

Chapter 5

Climate

Oct-2021

Genex Kidston Connection Project - Ministerial Infrastructure Designation Assessment Report

5.0 Climate

5.1 Regional Climatic Conditions

North Queensland is characterised by tropical and sub-tropical climates with pronounced wet and dry seasons. The Preferred Alignment is located within an area defined by the Bureau of Meteorology (BoM) as persistently hot grassland area with a marked wet summer and dry winter (BoM, 2021). As a result of its location near to the Tropic of Capricorn, the area is also sometimes affected by the seasonal migration of monsoon conditions as they move across the equator.

BoM operates a network of monitoring stations around Australia that have long-term climatic data available for analysis. As the Preferred Alignment spans a significant distance laterally, local meteorological conditions are likely to differ across this distance, especially at areas further inland and/or away from notable terrain features. Multiple BoM stations in the North Queensland region have been selected for review in this chapter to provide a greater regional coverage of conditions. Details of the stations selected are provided in Table 5-1.

The Townsville Aero and Ingham Composite BoM stations have been selected to assist in describing the Project area meteorology as they are the closest available to the eastern end of the Preferred Alignment. However, it should be noted that both these stations are situated in close proximity to the coast and therefore may experience greater influence from the sea-land interface and trade winds than the more inland sections of the Project area. The Charters Towers Airport, Georgetown Airport, and Georgetown Post Office BoM stations provide meteorological data from inland locations at elevation greater than sea-level, although are located some distance from the Project. It should be noted that although the Georgetown Post Office station is technically still operational, data from this station is only available until 2009, and therefore long term averages will not capture the climate extremes seen in this area in the last decade. Georgetown Airport has been included to supplement the missing data in this area.

In reality due to size, the Project area is likely to experience meteorological conditions that are representative of a combination of stations.

Table 5-1 BoM stations relevant to the Project (BoM, 2021)

Station Name	Station No.	Latitude, Longitude	Distance from Project*	Location Direction	Period Operational	Elevation (m)
Townsville Aero	032040	-19.2483, 146.7661	109 km	SE	1940 - Present	4
Ingham Composite	032078	-18.6494, 146.1769	43 km	ENE	1968 - Present	12
Charters Towers Airport	034084	-20.0464, 146.2708	140 km	SSE	1942 - Present	290
Georgetown Post Office	030018	-18.2922, 143.5483	89 km	NW	1872 - Present	292
Georgetown Airport	030124	-18.3039, 143.5309	90 km	NW	2004 - Present	304
Table Note: * at closest point from Preferred Alignment.						

5.1.1 Temperature

Mean minimum and mean maximum temperatures have been collected from the five selected BoM stations, and are displayed in Table 5-2. Significant variation between mean temperatures is seen at each station for winter (June, July, August) and summer (December, January, February) seasons.

Of the four locations, mean minimum temperatures are lowest at Charters Towers, with 11.6°C recorded in winter and 22.0°C in summer. Mean minimum temperatures at Georgetown Post Office and Georgetown Airport are 12.0 °C and 13.3 °C in winter and 23.8 °C and 22.9 °C in summer, respectively. Mean minimum temperatures Ingham Composite are recorded as 14.9 °C in winter and 23.2 °C in summer, whereas Townsville Aero experiences mean minimums of 24.3 °C in winter and 14.7 °C in summer.

Mean maximum temperatures are highest at Georgetown airport with mean maximum temperature values winter temperatures recorded at 30.3 °C during winter, 36.5°C in summer. Georgetown Post Office experiences mean maximums at 30.0 °C in winter and 36.3 °C in summer. The mean maximums are higher in Ingham (32.6°C in summer and 26.3°C in winter) than in Townsville (31.6°C in summer and 26.1 °C in winter). Charters Towers experiences mean maximums in the summer months of 34.7 °C and 36.9 °C in the winter months.

Mean maximum temperatures reached a peak of 30.0°C during winter and 36.6°C and during summer at Georgetown Post Office. It should be noted that maximum temperatures are generally experienced in November at Georgetown (37.0 °C at Georgetown Airport and 36.6 °C at Georgetown Post Office), which is typical of climate in the area. At the Townsville Aero and Ingham Composite stations the mean maximum temperatures for winter are 26.1°C and 26.3°C respectively, and the mean minimum temperatures for winter are 14.7°C and 14.9°C.

The two coastal stations (Townsville Aero and Ingham Composite) on average experience lower annual maximums and higher annual minimums, indicating less overall variation in temperature than the inland locations (Georgetown Post Office and Charters Towers Airport).

Overall, temperatures across the Project area are consistent with a warm and variable North Queensland climate. Temperature maximums and minimums vary considerably more at the stations located inland, but when assessing the five stations overall, temperatures generally only differ by two to three degrees Celsius.

Table 5-2 Mean maximum (top, red) and minimum (bottom, blue) temperatures per month at BoM stations (BoM, 2021)

Mean Maximum and Minimum Temperature (°C)													
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Townsville Aero (1940-2021)	31.4	31.2	30.8	29.7	27.7	25.7	25.2	26.1	27.8	29.5	30.8	31.6	29.0
	24.3	24.1	23.0	20.7	17.7	14.7	13.8	14.7	17.4	20.7	22.9	24.1	19.8
Ingham Composite (1968-2021)	32.4	31.8	30.9	29.1	27.1	25.3	25.0	26.3	28.5	30.4	31.8	32.6	29.3
	23.1	23.2	22.3	20.4	17.8	14.9	13.9	14.3	16.0	18.5	20.7	22.1	18.9
Charters Towers Airport (1992-2021)	33.8	33.0	32.0	30.3	27.4	25.0	25.1	26.9	30.4	32.9	34.2	34.7	30.5
	22.4	22.3	21.0	18.3	15.2	12.8	11.6	12.4	15.3	18.2	20.5	22.0	17.7
Georgetown Post Office ^a	34.4	33.5	33.4	32.5	30.4	28.2	28.2	30.0	33.0	35.8	36.6	36.1	32.7
	22.9	22.7	21.5	19.4	16.1	13.1	12.0	13.1	16.2	19.7	21.7	22.8	18.4
Georgetown Airport (2004-2021)	34.0	33.5	33.4	32.8	30.3	28.6	28.8	30.3	33.6	36.0	37.0	36.5	32.9
	23.4	22.8	22.0	19.4	16.6	14.0	13.3	13.6	16.9	20.4	22.8	23.8	19.1
Table notes: ^a : Mean maximum temperatures have been calculated based on data from period of 1901-2007, whereas mean minimum temperatures have been calculated based on data recorded during period 1894-2007 ^b													

