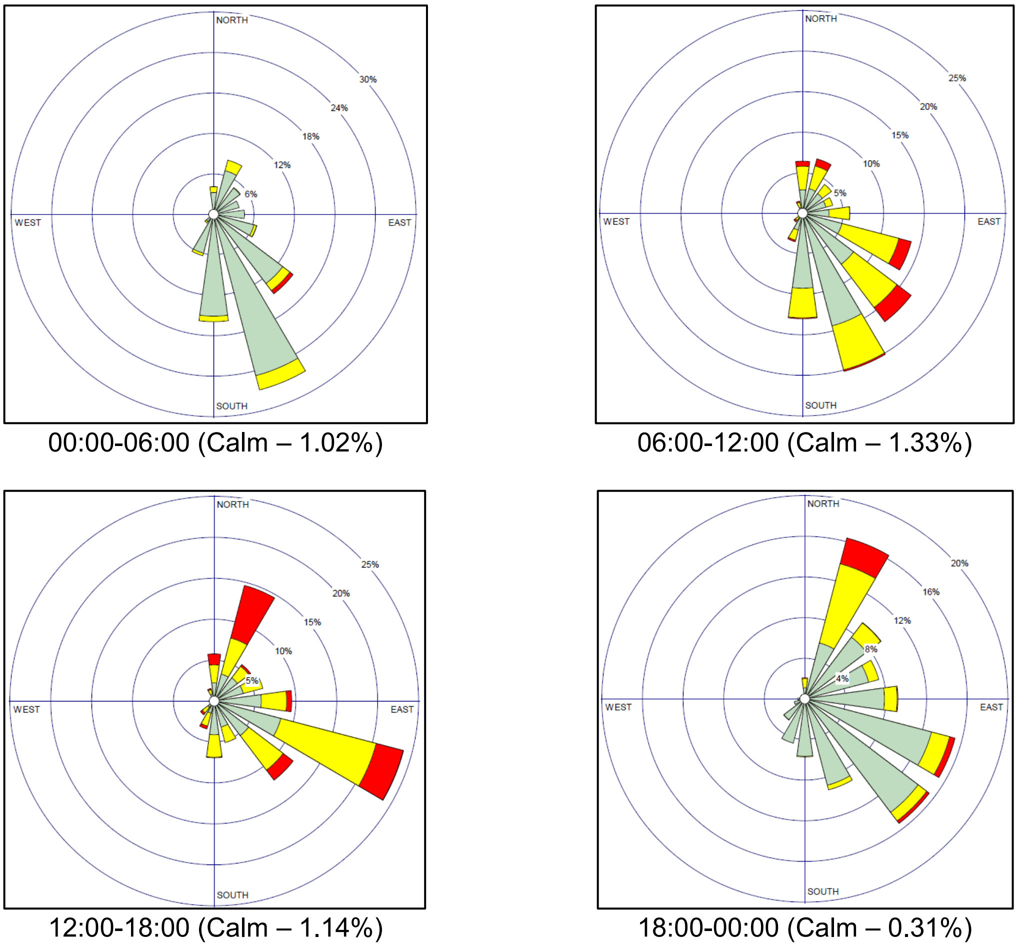


Figure 4-11 Diurnal wind rose

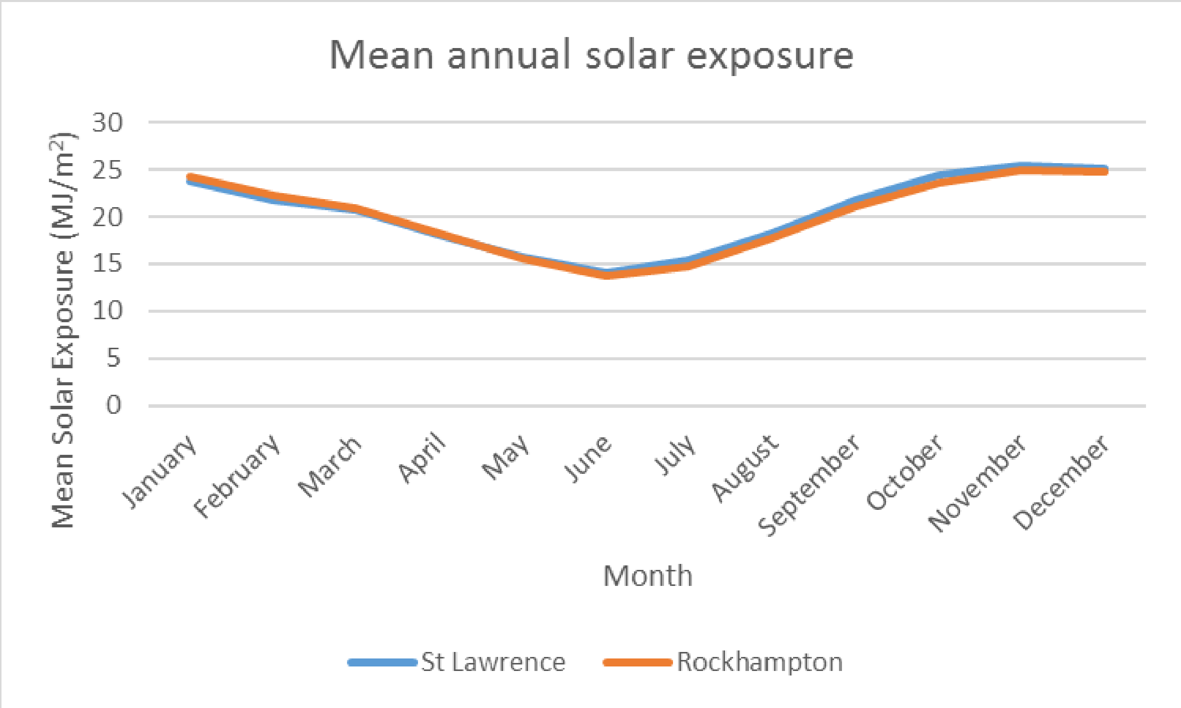
A comparison of the wind roses at 9 am and 3 pm for the TAPM derived dataset (Figure 4-9) at the Project site was also undertaken with the BoM long-term wind roses at St Lawrence. The 9 am wind roses from BoM and TAPM are very similar with slight differences in the percentage of time the wind blows from the southwest; the BoM wind rose, based on 18,029 observations, identifies easterly winds accounting for 7% of the time whereas TAPM identifies the south westerlies accounting for 3% at 9 am. The 3 pm wind roses are similar; the BoM wind rose shows a lower frequency of easterly winds (12%) to TAPM (21%). These slight differences in wind are influenced from the topography surrounding both the BoM monitoring station and the Project site. Overall, the meteorological data generated by TAPM is representative of the site.

Key features of the winds are therefore:

- The winds were calm for 1% of the year;
- The winds were 0.5 - 3 m/s for 67% of the year;
- The winds were 3 - 5 m/s for 25% of the year;
- The winds were greater than 5 m/s for 7% of the year; and
- The 9 am and 3 pm wind roses for the TAPM modelled data are generally consistent with the measured data from the St Lawrence BoM Weather Station.

4.5.6 Mean Daily Solar Exposure

Solar exposure is the total amount of solar energy falling on a horizontal surface. Solar exposure was highest during the summer months and lowest during the winter months (see Figure 4-12 for mean monthly solar exposure levels at St Lawrence and Rockhampton). The highest level of solar exposure is experienced during November for both locations with St Lawrence recording 25.4 megajoule per square metre (MJ/m^2) and Rockhampton recording 24.9 MJ/m^2. The lowest levels were experienced in June for both St Lawrence (14.1 MJ/m^2) and Rockhampton (13.7 MJ/m^2) (Figure 4-12).



Source: BoM 2017a

Figure 4-12 Mean annual solar exposure at St Lawrence and Rockhampton

4.5.7 Temperature Inversions

Temperature inversion data was not available on the BoM website. A temperature inversion is a reversal of the normal behaviour of temperature in the troposphere (the region of the atmosphere nearest the Earth's surface), in which a layer of warmer air overlays a layer of cool air at the surface (under normal conditions air temperature usually decreases with height). Low-level inversions occur at night at the earth's surface due to cooling of the ground layer and are most prevalent on clear, calm nights. 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 due to the longer retention of heat in water. In most cases, these inversions act like a lid to trap pollutants resulting in smog over cities (BoM 2012).

Temperature inversions also have the potential to affect how sound travels and the distance sound travels. The influence of temperature inversion can often cause distant sources of noise to sound closer than they are.

The Pasquill-Gifford stability categories are used to classify atmospheric stability and ranges from Category A, which represents very unstable atmospheric conditions that may typically occur on a sunny day with light winds through to Category F, which represents very stable atmospheric conditions that typically occur at clear nights with light wind condition. Unstable conditions (Category A to C) are associated with strong solar heating of the ground layer that induces turbulence close to the ground which is the main driver of dispersion during these conditions. Neutral conditions (Category D) are dominated by ground layer turbulence which is generated when wind passes over ground layer irregularities such as topographical features and buildings. Atmospheric conditions are neutral or stable at night (Category D, E and F).

The percentage of stability classes at the Project was predicted using TAPM/CALMET for the period of January to December 2014. As indicated in Table 4-6, Category D was the most frequently occurring stability category.

Table 4-6 Frequency of occurrence of surface atmospheric stability and average wind speed

Pasquil-Gifford stability category	Classification	Frequency (%)	Average wind speed (m/s)
A	Extremely unstable	0.6	2.1
B	Unstable	5	3
C	Slightly unstable	16.7	3.4
D	Neutral	43.6	2.5
E	Slightly stable	15.5	2.1
F	Stable	18.6	2.1

The potential for temperature inversions to occur within the Project area would be highest during the summer months when temperature and solar exposure levels are at their highest. Issues associated with temperature inversions can potentially include dust particulates and pollutants being trapped close to the ground which may cause temporary increases in air pollution levels.

4.6 Natural or Induced Hazards in the Region

4.6.1 Storms

Severe thunderstorms cause more damage than any other natural hazard in Australia and can result in flash flooding, significant soil erosion, large hailstones and destructive wind gusts (Emergency Management Australia (EMA) 2012). In Queensland, the most severe storms occur between September and March and coincide with increased solar energy (EMA 2012).

The Project area has an average annual lightning ground flash density of one to two strikes per square kilometre per year (km^2/yr) (see Figure 4-13). The Project area is within a region that experiences, on average 20 thunder days per year (EMA 2012) (see Figure 4-14).

Mining operations and infrastructure locations have been designed to account for stoppages due to storm activity to minimise any impacts on the operations. The mine will have site contingency plans in place to respond efficiently and safely in the event of storms.