5.1.2 Rainfall

The mean rainfall values measured at the five nominated BoM stations are detailed in Table 5-3. Table 5-3 highlights the distinct wet (summer) and dry (winter) seasons experienced by the region. Also demonstrated is the large variation in rainfall amounts received across the wider area.

Table 5-3 shows that on an annual basis Ingham receives the highest mean rainfall (2144.6 mm), followed by Townsville (1136.0mm), Georgetown Airport (819.8 mm) and Georgetown Post Office (819.8 mm) and then Charters Towers (641.7 mm). This indicates that rainfall is on average significantly higher in coastal locations.

In Townsville, Charters Towers and Georgetown, over half of average annual rainfall occurs during the three months of summer. Summer is also the distinct wet season for Ingham, with almost 50% of the average annual rainfall occurring. Of the five stations Georgetown has the least rainfall over the months of winter, with a mean total of 21.4 mm recorded at Georgetown Post Office, and 17.8mm recorded at Georgetown Airport (approximately 3% of total annual average rainfall). The months of winter are also driest for the other station locations, with rainfall over winter accounting for approximately 5% of annual average rainfall in Townsville (50.7 mm), 6% in Ingham (119.9 mm), and 9% in Charters Towers (54.9 mm).

Table 5-3 Mean rainfall per month at the four BoM stations (BoM, 2021)

Station	Mean Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Townsville Aero (1940-2021)	269.2	303.7	193.3	64.3	33.1	20.5	14.6	15.6	10.1	23.9	56.4	125.3	1,136.0
Ingham Composite (1968-2021)	388.9	480.5	396.7	207.3	107.8	45.1	39.4	35.4	37.7	53.2	113.5	211.1	2,144.6
Charters Towers Airport (1992-2021)	154.3	143.0	76.2	27.2	23.4	19.9	20.4	14.6	9.0	17.9	59.3	78.7	641.7
Georgetown Post Office (1872-2009)	224.9	212.9	123.1	28.8	9.3	10.4	6.7	4.3	6.4	16.7	50.7	127.8	819.8
Georgetown Airport (2011-2021)	245.1	192.4	137.5	21.8	14.5	7.3	8.8	1.7	3.7	12.6	56.7	126.2	821.0

5.1.3 Wind speed and direction

Long term hourly wind data was not available for all stations, therefore a representative inland station (Georgetown Airport) and coastal station (Townsville Aero) was chosen for review. Figure 5-1 and Figure 5-2 show annual wind roses for recent years Townsville Aero and Georgetown Airport, and Figure 5-3 and Figure 5-4 show seasonal wind roses for each station respectively.

Figure 5-1 shows winds at the Townsville Aero location are most predominant from the east, owing to the influence of coastal breezes. Winds are most frequent and strongest from the east-north-east direction with over 15% of observations from this direction. Strongest wind speeds are recorded up to 20 m/s. Mean annual windspeed is recorded as 4.3 m/s and calms (windspeeds less than 0.5 m/s) are recorded 6.6 % of the time.

Figure 5-2 shows wind directions in Georgetown are also most predominant from the east. The most dominant wind direction recorded is east-south-east, and maximum windspeeds reach up to 10 m/s. The mean annual windspeeds at Georgetown (3.0 m/s) are lower than at Townsville Aero and there are less calm conditions recorded (5.8% of the time).

Figure 5-3 shows significant seasonal variation at Townsville Aero, with strong directional variability recorded in autumn and winter, and strong coastal influence (north-easterly breezes) seen in the spring and summer months. Winter has the lowest mean wind speed (3.7 m/s) and the highest recorded percentage of calms (11.7%) when compared to spring (mean wind speed of 4.8 m/s and 4.4% calms) and summer (mean wind speed of 4.7 m/s and 2.7% calms).

Figure 5-4 shows there is less seasonal directional variability at Georgetown. Wind speeds are weakest during summer with a mean annual wind speed of 2.9 m/s and calm periods 6.8 % of the time. This is in contrast to Townsville Aero which experiences some of the strongest winds in summer months. Strongest winds at Georgetown were experienced in spring with a mean annual wind speed of 3.3 m/s and 4.4 % calms. Strong directionality from the east-south-east direction is seen for autumn and winter with over 25% of observations from this direction.

Townsville experiences significant coastal influence due to its proximity to the coastline, however it should be noted that the eastern-most point of the Preferred Alignment is approximately 100 km inland of the Townsville Aero monitoring station, therefore conditions experienced within the Project area are likely to be less variable and more sheltered. Contrastingly, Georgetown experiences relatively stable inland conditions, however it should be noted that Georgetown Airport is approximately 90km further inland of the western-most point of the Preferred Alignment. In reality, conditions experienced within the Project area are likely to vary across regions and wind conditions are likely to become stronger toward the coastline.

Wind speed and direction are expected to be greatly influenced on the local scale due to the mostly flat terrain in the Project area. Synoptic scale winds modified by occasional afternoon sea breezes, and valley drainage flows originating from the nearby mountain ranges at night, will affect wind speed and direction at the large scale. Topography of the Project area is discussed in detail in Chapter 4 Land, and summarised briefly below in Section 5.1.4.

5.1.4 Terrain

Terrain features and land use can influence meteorological conditions on both a local and regional scale. As discussed in Chapter 4 Land, the terrain along the Preferred Alignment drops from an elevation of around 650 m AHD at Mount Fox to an elevation of around 420 m AHD across the Valley of Lagoons. A number of elevated peaks occur along the Preferred Alignment, with terrain generally falling to the south and to the south-east towards the Burdekin River drainage system. However, across the majority of the alignment the terrain is predominately flat, as is typical of western Queensland.

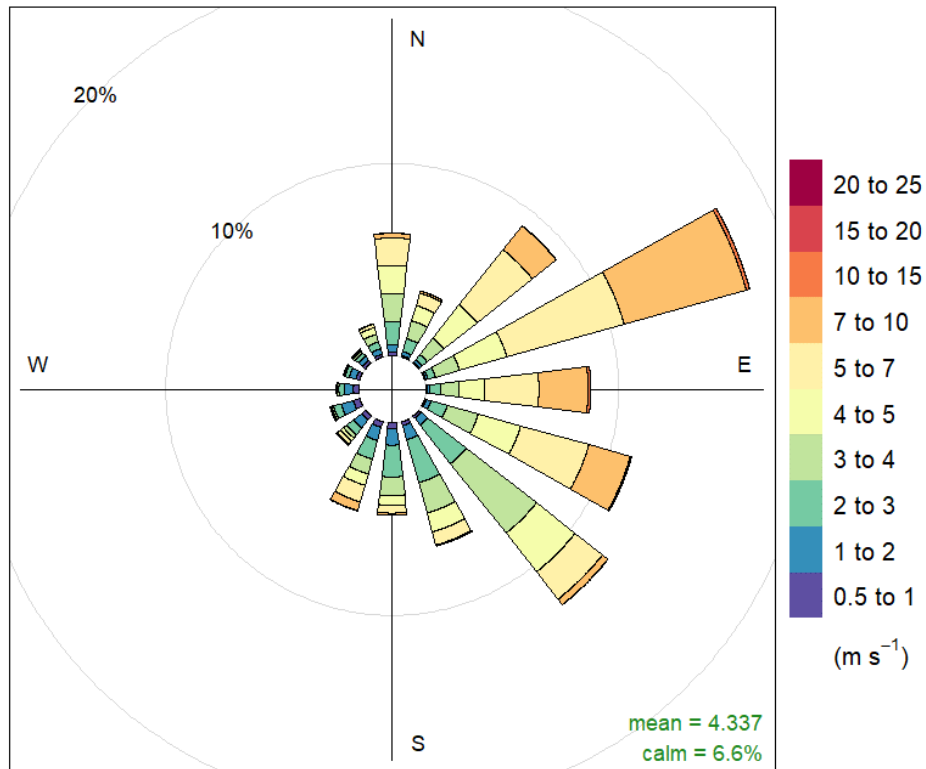


Figure 5-1 BoM annual wind roses for Townsville Aero (32040) for all hours (2001-2020)

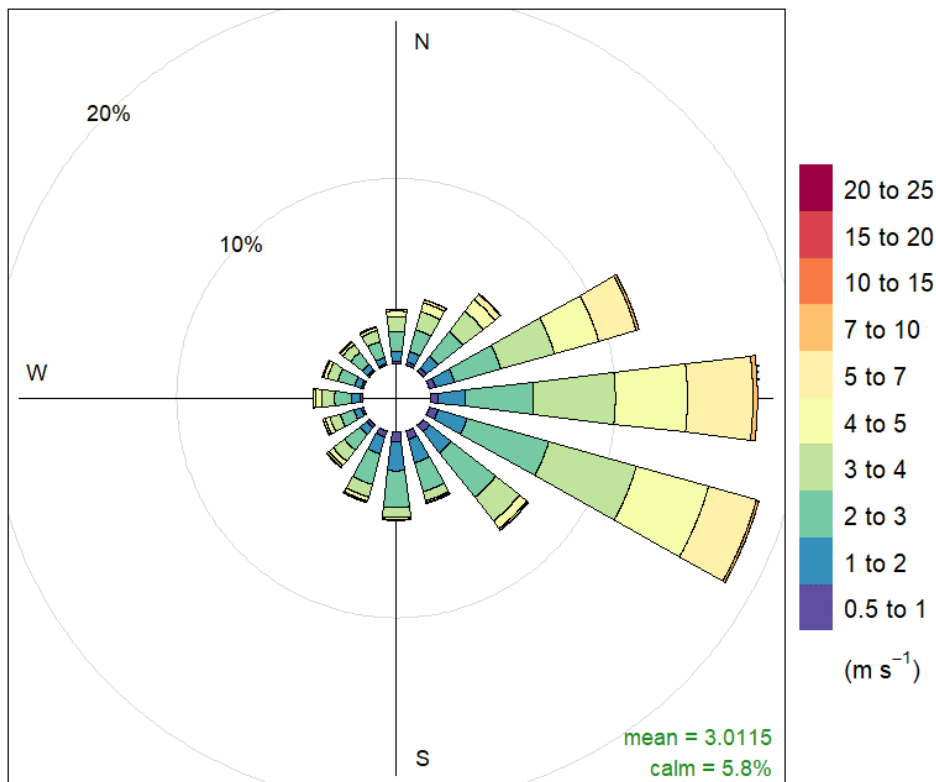


Figure 5-2 BoM annual wind roses for Georgetown Airport (30124) for all hours (2011-2020)