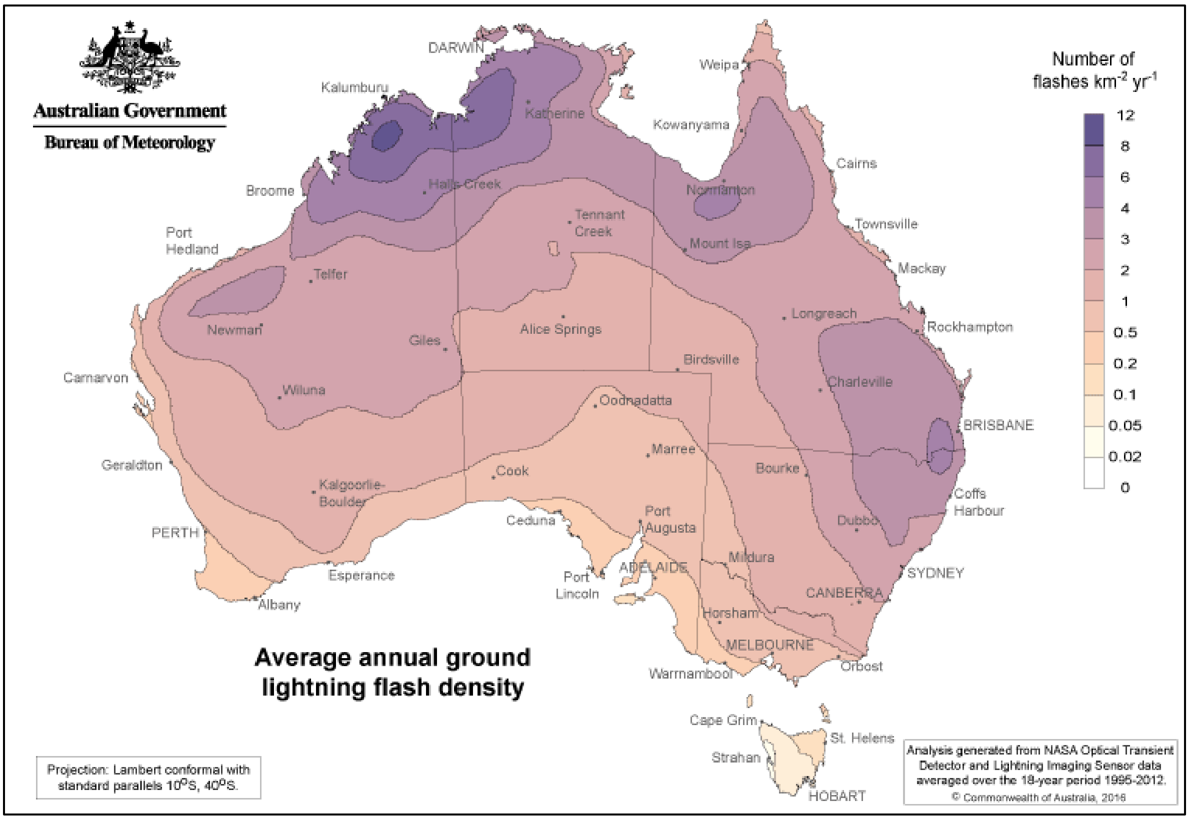


Figure 4-13 Average annual lightning ground flash density

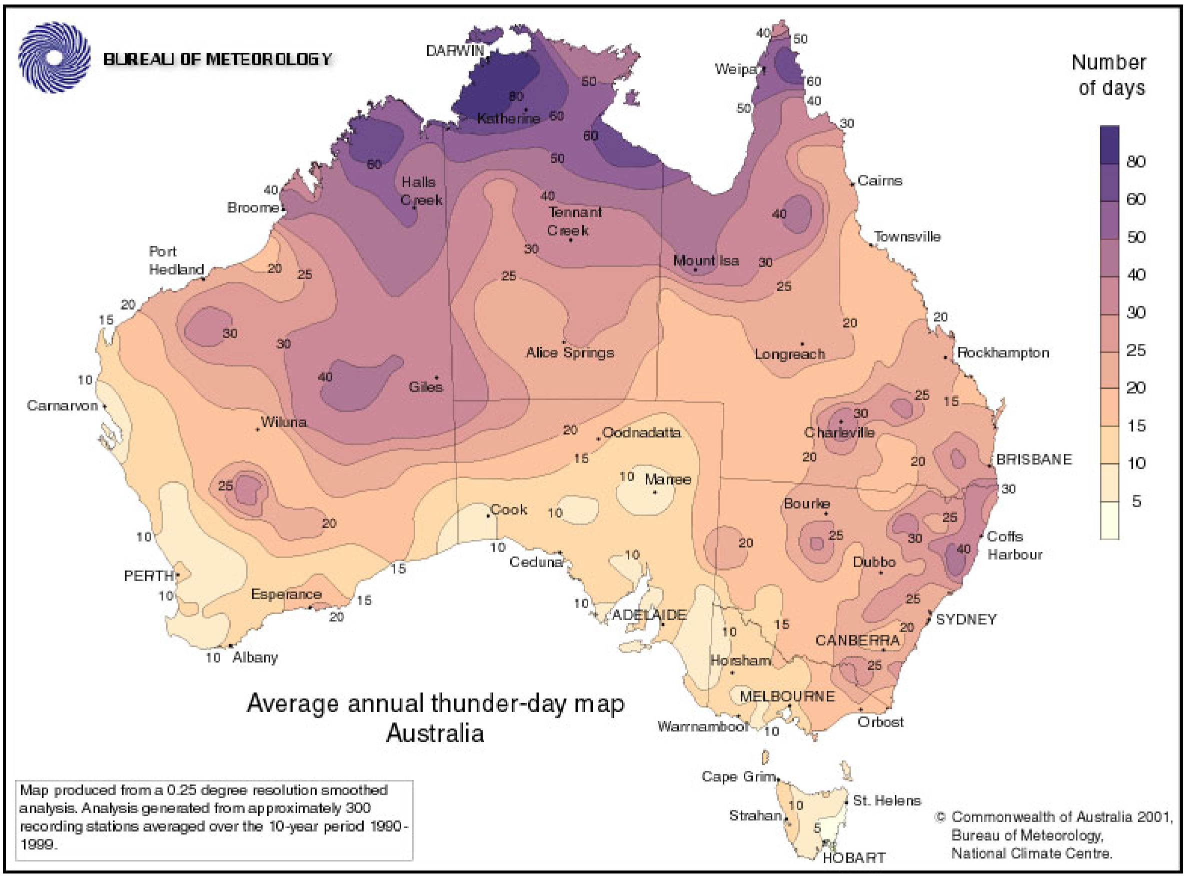
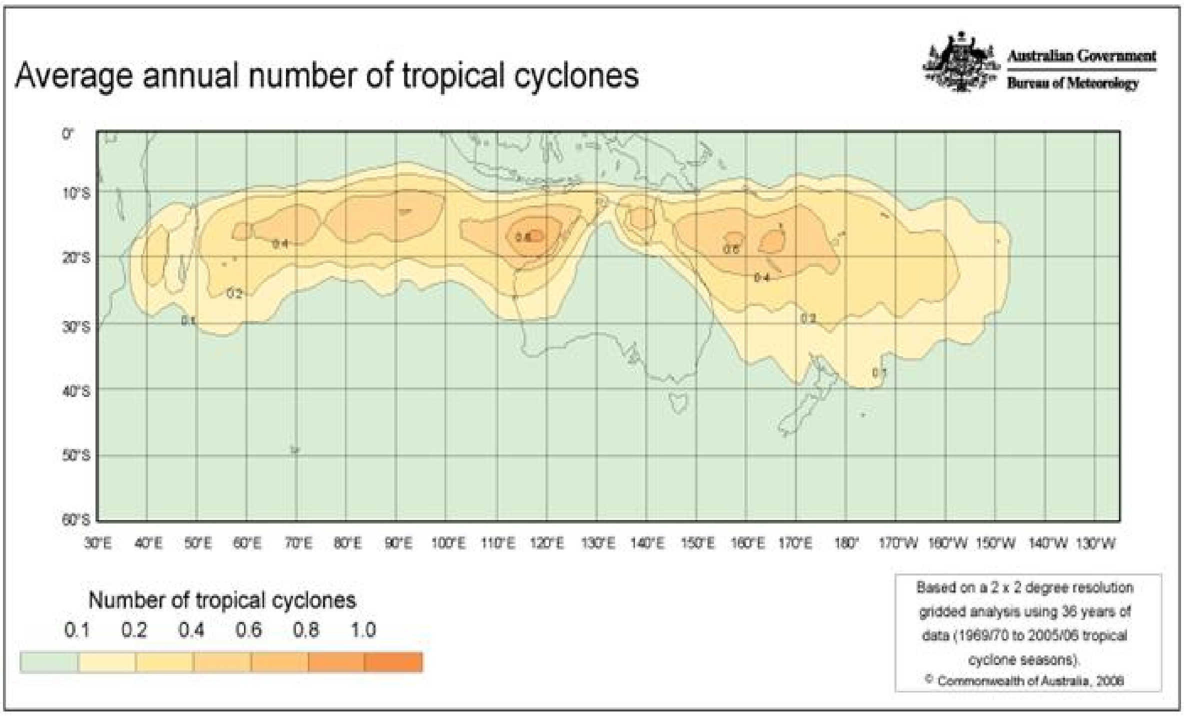


Figure 4-14 Average annual thunder-day map

4.6.2 Cyclones

Tropical cyclones are relatively small-scale weather phenomena that affect the tropical coasts of Western Australia, the Northern Territory and Queensland. Cyclones in the northern region of Queensland typically occur from late November through to April. Impacts from tropical cyclones in Queensland are characterised by catastrophic wind speeds, storm surges and extreme heavy rainfall and flooding (CSIRO 2015). Natural variability in the number of tropical cyclones making landfall in Australia is strongly influenced by ENSO, with more tropical cyclones during La Niña years and fewer in El Niño years (CSIRO 2015).

BoM cyclone predictive mapping suggests the average number of cyclones per year that have the potential to occur in the Project area is approximately 0.2 to 0.4 (see Figure 4-15).

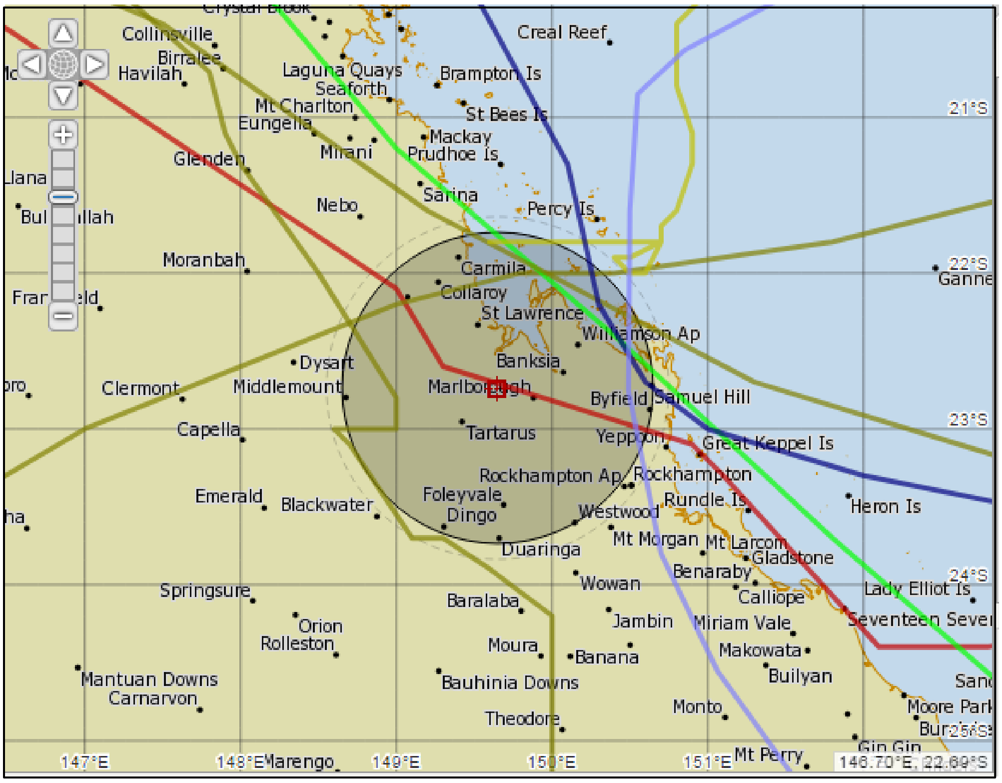


Source: BoM 2017a

Figure 4-15 Average number of cyclones per year

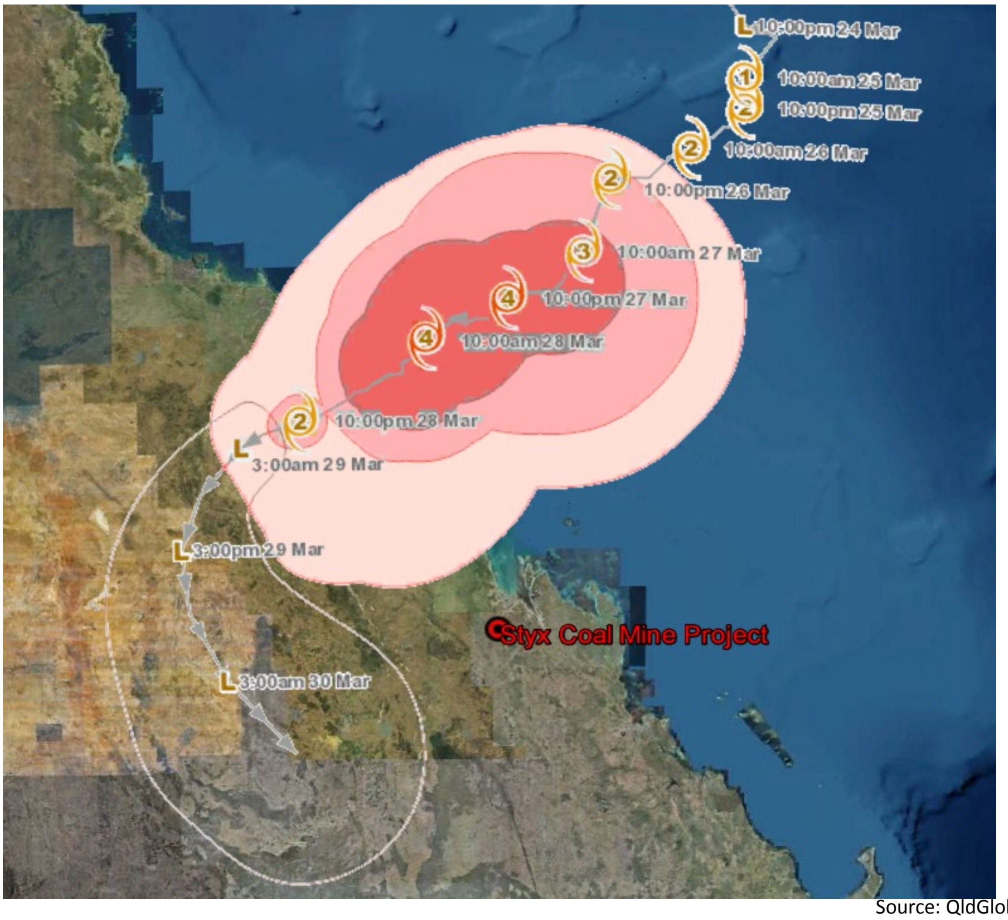
During the 47 year period from 1969 to 2016, eight cyclones were recorded within 100 km of the Project and one, Tropical cyclone Fiona: February 1 971 (red line), within 50 km (see Figure 4-16). In March 2017, Tropical cyclone Debbie hit the coast of Queensland just north of the Project as a Category 4 cyclone and tracked inland (Figure 4-17). Tropical cyclone Debbie did not track within 50 km of the Project; however, the low-pressure system associated with the cyclone resulted in high wind speeds of up to 76 km/hour at St Lawrence and significant rainfall of up to 145.4 mm (BoM 2017c). Notwithstanding only one cyclone has been recorded in the Project area since 1969, the risk of direct impacts to the Project area as a result of a cyclone exists. The Project infrastructure will be designed in accordance with current requirements for the design and construction of infrastructure located in cyclone prone areas. In addition a specific operational management plan will be prepared for operations leading upto and during a cyclone and the Emergency Response Plan (ERP) will manage the safety and health risks to workers.