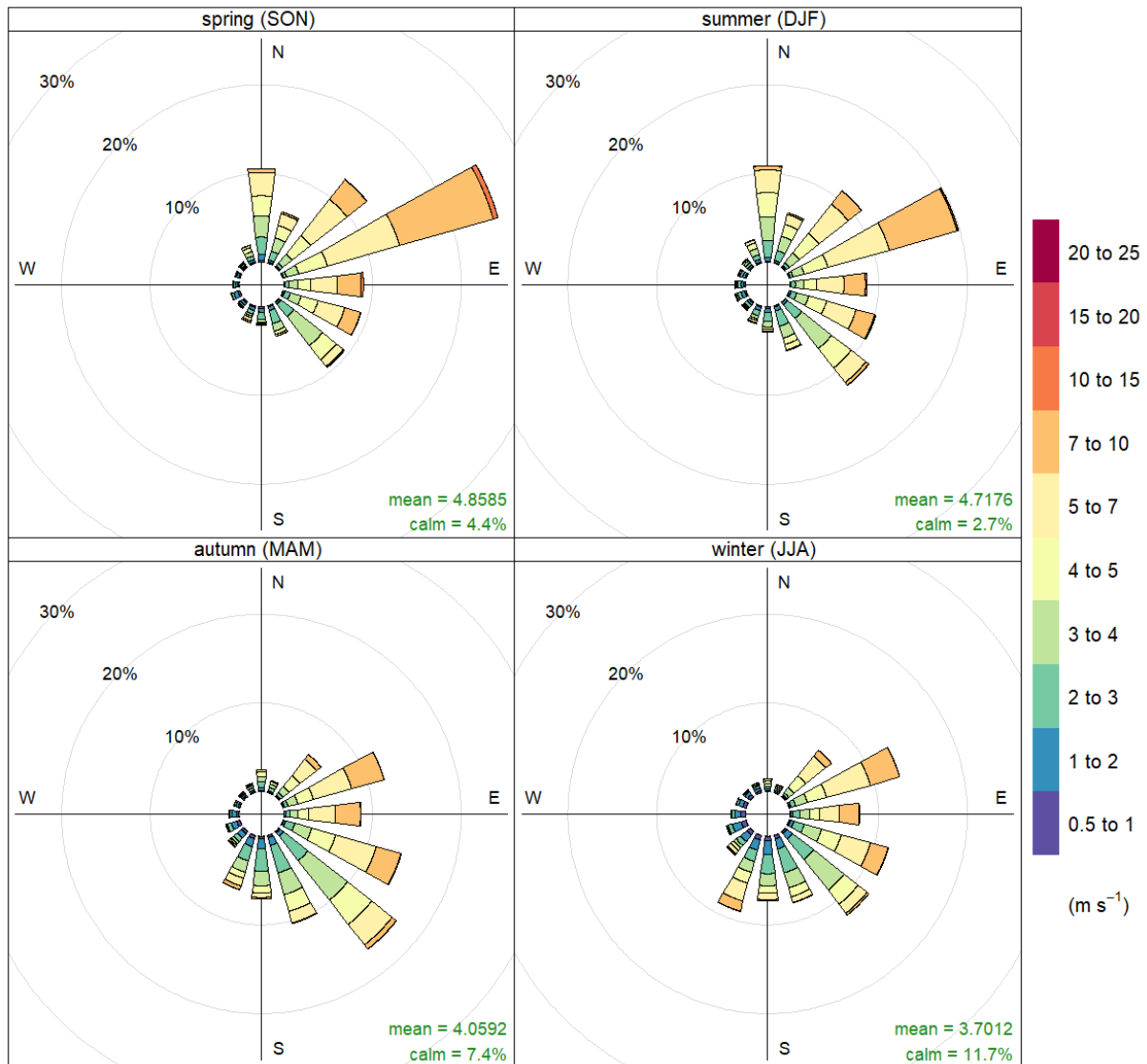


Figure 5-3 BoM seasonal wind roses for Townsville Aero (32040) for all hours (2001-2020)

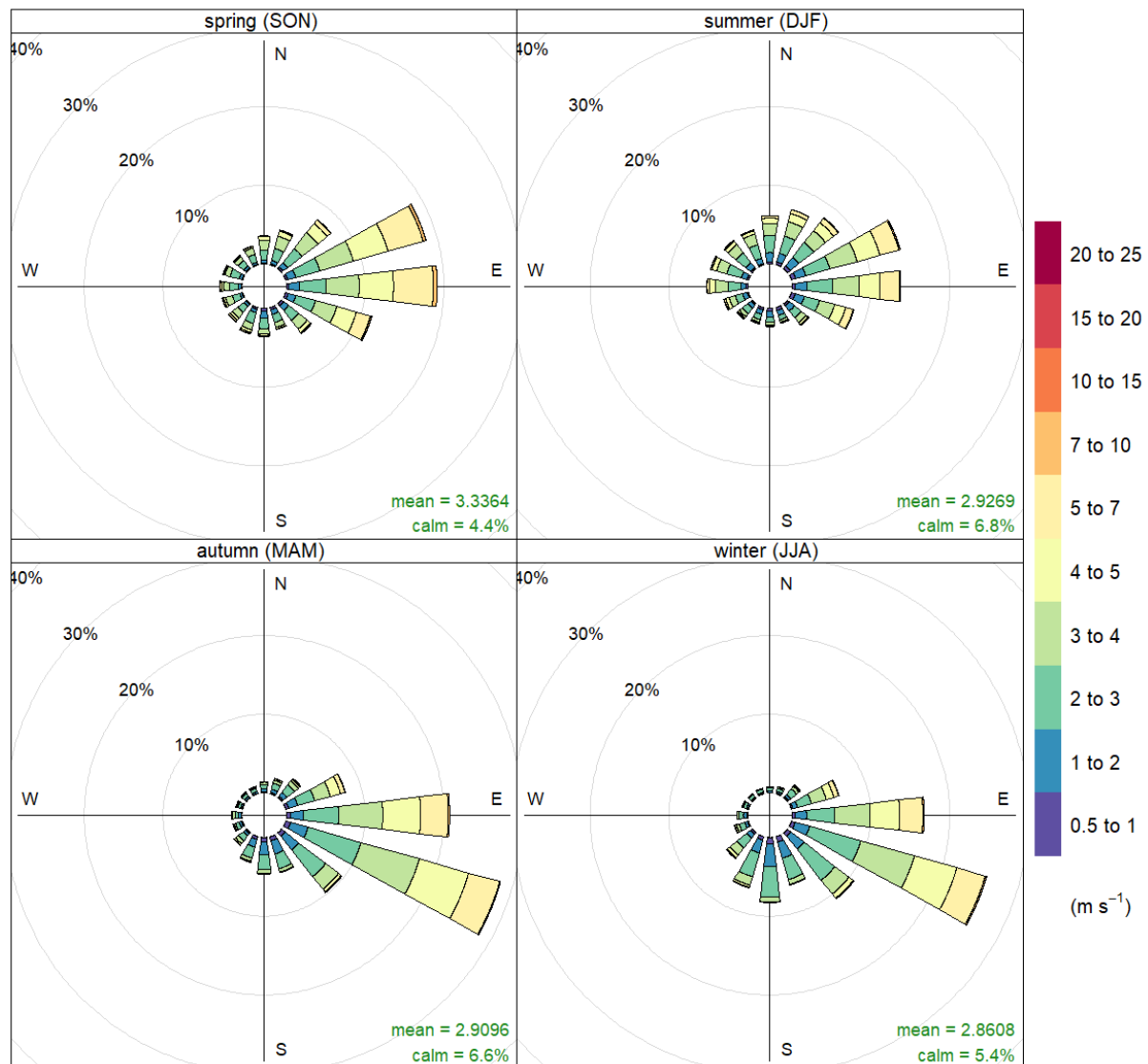


Figure 5-4 BoM seasonal wind roses for Georgetown Airport (30124) for all hours (2011-2020)

5.2 Extreme Climatic Conditions

Extreme weather or atypical meteorological conditions have the potential to adversely affect the Project during any phase of its lifecycle. Their occurrence may result in temporary or permanent interruption of construction, or operation, or damage to structures or the environment. The history of extreme weather for the Project area is an important consideration, and will allow for any risks to be identified and assessed. The Department of State Development, Manufacturing, Infrastructure and Planning (DSDMIP) provides mapping of local government natural hazard areas, and these have been reviewed for the Project.

5.2.1 Droughts

Droughts are an increasingly common occurrence in Australia, and affect grazing and agricultural land most significantly. Prolonged periods of water shortage (not unusual for the region) can have negative effects on vegetation growth, erosion and overall land quality. Information about climate risk, including droughts, for rural Queensland is provided by the Queensland Government's 'The Long Paddock' initiative (DES, 2021).

Historical data shows that Queensland experiences some of the highest rainfall variability in the world (DES, 2018), and as a result droughts have at some stage affected most of the state. A review of recent Queensland Drought Situation maps generated by DES indicates that, as of August 2021, the Project area (local government areas (LGA) of Etheridge, Charters Towers and Hinchinbrook) is not

drought declared. The Charters Towers LGA was fully drought declared as recently as April 2018. However, recent above average rainfall events over the last 2 wet seasons have resulted in lifting of the drought declaration for some areas of the LGA. Unfortunately as of April 2021, drought declaration status remains active for partial sections of the LGA. (DES, 2021). Figure 5.5 shows Queensland Rainfall Deciles from 2017 to 2020 (BoM, 2021), which indicate that sections along the Preferred Alignment have received rainfall in the “above average” rainfall decile ranges.

Despite the above average rainfall received along the Preferred Alignment, “lowest on record” rainfall was recorded in the south-east corner of the state and “very much below average” rainfall was recorded in the north-west. Therefore, it is likely that during the Project’s life-cycle drought conditions will be experienced, possibly more than once, and the risks associated should therefore be considered. Both Etheridge Shire Council and Charters Towers Regional Council have established drought management plans that address this ongoing issue.