The management measures associated with flood management and water balance during a cyclone are addressed in Chapter 9 – Surface Water.



Source: BoM 2017a

Figure 4-16 Occurrences of tropical cyclones within 100 km of the Project between 1969 and 2016



Source: QldGlobe 2017

Figure 4-17 Tropical cyclone Debbie

Storm surges are a condition associated with cyclonic weather whereby tidal levels are much higher than normal due to the pilling up effect of wind upon the ocean. Little information is available about the potential magnitude of storm surge in the Styx River. It is an ungauged catchment, so there is no history of flood heights from which surge data could be inferred. However, the relative elevations of landmarks on the river do provide some evidence – fieldwork has shown that the upstream extent of regular tidal inundation, as evidence by the presence of Marine Couch, occurs near the confluence of Deep Creek and Tooloombah Creek. Representative creek bed elevation at this location is approximately 5.5 m AHD. At the Bruce Highway Bridge over Deep Creek, the representative creek bed elevation is approximately 25 m AHD, almost 20 m higher than the regular tidal level. Whilst it is acknowledged that a storm surge creates tidal inundation (i.e. the storm tide) that travels further inland than regular tides, it would appear unlikely that cyclonic conditions could create a surge of this magnitude. The relative levels at four locations along Styx River and Deep Creek are presented in Figure 4-18.

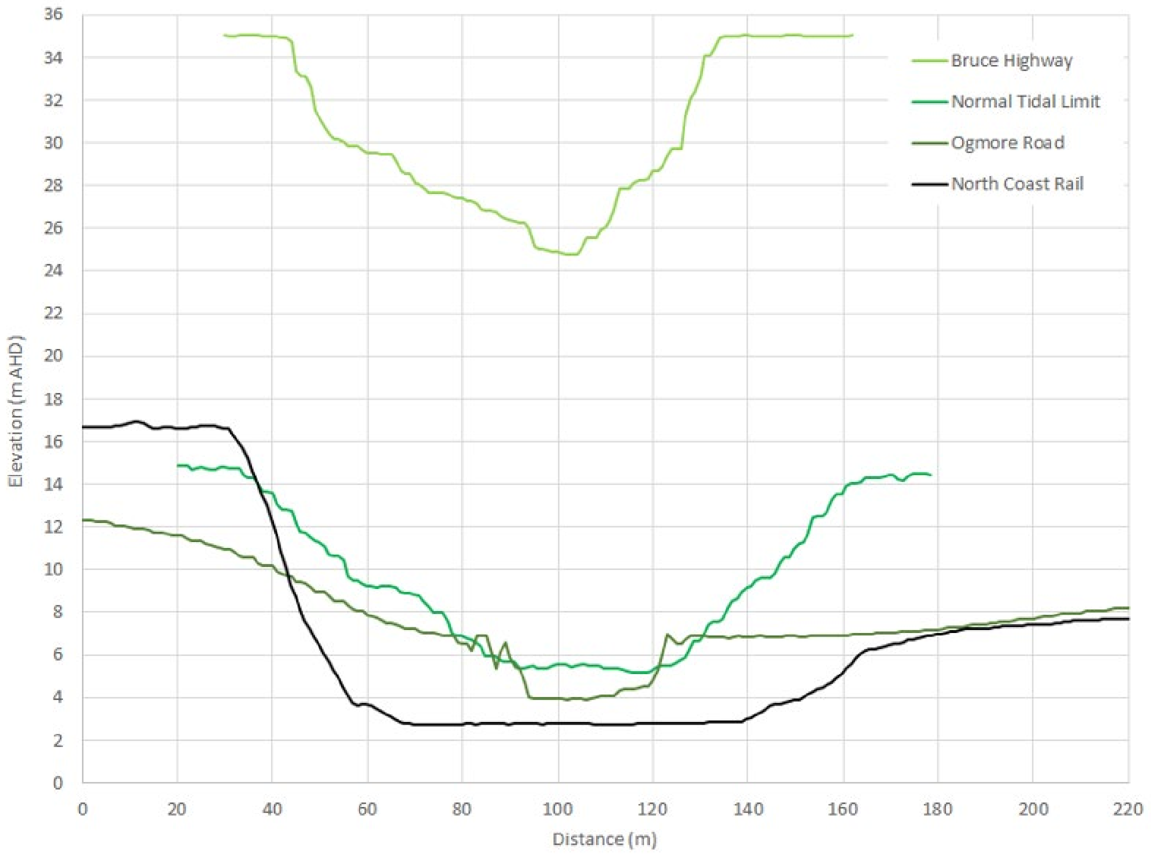


Figure 4-18 Storm tides at four locations

4.6.3 Floods

Flooding within the Styx basin is seasonal and is usually associated with a cyclonic event. Previous flood events have resulted in loss of communications, transport routes and damage to crops. These flooding events occur during the wet season, with the Styx River containing most the flow within the channel and overbank before overflowing into the floodplain areas. Within the vicinity of the Project, Deep Creek and Tooloombah Creek are incised with channel depths of more than 5 m. Tooloombah Creek is well-defined with little evidence of floodplain discharges while Deep Creek demonstrates numerous locations of floodplain discharges evident by the erosion on the bank and lack of vegetation.

The Styx River is a relatively small, ungauged catchment. There is no record of historical river flooding available, and therefore a flood frequency analysis could not be conducted. In the absence of gauged data, the Regional Flood Frequency Estimate model (see Chapter 9 – Surface Water) was used to compare design event peak runoff estimates (as calculated in the hydrologic model) against gauged estimates from adjacent catchments. Hydrologic model results were found to be reasonable in this context. No comment can be made as to the frequency and severity of flood events, for the reason that flood frequency (and its inverse, flood magnitude) are the independent variables against which flood behaviour is measured. The dependent variable in this case is peak discharge, which was compared to regional estimates (see Chapter 9 – Surface Water).

4.6.4 Bushfires

The Livingstone Shire Planning Scheme (2018) Map O5A - Storm Tide Hazard and Bushfire Hazard Risk Analysis overlay map identifies the Project area primarily occupying land where the fire risk has been undetermined (Figure 4-19). Bushfire risk is influenced by a combination of increased temperatures, higher winds, lower rainfall and woody vegetation. Given the extensive clearing of remnant vegetation to support cattle grazing, and the gentle to undulating landscape the area is assessed as having a 'low' and 'medium' bushfire threat. The bushfire danger period in the Project area is in spring (Figure 4-20); however, the actual danger period is determined by the existing seasonal weather conditions.

It is expected that the bushfire risk may increase under a combination of increased temperatures, higher winds and lower rainfall. An increased risk of bushfires for the Project may have the following impacts:

- Damage to Project infrastructure;
- Injury or fatality to workers and the public from bushfire starting off-site or onsite; and
- Rehabilitation failure due to bushfires destroying areas subject to rehabilitation.

Specific procedures will be outlined in the ERP to respond to the event of a bushfire. With the provision of management measures outlined in Section 4.8 the risk of bushfire starting or impacting the Project area is expected to be reduced. The ERP developed for the Project will include details of provisions for site access roads, for firefighting and emergency vehicles, as well as the safe evacuation of staff in the event of an emergency. Further information on the ERP is provided in Chapter 21 – Hazard and Risk.

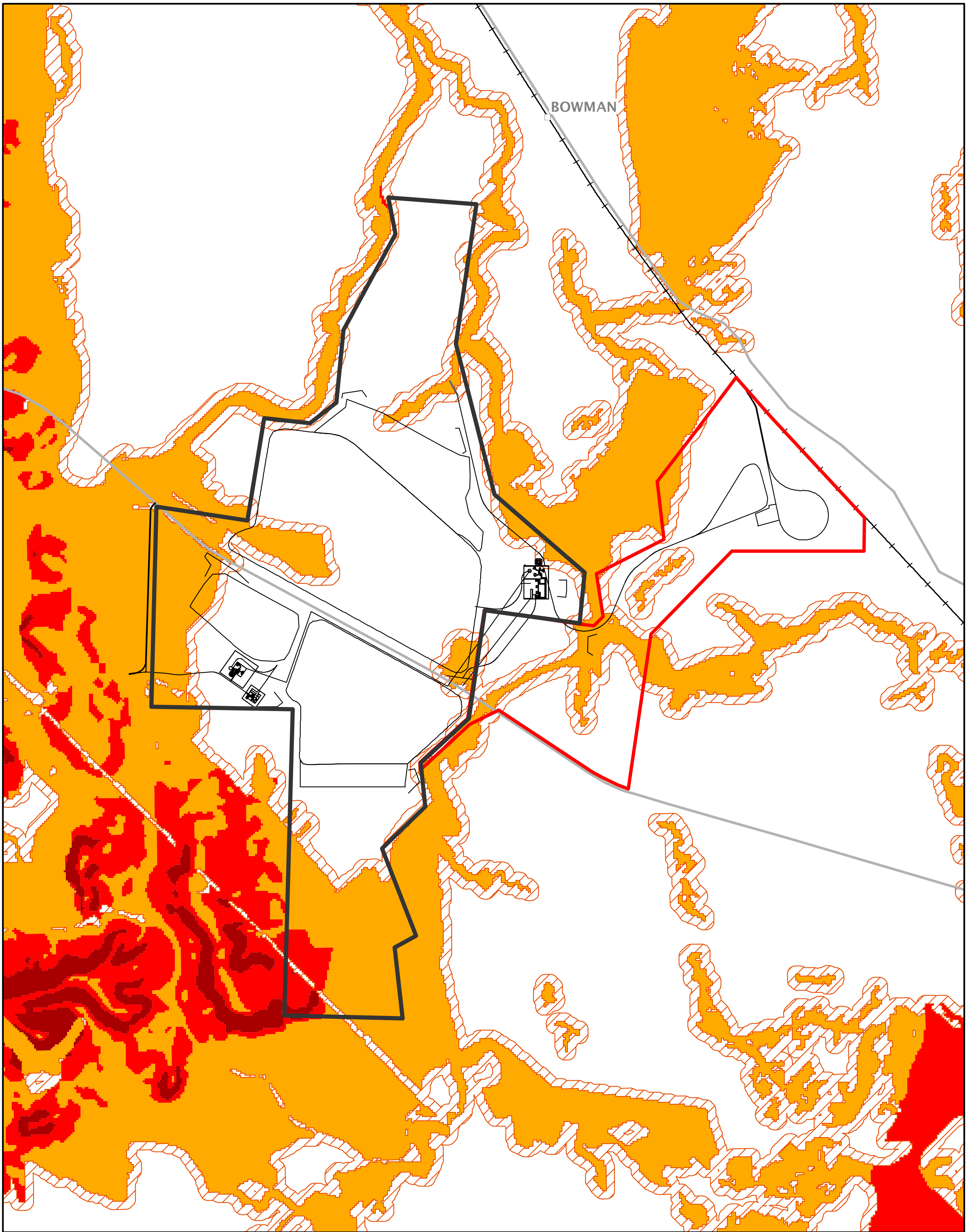


Figure 4-19

Livingstone Shire bushfire risk map

N

0 0.5 1 km

Scale @ A4 1:60,000
Date: 12/10/18
Drawn: Gayle B.