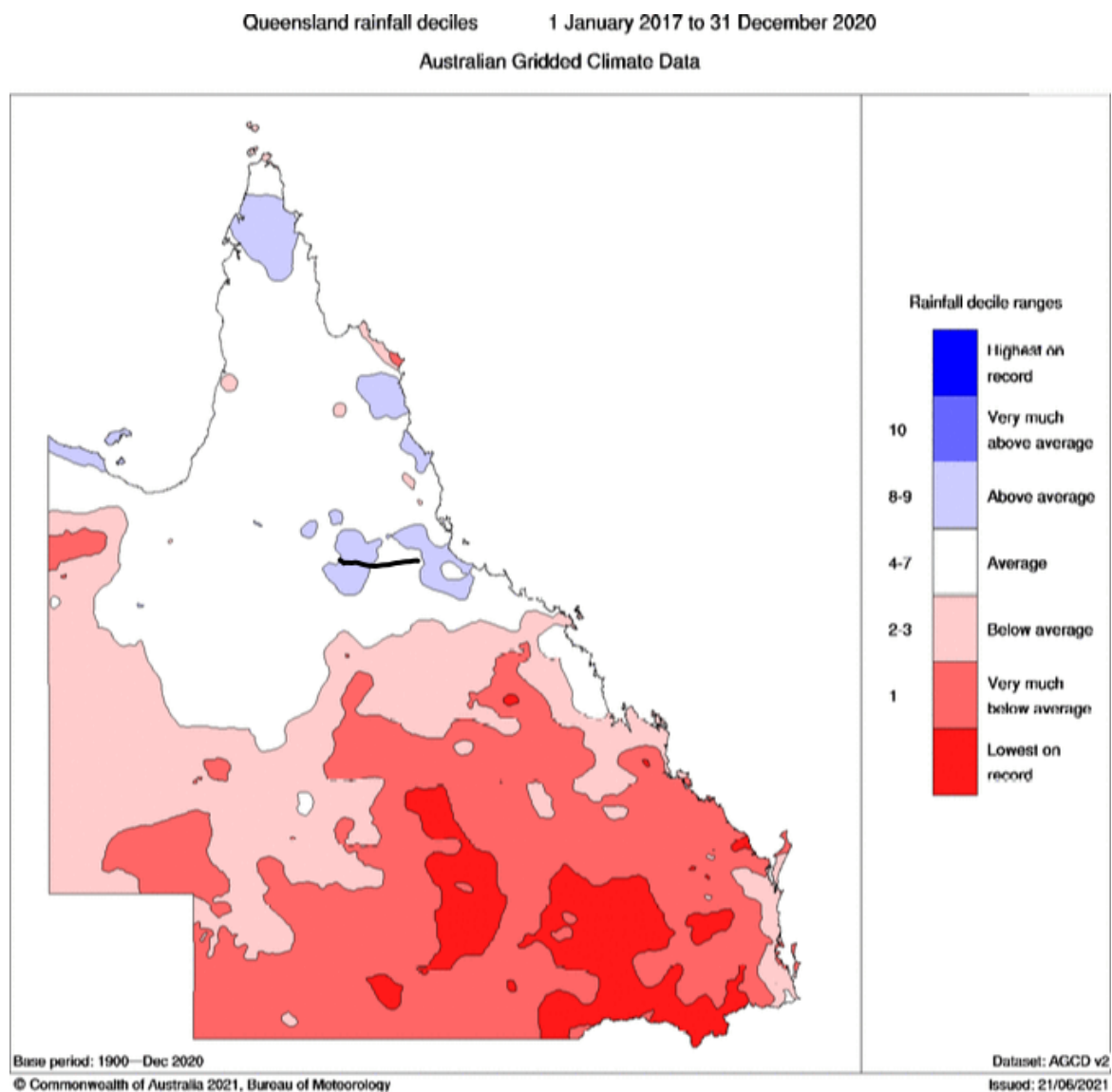


Figure 5-5 BoM Queensland Rainfall Deciles map – January 2017 to December 2020

5.2.2 Cyclones

Rotating low-pressure systems that form over warm tropical waters are known as tropical cyclones. Tropical cyclones produce destructive gale force winds (sustained winds of 63 km/h or more) which are generally strongest near the centre, but can extend for hundreds of kilometres. In severe systems peak wind gusts can exceed 360 km/h. The damage associated with gale force winds often includes extensive damage to infrastructure and agriculture, power failure and sometimes loss of life. Storm surges are also created by gale force winds, and can result in flooding of coastal areas.

Tropical cyclones generally begin to weaken after reaching land due to changes in temperature, moisture and friction. Large rainfall events are then produced as the system decays. According to BoM (2018), often the most significant impact from a tropical cyclone is flooding.

In Queensland, tropical cyclones mostly form from lows within the monsoon trough and affect the northern areas of the state (BoM, 2018). These systems are generally formed between the months November to April, and affect coastal areas most. Between the years 1970 and 2021, there have been 98 tropical cyclones which have tracked with 500 km of the Townsville Aero BoM monitoring station (BoM, 2021).

Of these, seven cyclones would have potentially hit the Project area directly. The climatic conditions of the area and historical frequency of tropical cyclones indicates that one or more is likely to occur in the Project area at some point within the life of the Project operation (estimated 50 year life). Direct effects (i.e. gale force winds), and indirect effects such as high rainfall and flooding should be considered in the design of the infrastructure and maintenance of access pathways.

5.2.3 Thunderstorms

Thunderstorms are a common weather event characterised by thunder, lightning, strong wind and often rain. Severe storms can also create hail. The combination of these effects can result in significant damages to infrastructure and restrict access to the Project. Thunderstorms are produced by a rapid upward movement of warm air. While they can develop anywhere, most frequently they occur at the border of tropical areas where warm air meets cool air. Figure 5-6 and Figure 5-7 show maps of the mean number of thunder days and total lightning strikes in strikes/km²/year (BoM, 2021).

In the Project area, the average number of thunder days varies spatially across the Project alignment, ranging between 20 and increasing towards the west to 30 to 40 days. Lightning flash density varies between 15 and 20 strikes/km²/year from east to west across the Preferred Alignment. Thunderstorms may be a more common occurrence in the western section of the Project area due to the presence of mountain ranges, which can forcibly move air upwards.