Legend

CLASS

- Very High Potential Bushfire Intensity
- High Potential Bushfire Intensity
- Medium Potential Bushfire Intensity
- Potential Impact Buffer
- ML 80187
- ML 700022
- Mine infrastructure
- Main Road
- North Coast Rail Line

DATA SOURCE
Waratah Coal, 2018
QLD Open Source Data, 2018

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\1000111 - Styx SEIS Post submission work\7Work\3GIS\DATA\MXD\Chapter 4_Supp_Report_Climate\1000111 bushfire risk__4-16.mxd 10/12/2018

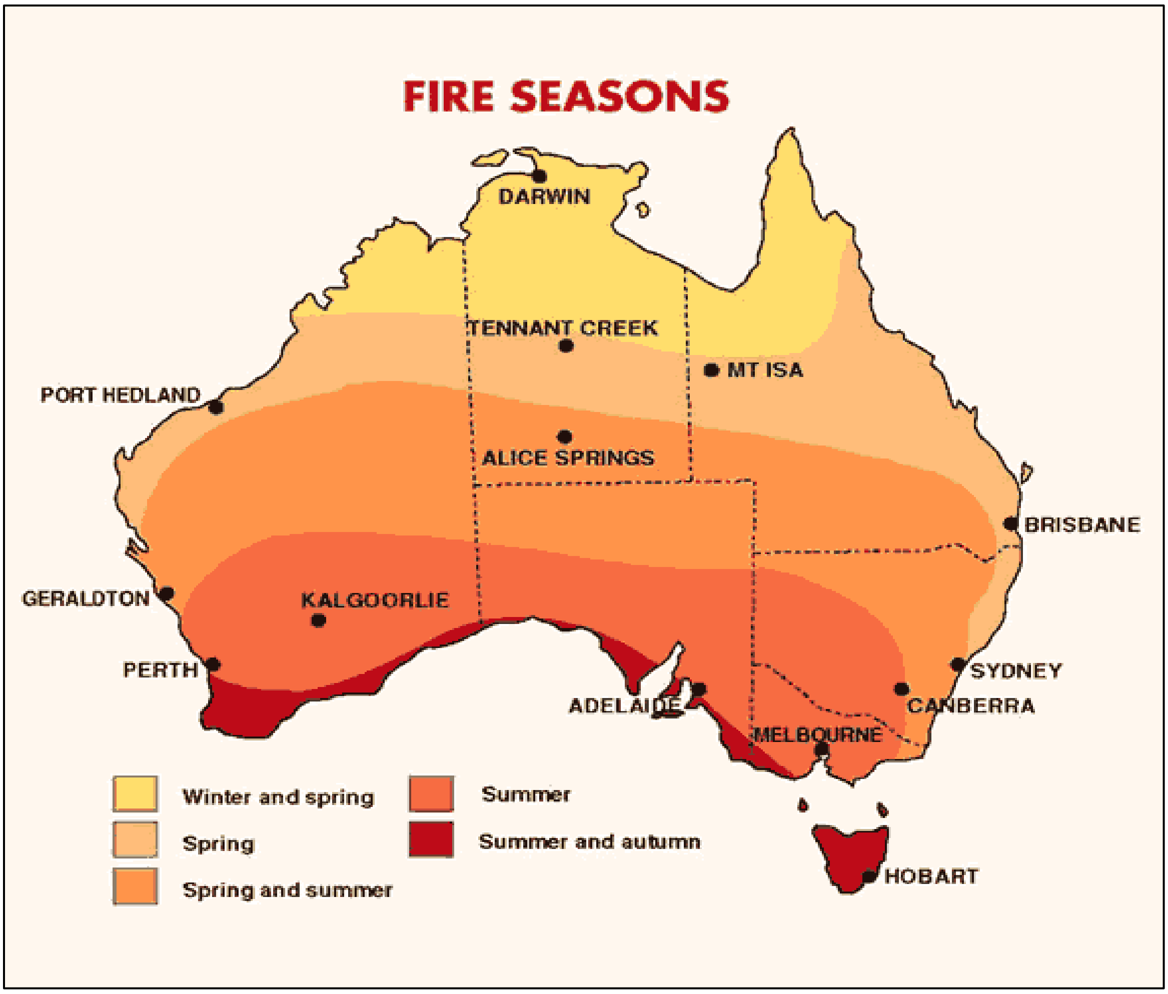


Figure 4-20 Australian bushfire threat

4.6.5 Earthquakes

Australia is typically considered to be a tectonically stable continent (GA 2014). Nevertheless between 1977 and 2000, an average of 110 earthquakes per year have been recorded by the Queensland seismic network (Earth Systems Science Computational Centre (ESSCC) 2012). Most were of very low magnitude. Over the last century, there have been 17 earthquakes of magnitude six or greater, including one in central Queensland in 1918 that caused property damage in Rockhampton (ESSCC 2012).

The potential for earthquakes to occur within or surrounding the Project has been determined as low. There has been one earthquake recorded within a 100 km radius of the Project area since 1990 to May 2017. This earthquake occurred in 1992 approximately 55 km south of the Project area. The closest recorded earthquake that was a magnitude above 4.0 occurred off the coast of Yeppoon, approximately 160 km east of the Project, in 1998. This earthquake measured a magnitude of 4.7.

As the Project area is considered geologically stable, it is highly unlikely that an earthquake of a magnitude that could adversely impact the Project would occur within or surrounding the Project area and as such has not been accounted for within design.

4.6.6 Landslides

The Livingstone Shire Planning Scheme (2018) Map O2A - Drainage Problem, Erosion Prone Land and Steep Land overlay map identifies the Project area primarily occupying land where the landslide risk has been undetermined (Figure 4-21). Given the topography within the Project area and immediate surrounding area is generally flat to gently undulating it is expected that the risk of a landslide occurring is low. The State Planning Policy (SPP) states that the potential for landslides occurs when a slope is 15% or greater (DILGP 2016). In general, topographic relief is quite flat, with only a very small minority of the site having an instantaneous surface slope of greater than 12% (see Figure 4-21).

Any landslide hazard shall be minimised by practicing erosion and sediment control best practice, including but not limited to reducing batter slopes, providing greater than 70% ground cover, minimising stockpile heights and diverting up gradient surface water around disturbed areas.

Considering the topographic nature in conjunction with the soil features of the Project, area it is unlikely that the Project area will be subject to severe landslides.

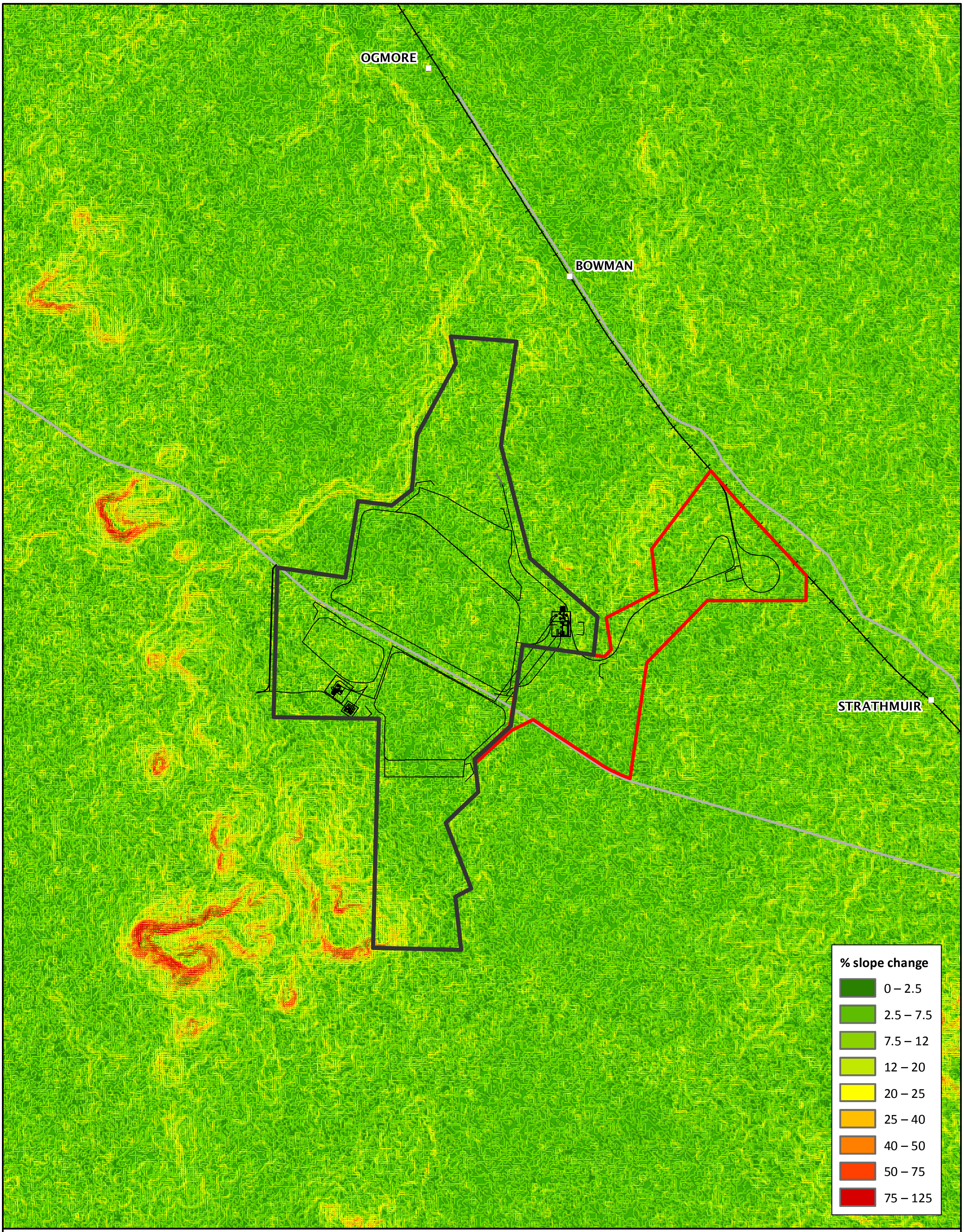


Figure 4-21

Surface slope analysis

N

0 1 2 km

Scale @ A4 1:80,000
Date: 13/11/18
Drawn: Gayle B.

Legend

- ML 80187
- ML 700022
- Mine infrastructure
- Main Road
- North Coast Rail Line

DATA SOURCE
Waratah Coal, 2018
QLD Open Source Data, 2018
1 sec STRM v1.0 DEM,
Geoscience Australia, 2011

CDM Smith

4.6.7 Droughts

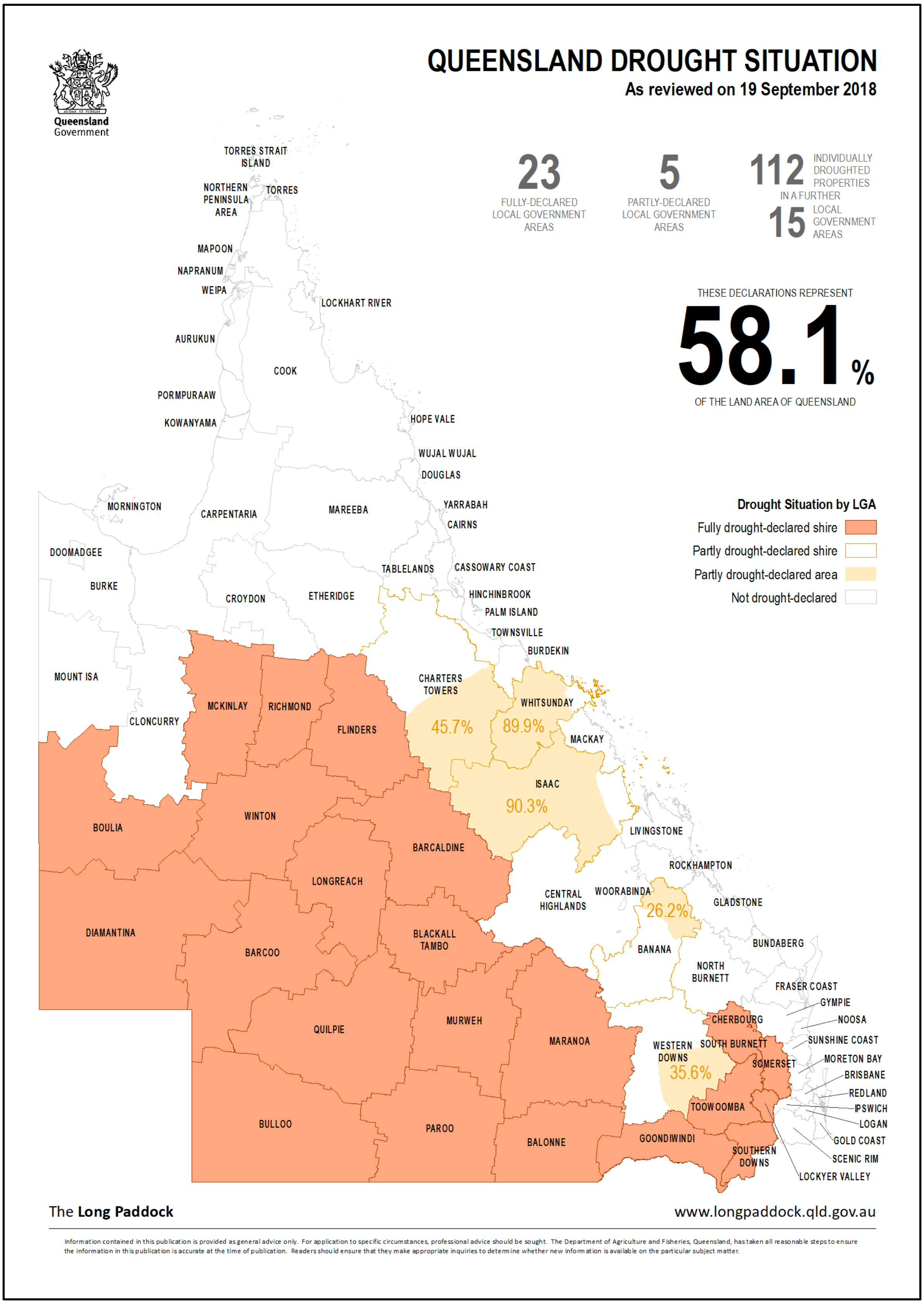
Droughts are usually associated with El Niño conditions. Low and variable rainfall is due to Australia's location under the sub-tropical belt of high pressure. As such, droughts are common in Australia and Queensland. The BoM predicts severe droughts (rainfall is among the lowest 5% for period in question) will affect some part of the Australian continent at least once every 18 years with intervals between severe droughts ranging from four to 18 years (BoM 2010). Queensland is particularly vulnerable to natural rainfall variability.

As at 19 September 2018 there are 23 fully declared Local Government areas and five part Local Government areas drought declared, with 112 Individually Droughted Properties in a further 15 Local Government areas (Longpaddock 2018) (see Figure 4-22). The drought declarations represent approximately 58.1% of the Queensland state land area.

The Livingston Shire is neither Drought or Partially Drought Declared. Whilst the Project is not in a drought declared area at the time of writing, the Project is located in an area which can experience very low rainfall.

Australia has experienced three major dry periods over the last century or more, including the "Federation drought" (1895-1903), the "World War II drought" (1939-1945), and the so-called "Millennium drought" (1996-2010). These major droughts have been related to variability of large-scale drivers including ENSO, the monsoonal circulation over northern Australia, Indian Ocean sea surface temperatures, and the large-scale circulation in the Southern Hemisphere (e.g. Timbal and Hendon 2011).

Periods of low rainfall are associated with central Queensland as well as the Livingstone Shire LGA. In the past, periods of low rainfall have occurred at the St Lawrence and Rockhampton weather stations. Based on analysis of long-term climate data at the St Lawrence weather station, eight major drought periods have occurred since 1880. These are generally associated with El Niño conditions. The droughts occurred over the following periods: 1884 to 1886, 1899 to 1903 (coinciding with the Federation drought), 1915 to 1916, 1923 to 1925, 1937 to 1939 and 1945 to 1949 (coinciding with the World War II drought), 1964 to 1966, 1984 to 1987, and 1992 to 1999 and 2000 to 2007 (coinciding with the Millennium drought). Significant low rainfall years occurred 1919, 1957, 1972, 1979 and 2009.



Source: www.longpaddock 2018

Figure 4-22 Queensland drought situation as at 19 September 2018

Record months of low rainfall recorded at the St Lawrence and Rockhampton Aero weather stations are detailed in Table 4-7. As observed there are months that throughout the wet season, recorded extremely low rainfall. These record low rainfall months have implications for the Project, as the Project will have to be able to effectively manage water supplies. A water supply strategy will outline efforts to minimise the risks associated with droughts. Further impacts and mitigation strategies are identified in Section 4.8.

Table 4-7 St Lawrence and Rockhampton Aero monthly rainfall low records

Month	Lowest (mm)		5th percentile (mm)		10th percentile (mm)	
	St Lawrence	Rockhampton Aero	St Lawrence	Rockhampton Aero	St Lawrence	Rockhampton Aero
Jan	0.2	1.6	20.9	24.4	32.4	34.9
Feb	3.8	2.8	19.3	13.0	36.5	16.6
Mar	0.0	2.3	7.2	5.2	11.9	10.8
Apr	0.0	0.0	0.0	3.3	3.5	4.4
May	0.0	0.3	1.1	2.5	4.2	3.6
Jun	0.0	0.0	0.0	0.6	3.1	2.2
Jul	0.0	0.0	0.0	0.3	0.0	0.8
Aug	0.0	0.0	0.0	0.2	0.0	0.7
Sep	0.0	0.0	0.0	0.3	0.0	0.9
Oct	0.0	0.4	1.0	4.4	2.6	6.8
Nov	0.0	0.0	1.1	8.6	6.9	15.3
Dec	0.0	2.8	11.6	14.3	22.0	23.7
Annual	197.7	360.0	476.9	455.7	599.3	518.1

Source: BoM 2017a

4.6.8 Heatwaves

Heatwaves are a prolonged period where there is excessively hot weather. The BoM classifies a heatwave as a period of three days or more of high maximum temperatures that is unusual for that location. Heatwaves can result in significant stress on vulnerable people. This stress can result in death during and after the heatwave.

The duration, frequency and intensity of heatwaves have increased across many parts of Australia (CSIRO 2016). Extreme weather events of the hottest months have been used to identify extreme high temperatures. Daily maximum temperature records at the St Lawrence weather station between 1957 and 2012 are shown at Table 4-8. The hottest recorded temperature was 44°C recorded in January 1994.

Table 4-8 St Lawrence daily high temperature records

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High Max (°C)	44.0 1994	41.3 1990	39.3 2007	35.3 1988	32.0 2002	31.7 1963	31.6 1995	32.8 1990	36.7 1982	39.1 2003	41.1 1971	40.7 1964

Source: BoM 2017a

The mean number of days where high temperatures are recorded over 30°C, 35°C and 40°C at the St Lawrence weather station between 1957 and 2012 are shown at Table 4-9. Temperatures over 35°C and 40°C occur very infrequently. Temperatures over 30°C are relatively common throughout the summer months.

Table 4-9 St Lawrence average number of days with high temperatures

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
≥ 40.0 (°C)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
≥ 35.0 (°C)	1.3	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.7	1.0	4.8
≥ 30.0 (°C)	25.1	22.5	23.0	12.1	0.9	0.2	0.1	0.3	2.0	7.3	18.0	24.0	135.5

Source: BoM 2017a

Continuous and unrelenting high temperatures have potential health implications on workers. The high temperatures and potential heatwaves can lead to stresses and dehydration, and potentially death. Heat exhaustion is marked by dehydration and electrolyte depletion, with symptoms including diarrhoea, headache, nausea, vomiting, dizziness and others.

Heatwaves can also lead to other impacts, including impacts to infrastructure and Project facilities. Heatwaves can cause implications including power outages, fires and physical damage to roads, rail systems, waterlines, and power transformers.

Rising temperatures because of climate change are discussed in Section 4.7.1.1.

4.7 Climate Change

The following section presents the climate change impact assessment for the Project. Projections put forward in this section are based on the following sources:

- Climate Change in Queensland, What the Science is Telling Us (QOCC 2010);
- The Critical Decade: Queensland Climate Impacts and Opportunities (Steffen et al. 2012);
- Climate Change 2014: Impacts, Adaptation and Vulnerability (IPCC 2014);
- Climate Change in Australia: Projections for Australia’s NRM Regions (CSIRO 2015); and
- State of the Climate 2016 (CSIRO 2016).

The Intergovernmental Panel on Climate Change (IPCC) technical definition of climate change is: ‘any change in climate over time, whether due to natural variability or because of human activity’ (IPCC 2014). Temperatures are predicted to rise, and climate extremes are predicted to amplify with the continued release of GHGs in Australia (CSIRO 2016). The projections are discussed in more detail below.

The preparedness of the Project for climate change depends on adaptation planning for a range of climate change effects including severe droughts, conflict over water use, heatwaves and intense rainfall.

4.7.1 Climate Change Projections

4.7.1.1 Temperature

There is very high confidence that temperatures in Queensland will rise over the next century (CSIRO 2015). On average Queensland temperatures have risen by approximately 1°C resulting in an increase in the amount of hot days (more than 35°C) and it is anticipated that temperatures could rise anywhere between 1 and 5°C by 2070 depending on global emissions (Steffen et al. 2012).

Across Queensland, annual average temperatures are projected to increase, with inland areas expected to warm more rapidly than the coastal areas (QOCC 2010). The average warming in central Queensland is projected to be approximately 0.4°C to 1.5°C by 2030 and 1.0 to 3.8°C, depending on future emissions. There is likely to be a substantial increase in the temperature reached on the hottest days, and an increase in the frequency of hot days and the duration of warm spells. There is very high confidence that there will be up to two to three times the average number of days above 35°C under intermediate emission scenarios (CSIRO 2015).

The temperature projections for the Central Queensland region for 2070 using the high emissions (A1FI) scenario are summarised in Table 4-10. The current / historical conditions for Rockhampton and resulting conditions using data from the Rockhampton Aero weather station taking the best estimate (50th percentile) climate change projections for the region into account are also presented.

Table 4-10 Climate change projections summary for Central Queensland - temperature

Climate variable	Current / historical conditions (Rockhampton Aero*)	Climate change projection 50th (10th and 90th) percentile^	Projected 2070 conditions (50th percentile)
Annual mean maximum temp	28.3°C	+3.2 °C (+2.2 and +4.5 °C)	31.5°C
Summer mean maximum temperature	31.9°C	+3.2 °C (+2.0 and +4.7 °C)	35.1°C
Winter mean maximum temperature	24.8°C	+3.1 °C (+2.1 and +4.5 °C)	27.9°C
Mean annual number of hot days (over 35°C)	18.2 days	+46 days (+24 and +82 days)	64.2 days

*All years of data (1939 – 2016) (BoM 2017a)

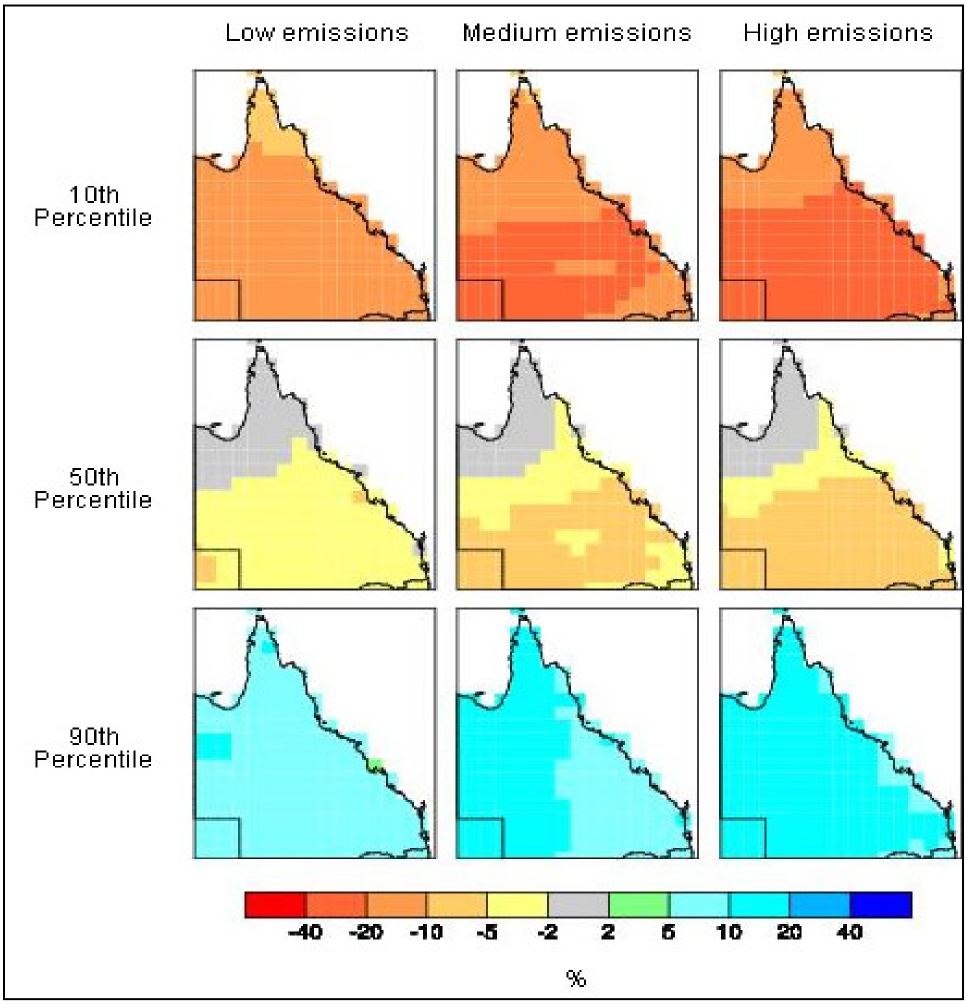
^ Source QCCCE 2009

4.7.1.2 Rainfall

Australia has been experiencing an increase in extreme rainy days (greater than the 90th percentile for 24 hour rainfall) since the 1970s. However, by 2030, annual rainfall is projected to decrease by up to 3% under a high emission scenario. By 2050, under the high emissions scenario, annual rainfall is expected to decrease by 7% (-59 mm). The frequency or intensity of high rainfall events is likely to increase. Historical rainfall for the Project area is discussed at Section 4.5.1.