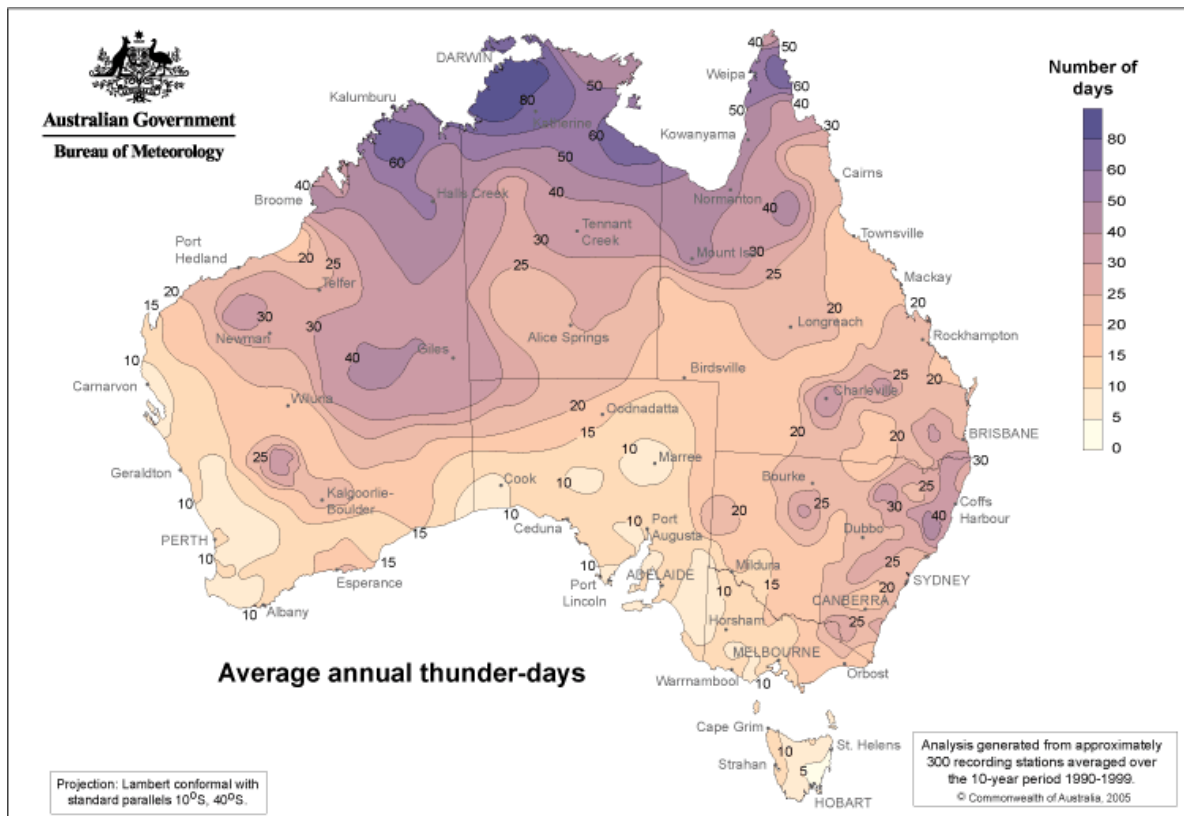


Figure 5-6 Average annual thunder-days (BoM, 2005)

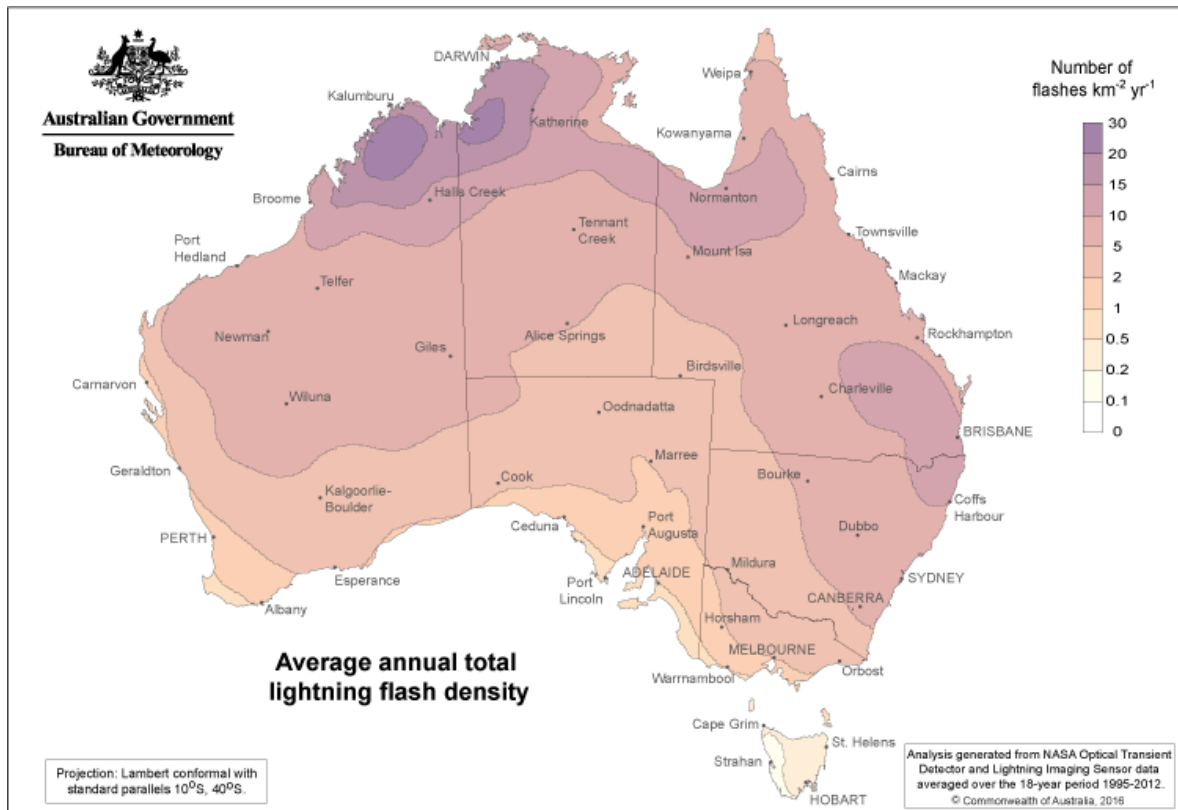


Figure 5-7 Annual average total lightning flash density (strikes/km²/day) (BoM, 2016)

5.2.4 Flooding

Rainfall across Queensland varies considerably both spatially and temporally. However, high rainfall is known to occur in North Queensland as a result of monsoonal troughs and can lead to flooding. Impacts from flooding events can include damage to infrastructure foundations, increased erosion, and general land degradation. Elevated water levels can result in major road closures and restrict access especially in rural areas.

As discussed in Section 5.2.1, the Department of State Development, Manufacturing, Infrastructure and Planning (DSDMIP) provide mapping of local government natural hazard areas. A Natural Hazards 2021 DSDMIP map including Queensland Floodplain Assessment Overlay (QFAO) data indicates that sections of the Project area, specifically those that cross the Burdekin and Einasleigh Rivers and connecting waterways, are prone to flooding. Almost a third of Queensland was declared a natural disaster by the State Government after the flooding event of 2000.