The uncertainties in annual average rainfall expected in Queensland across low, medium and high emissions scenarios are shown at Figure 4-23. The figure shows the predicted variation (uncertainty) in rainfall by 2050 at the Project area, ranges from a decrease of 10 to 20% for the 10th percentile to an increase of between 10 to 20% for the 90th percentile.

Annual potential evaporation is expected to increase by up to 9% with the greatest increase predicted to occur in autumn.



Source: CSIRO and BoM 2007

Figure 4-23 Uncertainties in annual average rainfall in Queensland in 2050

The rainfall and evaporation projections for the Central Queensland region for 2070 using the high emissions (A1FI) scenario are summarised in Table 4-11. The current/historical conditions for Rockhampton and resulting conditions using data from the Rockhampton Aero weather station taking the best estimate (50th percentile) climate change projections for the region into account are also presented.

Table 4-11 Climate change projections summary for Central Queensland – rainfall and evaporation

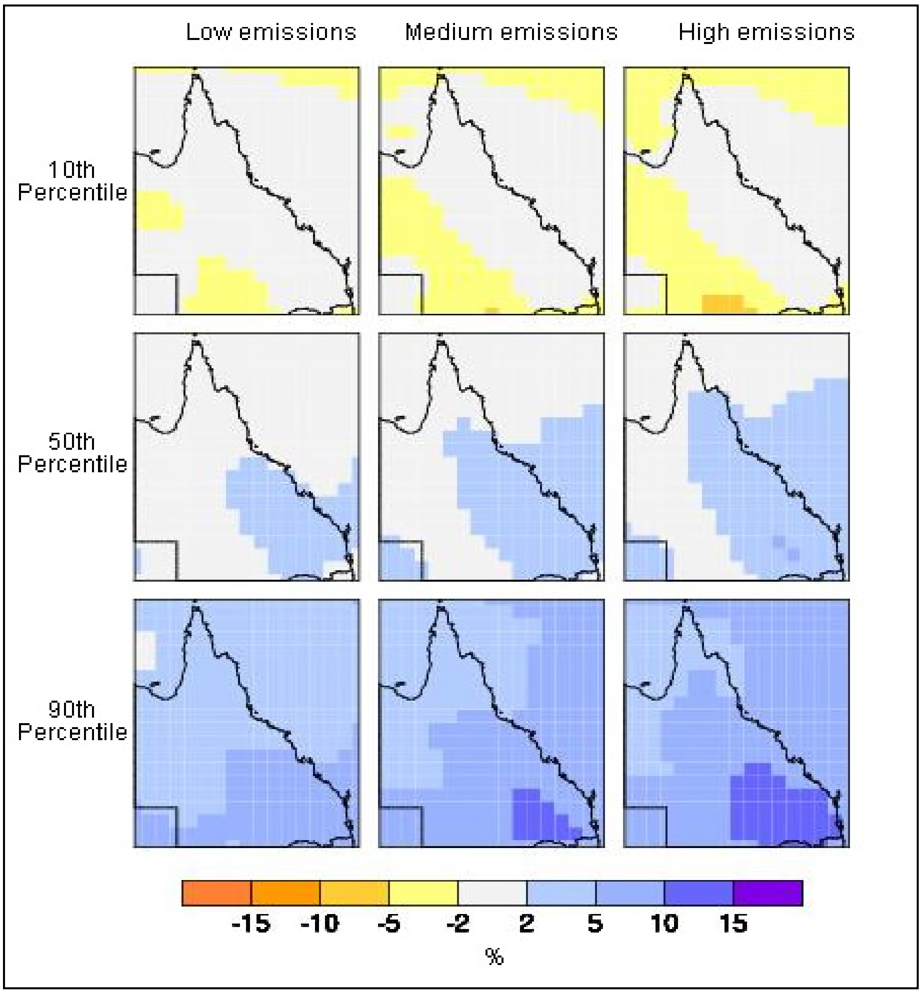
Climate variable	Current / historical conditions (Rockhampton Aero*)	Climate change projection 50th (10th and 90th) percentile^	Projected 2070 conditions (50th percentile)
Mean annual rainfall	812.9 mm	-10% (-35 and +17%)	731 mm
Mean summer rainfall	385.4 mm	-5% (-34 and +26%)	366 mm
Mean winter rainfall	98.6 mm	-14% (-45 and +25%)	84 mm
Mean annual daily evaporation	5.7 mm	+10% (+7 and +15%)	6.3 mm
Average summer daily evaporation	6.9 mm	+10% (+5 and +15%)	6.6 mm
Average winter daily evaporation	3.8 mm	+12% (+7 and +19%)	4.2 mm

*All years of data (1939 – 2016) (BoM 2017a)
^ Source QCCCE 2009

4.7.1.3 Winds and Cyclones

It is projected that there will be a southern shift in the primary region of cyclone activity. Given the location of the Project, greater cyclonic impacts may be experienced. Wind prediction for the Project location estimates an annual increase in wind intensity of 2 to 5% regardless of the emission intensity scenario. This is not anticipated to have an adverse impact on Project operations and/or infrastructure.

The uncertainties in annual average wind speeds expected in Queensland across low, medium and high emissions scenarios are shown at Figure 4-24. The figure shows that the predicted variation (uncertainty) in winds speeds by 2050 ranges from a decrease of 2% for the 10th percentile to an increase of between 5 to 10% for the 90th percentile in the region surrounding the Project area.



Source: CSIRO and BoM 2007

Figure 4-24 Uncertainties in annual average wind speeds in Queensland in 2050

4.7.2 Climate Change Adaptation

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. It is therefore unlikely that there will be material changes to the infrastructure design or its operation because of climate change, particularly as the Project is anticipated to only have a 20-year operating life. 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 in an area that is already subjected to a significant number of high temperature days annually it is not expected that the projected increases will have a detrimental impact on the operational or safe working environment at the Project.

In terms of annual variation in rainfall because of climate change, the water management system will be designed to include tolerances to cater to 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 mine water management system. Raw water supply for the mine will be secured from groundwater supplies, surface water containment and treated water from onsite water storages.

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 projected increases will be within design tolerances and will not pose a significant risk to operations or workplace safety. For example, infrastructure such as the 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 storm events will be addressed as part of the flood immunity design for the infrastructure. This will take into consideration the protection of assets and in particular, open cut pits 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 as 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 Land Use Management Plan (LUMP) 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 systems that best mitigate wild fire risks. The LUMP will be focused on preservation of life and infrastructure in a context that adheres to ecological needs wherever possible. Moreover, the strategy also aims to implement measures that minimise the risk of fires leaving the Project area.

In addition to the LUMP the infrastructure will have fire protection embedded into the design 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.

Climate change projections show that the frequency of cyclones is predicted to decrease; however, the intensity could increase. The Project area is located within a cyclone risk area. As such the infrastructure will be designed in accordance with the necessary building code requirements relating to cyclonic activity mitigation. It is expected that the projected intensification in cyclonic activity will be managed adequately through the initial design of the infrastructure and the implementation of routine management and maintenance systems. Health and safety procedures for working during periods of extreme cyclonic conditions would be implemented from the onset of construction. These systems would be regularly reviewed and amended as part of routine management and would be adapted to address any changes required due to climate change.

The adaptation strategies described above will aim to continually improve and monitor climate change and events and effectiveness of strategies. Adaptation strategies will:

- Comply with applicable regulatory requirements and monitor relevant regulations for changes;
- Identify, assess and monitor current and changing environmental impacts;
- Involve contractors and service providers where necessary;
- Implement appropriate environmental management programs and controls; and
- Track actual environmental performance.

Central Queensland Coal is committed to undertaking and maintaining, where practicable, a cooperative approach with government and other industry sectors to address the Project's adaptation to climate change.

Potential impacts and mitigation measures related to climate change have been included in Table 4-13. These include the strategies which will be incorporated to mitigate and manage the impacts of climate change.

4.8 Potential Impacts and Mitigation Measures

The underlying climatic conditions have the potential to impact the Project activities. These potential impacts associated with storms and cyclones, floods, bushfires, droughts and heatwaves are discussed below. Landslides and earthquakes are not considered likely to pose any risks to the Project. Projected climate change conditions are not anticipated to impact the Project except for temperature rises. Potential impacts and management associated with heat is discussed in the following sections.

4.8.1 Storms and Cyclones

The Project is not located in a floodplain that is engaged during moderate to large flood events. The watercourses that bound the Project, namely Tooloombah and Deep Creek, are deeply incised and contain large flows within the channel bank i.e. do not engage the floodplain regularly in the vicinity of either pit or processing infrastructure. Excessive rainfall events above the 0.1% AEP may cause risk of:

- The flooding of open cut pits;
- Disruption to the production and haulage of coal;
- The uncontrolled release of potentially hazardous waters from dams; and
- The removal of excess flood waters contained on site, for example within open pits.

When considering the impact of the Project in terms of extreme cyclonic events and climate change, it is important to note that the mine life is estimated to be 20 years and that the processing facilities (CHPP and MIA), water dams, environmental dams and open pits are flood immune up to and including the 0.1% AEP flood event. The 0.1% AEP event has a 0.1% probability of being exceeded in any given year. Moreover, there is only a 1.98% percent probability that the 0.1% AEP event is exceeded over a 20 year period. It can therefore be concluded that the dams, processing facilities and the mine pits have a 98% probability of not becoming inundated by flooding from Tooloombah and Deep Creek over the 20 year mine life. Chapter 9 – Surface Water provides detailed discussion and mapping of the flood modelling for the Project, including the probable maximum flood (PMF) event. However, it should be noted that this event has a 0.0002% probability of occurrence over the 20 year mine period.

Chapter 9 – Surface Water confirms that all environmental dams can contain the waste rock stockpile area surface runoff generated by the 9.5% AEP event without overtopping, in accordance with the DES Stormwater Guideline (EHP 2014b). During extreme events rarer than the 9.5% AEP, the environmental dams will become overloaded and controlled spills and/or releases may occur. Water captured in the environmental dams will be preferentially used in the mine operations at the MIA, CHPP and for dust suppression use. Excess water from the environmental dams will be directed to Dam 2. The Environmental Dams 1b, 2a and 3 will have low flow perforated riser-pipe decant outlets to discharge treated water to the receiving environment as controlled discharges under conditions licensed by the Environmental Authority.

The environmental dams; however, have only been proposed to reduce sediment loads for material considered not to be a source of major contaminants that pose a risk to environmental values. The effect of climate change, notably the decrease in frequency but increase in intensity of rainfall events, could potentially result in a greater magnitude of controlled spills from the environmental dams and therefore result in a greater sediment load migrating to the receiving environment. Erosion and sediment control measures will be established to reduce this potential risk.

Dams potentially containing contaminants (associated CHPP and MIA) have been conceptualised with a design storage allowance equal to the 4.9% AEP wet season plus a 50% contingency. Given these storages don't have external catchments, even a significant cyclonic event such as Cyclone Debbie, which contributed 245 mm of rainfall, would not be enough to cause an uncontrolled release from these storages in most cases. This is because with no external catchment, a single rainfall event is not the critical case for uncontrolled release. Furthermore, the CHPP and MIA Dams will have spillways capable of safety passing the 0.2% AEP flood event to mitigate catastrophic failure during extreme events.

The total average number of lightning strikes and days where thunder occurred in the region suggests that there are 15 to 20 storms per year ranging in intensity, there is medium risk of impacts from more severe storms (which severity may increase with climate change) on the Project area. The potential for excessive wind and cyclonic events to occur is also relatively low and poses a low risk to the Project.

Infrastructure will be designed for severe weather events. Mine design and capacity will be constructed to the Building Code requirements for the local area. Climate change results in relatively low risk of impact to the Project.

Design features associated with Project infrastructure and their resilience to severe weather conditions are further discussed in Chapter 3 – Description of the Project and Chapter 9 - Surface Water.

4.8.2 Floods

The details of the flood assessment conducted for Tooloombah Creek, Deep Creek and the Styx River are discussed in Chapter 9 – Surface Water. The aim of the assessment was to:

- Demonstrate the flood immunity of critical mine infrastructure and haul roads; and
- Assess impacts on flood behaviour due to mine construction.

Also discussed in Chapter 9 – Surface Water is the conceptualisation and hydraulic performance of the stormwater management system, including diversion drains, culverts, floodways and environmental sediment basins.

The hydrologic and hydraulic modelling was conducted in terms of Annual Exceedance Probability (AEP) as is recommended by industry with the recent implementation of the 2016 Australia Runoff and Rainfall national guideline document, data and software suite, which is used for the estimation of design flood characteristics in Australia (Ball et al. 2016). The change in terminology comes from a common misinterpretation of Average Recurrence Interval (ARI) terminology, in which it is erroneously assumed that a 1 in 10 year ARI, for example, will only occur exactly once in every ten years.

The AEP better handles this by describing the probability of a magnitude flood event being exceeded in any given year as a percentage probability. However, there are some guidelines and analyses that have not adopted the AEP definition, which ultimately means that the design standard for environmental dams, diversion drains, and culverts are still established in terms of ARI. The relationship between AEP and ARI is as follows: 9.5% AEP (10 year ARI), 4.9% AEP (20 year ARI), 2% AEP (50 year ARI), 1% AEP (100 year ARI) and 0.1% AEP (1,000 year ARI).

To assess the potential impacts relevant to flooding, hydrologic assessment and hydraulic assessments were undertaken. The aim of the hydrologic assessment (discussed in detail in Chapter 9 – Surface Water) was to produce flood hydrographs for input to hydraulic model simulations that predict flood characteristics such as inundation depth, flood extent and flow velocities.

The aim of the hydraulic assessment (discussed in detail in Chapter 9 – Surface Water) was to identify the Project's impact on localised flood characteristics such as flood depth, extent and velocity, as well as to quantify the immunity of critical infrastructure and the mine pits. Hydrodynamic modelling was used to create thematic maps showing flood extents, water depths and velocities, through input of the flood hydrographs developed by the hydrologic assessment.

As part of the hydraulic assessment, baseline case and developed case simulations were modelled and the results are discussed in detail in Chapter 9 – Surface Water. The assessment included modelling of the PMF and figures showing inundated and flooded areas for the full range of AEPs up to the PMF were presented for the Project.

The PMF is the largest flood that could conceivably occur at a location and is typically estimated from probable maximum precipitation, coupled with the worst flood producing catchment conditions. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event has been addressed in a floodplain risk management study presented in the EIS.

Based on the short duration of the Project (~20 years which includes final rehabilitation and closure activities), is it expected that any changes to local flooding regimes because of climate change have been adequately modelled and considered through the assessment of a PMF event. Notwithstanding, on commencement of mine construction, a detailed flood model reflecting detailed design reduced levels will be constructed, continually updated with new data and validated to reflect the 'as built' conditions. Ultimately, the flood model will be used to inform the final landscape design as part of mine closure activities.

Based on historical data, there is a distinct dry season between the months of April through October. Excessive rainfall is therefore not anticipated during the dry season construction period. Moderate to large flood events are not anticipated to adversely affect the Project during operations as the watercourses that bound the Project are, namely Tooloombah and Deep Creek, are deeply incised and contain large flows within the channel bank i.e. do not engage the floodplain regularly in the vicinity of pit and processing infrastructure. Excessive rainfall events above the 1:1,000 AEP may; however, cause:

- The flooding of open cut pits;
- Disruption to the production and haulage of coal;
- The uncontrolled release of potentially hazardous waters from dams; and
- The removal of excess flood waters contained on site, for example within open pits.

Both MIAs have been located above the 1:1,000 AEP flood level thus minimising potential impacts associated with flooding. Furthermore, mine site coal stockpile capacity has been designed to allow for operations to continue even if the haul road is closed by flooding. Likewise, open pit flood immunity has been increased to 1:1000 AEP through the inclusion of flood protection levees.

Should an extreme event occur, and excess water be stored on site, then consultation with DES will be carried out to enable the lawful and temporary release of flood water.

Detailed flood modelling and hydraulic design will be undertaken during the detailed design stage of the Project for all proposed mine infrastructure. Minor and major flood events will be modelled to establish:

- The appropriate size of Project dams to account for the additional volume of wet season rain events;
- The appropriate size of flow conveyance structures (culverts / bridges etc.) to minimise upstream and downstream flooding off lease and minimise risk of afflux;

- Protection of open cut pits from flood events of 1 in 1,000 ARI to minimise events where excess water enters the pits; and
- Should an extreme event occur, and excess water be stored on site then consultation with DES will be carried out to enable the lawful and temporary release of flood water.

4.8.3 Bushfires

Fire has the potential to damage infrastructure and may result in injury or fatalities. It is not anticipated that the Project will be at increased risk of fire as much of the Project area, particularly the MIA area contains only sparse vegetation.

Fire protection and response systems will be available on site and all staff will be adequately trained in the correct usage of relevant equipment as outlined in Chapter 21 – Hazard and Risk.

4.8.4 Droughts

The Project's water balance is discussed in detail in Chapter 9 – Surface Water. The water balance of the Project's water management network (as described in Chapter 9 – Surface Water) was simulated in GoldSim. The primary objectives of the water balance were to determine the net balance of water to be held in storages, the water reuse potential and raw water requirements.

A total of 127 years (1889 to 2017) of SILO historical climate data (DSITI 2017b) was used to simulate climate variability within the water balance model (see Chapter 9 – Surface Water for a climate data and variability discussion). By running multiple simulations of the 19-year operational mine plan and by stepping through the full 127 years of available historical climate data, the net water balance in the driest and wettest years were analysed.

During the driest years, there is more reliance on raw water supply, whereas during the wettest years there is more opportunity for water reuse. Moreover, during the wetter years there is a greater net storage requirement to contain open pit mine dewater volumes as well as catchment runoff volumes and direct rainfall falling on the storage areas. Morton's Lake evaporation was used to simulate evaporation from storages; whereas Morton's Wet evapotranspiration rates were used to estimate evaporation from soil moisture stores.

The primary objective of the water balance model was to determine the net water balance and the required storage sizes for the water supply dams. The maximum storage requirements are presented in Table 4-12. The water dams were sized based on having no non-compliant discharges, considering reuse and licenced controlled discharges. The Dam 1 capacity was maximised to the extent of topographical constraints to provide reliable supply to the MIAs and CHPPs. The MIA process water dams were sized to have a maximum 10 days CHPP demand storage capacity to account for maintenance and down-time of the water management network.

Table 4-12 Maximum storage requirement

Storage	Design capacity (ML)
Dam 1	700
Dam 2	600
Dam 3	150
Dam 4	200
Environmental combined	150
MIA 1 Process Water Dams	30
MIA 2 Process Water Dam	30

The following conclusions were reported in the EIS:

- For MIA 1 and MIA 2 Process Dams, the inflows and water transfers were able to meet the CHPP demand; and
- For Dam 1, the storage capacity of 700 ML when combined with the other mine water storages, is able to supply the mine demand for the majority of historical climate simulations.

The modelling simulations discussed in EIS Chapter 9 – Surface Water demonstrate water deficit over the 18 years of mining operations is predicted to be minimal, with any deficit most likely to occur during peak production years. The mine water dam system is able to supply the whole mine demand over the 19-year mining simulation within the 99th percentile dry sequence coinciding with the peak demand years, as demonstrated at Figure 4-25. No possible deficits were observed. Thus, the predicted reliability of supply is greater than 99%.

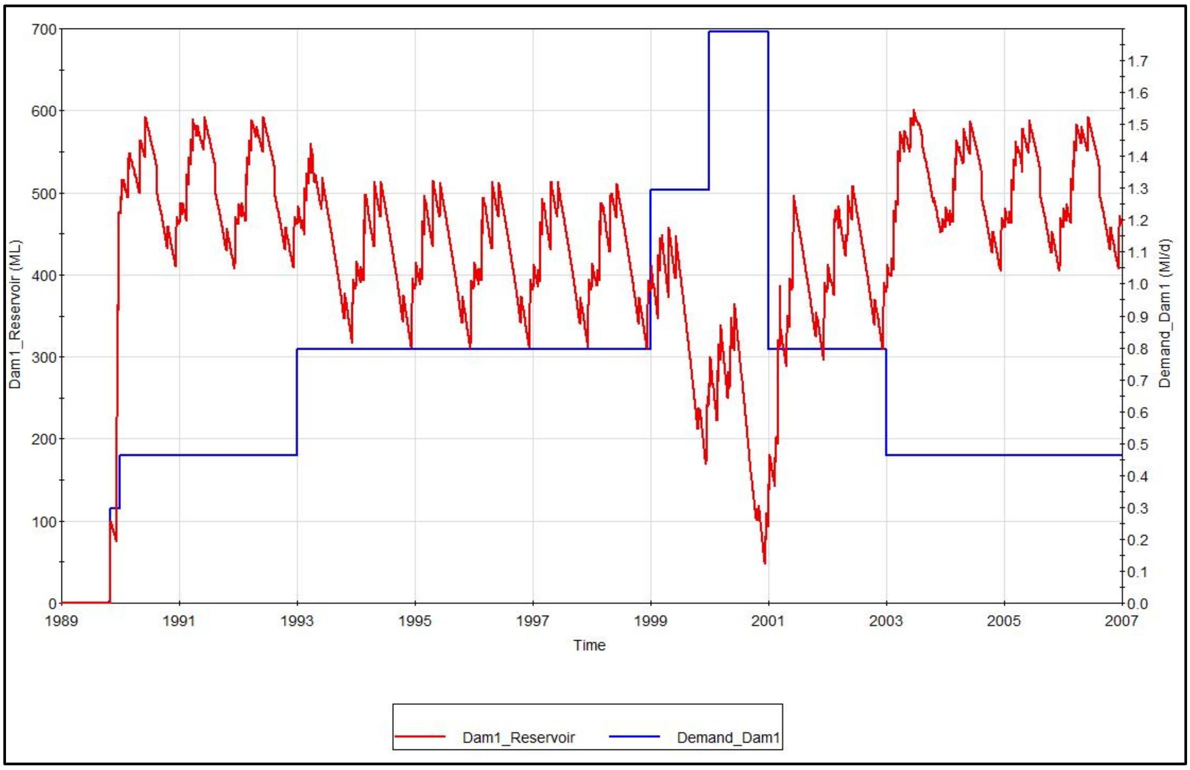


Figure 4-25 Dam 1 99th percentile storage with whole mine water demand

Based on the short duration of the Project (~20 years which includes final rehabilitation and closure activities), together with the results of the mine water balance simulation, there is low risk that the operation of the mine will be significantly affected by drought because of climate change. Notwithstanding, on commencement of mine construction, detailed water balance models will be constructed, continually updated with new data and validated to reflect the conditions encountered.

Periods of low rainfall are associated with central Queensland as well as the Livingstone Shire LGA where the Project is located. Drought may result in:

- Competition between water users in rural areas;
- Failure of rehabilitation and stabilisation from vegetation die back; and
- Increased dust generation.

The risk of drought adversely impacting the Project at some point throughout the life of the mine is considered to be low given the Project is modelled to be self-sufficient at 10 Mtpa ROM throughput.

The Project water management system will consider the risk of drought during detailed design. Water demand and usage will be minimised, and water recycled where possible. Onsite water management will also include a consideration of the volume, duration and intended use of water stored in supply dams with a view to future rainfall forecasts and during periods of drought. The water management system will include a contingency planning process to adapt the site's water supply and demand in the event of any water shortfall, noting; however, that the likelihood is low given the Project is modelled to be self-sufficient at 10 Mtpa ROM throughput.

4.8.5 Heatwaves

Infrastructure and machinery utilised onsite will be designed to withstand all temperatures well above and below those likely to be experienced in this locality, notwithstanding the Project only has an estimated 20-year operational life.

Materials which are less prone to heat related cracking / deterioration will be used where practicable and economically equivalent to other materials.

Increased temperatures may result in heat related health issues. Increase in temperature can increase the levels of stress, illness or injury for site personnel. Extreme heats can lead to dehydration and electrolyte depletion, with symptoms including diarrhoea, headache, nausea, vomiting, dizziness and others.

Higher temperatures can also increase the transmission of some diseases, e.g. mosquitoes and their potential to affect site personnel through mosquito borne diseases. Monitoring permanent and temporary sources of water for presence of species that carry infectious diseases. Site works will also be encouraged to take precautions against being bitten.

The MIA will also be designed with adequate shaded areas and available drinking water. Staff will be encouraged to hydrate regularly with adequate drinking water to be supplied.

Personal protective equipment (for example sunscreen and hats) will be available for staff.

4.9 Qualitative Risk Assessment

Potential impacts resulting from the current underlying climatic conditions as well as climate change projections within the Project area have been assessed utilising the risk assessment framework outlined in Chapter 1 - Introduction. Potential climatic related impacts and associated mitigation measures are presented in Table 4-13.

The impact assessment is based on the risk prior to mitigation and is defined as Low, Medium, High or Extreme based on the following:

- Extreme – works are not to proceed. Activity or process must be revised to reduce the risk;
- High – works must not proceed until suitable mitigation measures have been adopted to minimise the risk;
- Medium – acceptable with formal review. Documented action plan to manage risk is required; and
- Low – acceptable with review.

Table 4-13 Qualitative risk assessment

Issue and associated Project phase	Potential impacts	Potential risk	Mitigation measures	Residual risk
Current climatic conditions				
Drought (Construction, Operation and Decommissioning)	Periods of low rainfall are associated with central Queensland as well as the Livingstone Shire LGA where the Project is located. Drought may result in: ▪ The reduction or cessation of water supply; ▪ Competition between water users in rural areas; ▪ Failure of rehabilitation and stabilisation from vegetation die back; and ▪ Increased dust generation. The risk of drought adversely impacting the Project at some point throughout the life of the mine is high.	Medium	The Project water management system will consider the risk of drought during detailed design. Water demand and usage will be minimised, and water recycled where possible. Onsite water management will also include a consideration of the volume, duration and intended use of water stored in supply dams with a view to future rainfall forecasts and during periods of drought. The water management system will include a contingency planning process to adapt the site's water supply and demand in the event of any water shortfall.	Low
Excessive Rainfall (Construction, Operation and Decommissioning)	Excessive rainfall events above the 0.1% AEP may however cause: ▪ The flooding of open cut pits; ▪ Disruption to the production and haulage of coal; ▪ The uncontrolled release of potentially hazardous waters from dams; and ▪ The removal of excess flood waters contained on site, for example within open pits.	Medium	The MIA has been located above the 0.1% AEP flood level thus minimising potential impacts associated with flooding. Furthermore, mine site coal stockpile capacity has been designed to allow for operations to continue even if the haul road is closed by flooding. Likewise, open pit flood immunity has been increased to 0.1% AEP through the inclusion of flood protection levees. Should an extreme event occur, and excess water be stored on site, then consultation with EHP will be carried out to enable the lawful and temporary release of flood water.	Low
Humidity, Wind and Temperature Inversions (Construction, Operation and Decommissioning)	Humidity, wind and temperature inversions will directly affect the extent and magnitude of impacts on air quality, particularly in relation to dust deposition rates and airborne dust levels. Air quality modelling using underlying climatic conditions within the Project area has identified that potential impacts to sensitive receptors will be minimal.	Low	Eight sensitive receptors are in the Project vicinity. A range of dust suppression measures for stockpiles and roads have been developed to ensure airborne dust impacts are minimised. These measures and the potential impacts on air quality in the Project area are further discussed in Chapter 12 – Air Quality.	Low

Issue and associated Project phase	Potential impacts	Potential risk	Mitigation measures	Residual risk
Severe Storms (Construction, Operation and Decommissioning)	Severe storms may: ▪ Damage infrastructure; ▪ Create erosion and sediment runoff control failures; and ▪ Impact operations if damage to transport or services infrastructure. The total average number of lightning strikes and days where thunder occurred in the region suggests that there are 15 to 20 storms per year ranging in intensity, there is medium risk of impacts from more severe storms (which severity may increase with climate change) on the Project area. The potential for excessive wind and cyclonic events to occur is also relatively low and poses a low risk to the Project.	Medium	The Project infrastructure will be built to meet local industry codes which consider severe storms and cyclones, resulting in a relatively medium risk of impact to the Project. Design features associated with Project infrastructure and their resilience to severe weather conditions are further discussed in Chapter 3 – Description of the Project and Chapter 9 - Surface Water.	Low
Fire (Construction, Operation and Decommissioning)	Fire has the potential to damage infrastructure and may result in injury or fatalities. It is not anticipated that the Project will be at increased risk of fire as much of the Project area, particularly the MIA area contains only sparse vegetation.	Medium	Fire protection and response systems will be available onsite. Along with a well-trained Mines Rescue Team, all staff will be adequately trained in the correct usage of relevant equipment as outlined in Chapter 21 – Hazard and Risk.	Low
Climate change				
Reduced Rainfall (Construction, Operation and Decommissioning)	Reduced rainfall will increase water demand for construction and operational phases placing pressure on proposed water sources. It is not anticipated that the projected decrease in rainfall will have significant impacts on the Project. Rainfall projections suggest a 2 to 10% average (50 percentile) decrease of rainfall in the Project area. The water management system developed for the Project has also been designed to reuse and recycle water from onsite sources.	Medium	Central Queensland Coal will reuse and recycle water through all stages of mine operations. MIA surface water will be stored in environmental dams and used for dust suppression on coal stockpiles / conveyors and for mine operations. Reusing water captured onsite will reduce the Project's water demand. Mine infrastructure and equipment will be subject to detailed analysis during the design and procurement phase. Where possible, infrastructure and equipment will be designed to promote efficient use of water.	Low
Intense Storm and Severe Weather Events	Intense storms and severe events may cause damage to infrastructure and pose a risk to staff. Frequency or intensity of severe weather events is not anticipated to change significantly because of climate change. Based on historical data the risk	Low	All infrastructure onsite will be constructed to Australian and local building standards and policies. Measures will be adopted to improve design to strengthen structures.	Low

Issue and associated Project phase	Potential impacts	Potential risk	Mitigation measures	Residual risk
(Construction, Operation and Decommissioning)	posed from storm impacts within the MIA area are considered low. Minimal to no impacts are anticipated because of climate change.			
Flooding Events (Construction, Operation and Decommissioning)	Flooding events may hinder the construction, operation and decommissioning phases of the Project. It is not anticipated that the Project will be adversely impacted by intense storm and flooding events, as described in Chapter 9 – Surface Water. Impacts to productivity can occur when large volumes of water enter the open pits, resulting in inaccessibility and heavy mobile equipment can't be utilised. Climate change prediction for the region suggest that the frequency and severity of such events will not alter significantly from current patterns.	Medium	It is not anticipated that the Project will be adversely impacted by intense storm and flooding events resulting from climate change (Chapter 9 – Surface Water). Modelling of 1% and 0.1% AEP flood events identified that the two MIAs and CHPPs will be outside of the area of flood risk, as such, is not anticipated to be impacted from flooding. Mitigation and management measures such as drainage, levees and erosion control devices will also be utilised throughout the site. These measures and the positioning of mine infrastructure are considered sufficient to manage impacts from flooding. All dams will be designed and operated to be able to store a wet season volume of rainfall and allow for controlled releases of excess water. Dams will also be designed to enable uncontrolled releases via a spillway should extreme flooding occur.	Low
Increased Temperature Damaging Infrastructure (Construction, Operation and Decommissioning)	An increase in temperature may impact the structural integrity of the mine infrastructure. Increases in temperature can impact on mine operations. Worst case predictions for the Central Queensland region predict a maximum 2.9°C in overall temperature by 2070 (see CSIRO, 2015).	Low	Infrastructure and machinery planned to be utilised onsite is designed to withstand any current predicted increase in temperatures, notwithstanding the Project only has an estimated 20-year operational life. Infrastructure assets will be monitored due to climate change as part of ongoing condition audits. An asset management system will be used to identify assets due for repair, replacement or removal. Materials which are less prone to heat related cracking/deterioration will be used where practicable and economically equivalent to other materials. Infrastructure and machinery planned to be utilised onsite is already designed to withstand such increases.	Low

Issue and associated Project phase	Potential impacts	Potential risk	Mitigation measures	Residual risk
Increased Temperature Impacting Staff (Construction, Operation and Decommissioning)	Increased temperatures may result in heat related health issues. Increase in temperature can increase the levels of stress, illness or injury for site personnel. Extreme heats can lead to dehydration and electrolyte depletion, with symptoms including diarrhoea, headache, nausea, vomiting, dizziness and others. Higher temperatures can result in increased costs for maintaining a working environment that is well suited to workers and machinery. Higher temperatures can also increase the transmission of some diseases, e.g. mosquitoes and their potential to affect site personnel through mosquito borne diseases.	Medium	Facilities will be purpose built for the prevailing climatic conditions (for example maintenance workshop). The MIA will also be designed with adequate shaded areas and drinking water will be available throughout the MIA. Staff will be encouraged to hydrate regularly with adequate drinking water to be supplied. Personal protective equipment (for example sunscreen and hats) will be available for staff. Monitoring permanent and temporary sources of water for presence of species that carry infectious diseases. Site works will also be encouraged to take precautions against being bitten.	Low
Fire (Construction, Operation and Decommissioning)	Fire has the potential to damage and destroy infrastructure. It is not anticipated the Project will be at increased risk of fire from increased temperatures and reduced rainfall, as much of the Project area is free of vegetation and not in a high fire risk area.	Medium	Fire will be managed through fire protection and response systems which will be available onsite. Along with a well-trained Mines Rescue Team, all staff will be adequately trained in the correct usage of such fire safety equipment. Further, an ERP will be in place for the Project area which will include measures to manage fire.	Low

4.10 Conclusion

The climate assessment of the region identified that the Project area experiences a tropical climate which is characterised by high variability rainfall, evaporation and temperature. The Project region experiences warmer summer months and cooler winter months with the majority of rainfall occurring in the warmer months between December and March. This is typical of the tropical Queensland climate. Relative humidity in the region is generally higher in the mornings and in summer. The primary wind direction is from the southeast and east and is greater in the summer months and in the mornings.

Natural or induced climate related hazards such as severe storms, cyclones, floods, bushfires and droughts are likely to occur and pose risks which require management. Landslides and earthquakes are not considered likely to pose any risks to the Project. Climate change predictions show a certain anticipated increase of severe climate events, particularly drought, floods and storms.

The Project has proactively considered climate change adaptation measures in the design and operation to ensure the mine can minimise high risk impacts from these events which have potential to cause significant damage and impacts on the Project. The residual risk, the risk after mitigation measures have been implemented, for all climate related impacts is low to medium. Medium risk scores relate to the damage or destruction of mine infrastructure and the pump out of mine pit waters which may result in the release of potentially hazardous wastes to the environment; however, releases during high flows will dilute impacts.

Central Queensland Coal is committed to undertaking a cooperative approach with government and other industry and sectors to address adaptation to climate change.

4.11 Commitments

Central Queensland Coal's commitments, in relation to the Project's climate risks, are provided in Table 4-14.

Table 4-14 Commitments - climate

Commitments
Develop an ERP, in accordance with relevant legislation requirements, including training for emergency response personnel, prior to construction.
Develop and implement a Land Use Management Plan which will establish a vegetation monitoring program, identify pest and weed management controls, fire management measures and principles for managing fauna.
Design and implement a Project Erosion and Sediment Control Plan to be certified by a suitably qualified person, prior to construction.
Implement a Safety and Health Management System that integrates risk management elements and practices to safety of workers, contractors and the community.
Undertake and maintain, where practicable, a cooperative approach with government and other industry sectors to address the Project's adaptation to climate change.
Develop a Project risk register and appropriate controls to manage any onsite natural hazards and reassess the existing risks and identify any additional mitigation measures.
Communicate potential risks and associated mitigation measures during site induction.
Incorporate appropriate standards into infrastructure design and construction.
Design a water management system to allow for variations in rainfall and evaporation.
Develop a flood model for the site using "as built" design information. The flood model is to be updated as new design data becomes available.

4.12 ToR Cross-reference Table

Table 4-15 ToR Cross-Reference table

Terms of Reference	Section of the EIS
8.1 Climate	
Describe the project area's climate patterns that are relevant to the environmental assessment, with regard to discharges to water and air, and the propagation of noise.	Sections 4.5, 4.6 and 4.7
Climate data should be provided in a statistical form including long-term averages and extreme values. It should also be graphically represented by bar charts, wind rose diagrams, or other means.	Section 4.5
Assess the vulnerability of the area to natural and induced hazards, including floods, bushfires and cyclones.	Section 4.6
Consider the relative frequency and magnitude of these events together with the risk they pose to the construction, operation and rehabilitation of the project.	Sections 4.5, 4.6 and 4.7
Measures that would be taken to minimise the risks of these events should be described.	Section 4.8
Assess the project's vulnerabilities to climate change (e.g. changing patterns of rainfall, hydrology, temperature and extreme weather events).	Section 4.7.1
Describe possible adaptation strategies (preferred and alternative) based on climate change projections for the region.	Section 4.7.2