Flooding is likely to occur in the Project area within the Project life-cycle, and the risks to the Project especially in low-lying land should be considered. A detailed study of the hydrology of the Project area, including a risk assessment of flooding is discussed in Chapter 7 Hydrology.

5.3 Climate Influence on Design and Construction

Historical meteorological data indicates that the Project area has a tropical climate and is likely to experience the effects of a range of extreme weather including drought, flooding, bushfire, and cyclones. Most of these events are expected to individually affect the area more than once throughout the Project life-cycle. The risks associated with bushfire are discussed in detail in Chapter 22 Bushfire Risk. The risks associated with flooding are discussed in detail in Chapter 7 Hydrology.

The electricity transmission infrastructure will be designed and constructed to reasonably withstand severe weather events, including potential cyclonic conditions near the North Queensland coast. Other impacts to be considered are those associated with flooding such as soil erosion and land degradation, which can lead to reduced or limited access to areas of the Project for construction and maintenance.

5.4 Climate Change

To investigate regional climatic trends in Australia, climate projections have historically been modelled by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and BoM. The CSIRO and BoM high emissions future scenario model (RCP 8.5) assumes that greenhouse gas emissions continue to be released at present day rates with CO₂ concentrations continuing to rise. Predicted climate change in North Queensland for the high emissions scenario for 2030, 2050 and 2070 are presented in Table 5-4. The high emissions scenario was selected to determine worst-case future conditions for the region. The potential impacts these climatic changes may have on the Project have been identified in Table 5-5.

Table 5-4 CSIRO and BoM climate change projections for 2030, 2050 and 2070.

Variable	Season	2030 – High Emissions	2050 – High Emissions	2070 – High Emissions
Mean Temperature (°C)	Annual	+1.0	+1.7	+2.6
	Summer	+0.9	+1.7	+2.4
	Autumn	+1.0	+1.6	+2.6
	Winter	+1.0	+1.8	+2.9
	Spring	+0.9	+1.6	+2.4
Rainfall (mm, %)	Annual	-8	-7	-9
	Summer	-6	-1	+2
	Autumn	-6	-2	-2

Variable	Season	2030 – High Emissions	2050 – High Emissions	2070 – High Emissions
Potential Evaporation (mm, %)	Winter	-9	-5	-11
	Spring	-9	-12	-18
	Annual	+3	+6	+9
	Summer	+3	+5	+8
	Autumn	+4	+8	+11
	Winter	+4	+7	+12
	Spring	+3	+6	+8

Table 5-5 Potential impacts of climate change and proposed mitigation measures

Potential Climate Change Impacts	Risk Scenario	Risk to Project	Mitigation Measures (if required)
Increase in annual average temperature	High temperatures lead to increased demand for electricity while also negatively affecting reliability and efficiency of infrastructure and/or equipment.	Low	Not applicable.
	Health impacts on work personnel from increased temperatures (i.e., heat stress).	Medium	Implementation of heat stress management procedures including as low as reasonably practicable controls for workers.
Change in seasonal average rainfall	Decrease in rainfall especially during winter and spring may lead to greater potential for erosion. Decrease in rainfall in conjunction with increased temperatures will also increase bushfire risk.	Low	Monitoring of erosion during routine service maintenance. Emergency response procedures for bushfire.
Increase in annual average potential evaporation	Increased dust emissions due to drier surface conditions, resulting in increased water demand for dust suppression during construction. Increased dry foliage and vegetation will increase amount of fuel available for bushfires.	Low	Dust control measures including watering of haul roads and stockpiles during construction. Regular routine service maintenance of vegetation for transmission line easements and switching station buffer.
Increased risk of tropical cyclone impact	Increased impacts from gale force winds and flooding.	Medium	Emergency response procedures for natural disasters.
	Increased risk of erosion especially from exposed areas due to increase in rainfall intensity.	Medium	Identify flood prone areas of Project area (Chapter 7). Adaptive management as soon as practical to minimise risk.

As the population in Queensland continues to increase, so too will energy requirements and the need for efficient energy distribution. In 2008 the Australian Academy of Technological Science and Engineering (ATSE) identified that the electricity production and distribution sector had a very high

degree of vulnerability to climate change due to power stations traditionally being located in coastal regions. However, due to the Project's inland location (most eastern point is 45km from the coast) it is expected to have mostly low vulnerability, with the greatest potential impact an increased risk of extreme weather events and potential for increased soil erosion and access restrictions.

Extreme weather events such as cyclones, thunderstorms and floods are likely to increase in frequency with the changing climate and can severely impact infrastructure. Power losses due to damaged or ageing infrastructure have a high likelihood of occurring, however efficiency in response and maintenance scheduling should allow for risks to be managed. The risk of bushfire is also considered likely to increase in the future but continued routine maintenance of easements and access tracks should suffice in line with current bushfire management techniques. An assessment including the potential impacts fire may have on the Project is discussed in Chapter 22 Bushfire Risk.

A study completed by PB Associates (2007) found that increased peak and average temperatures are likely to reduce transmission line capacity, transformer capacity and the longevity of switchgear and other components. Increased temperatures, ground water and subsequent ground movements may also accelerate the degradation of materials such as concrete, which in turn will reduce the life of infrastructure foundations (Department of Climate Change, 2009). However, as these risks are not isolated to the Project, there is the potential that equipment specifications and standards will change in the future in response to climate change pressures.

5.5 Greenhouse Gases

Greenhouse gases (GHG) in the atmosphere trap incoming radiation from the sun, which in turn increases temperature. This process is known as the greenhouse effect. The six GHGs that are reported under the *National Greenhouse and Energy Reporting Act 2007* (Cth) (NGER Act) are:

- carbon dioxide (CO₂)
- methane (CH₄)
- nitrous oxide (N₂O)
- specified hydrofluorocarbons (HFCs)
- specified perfluorocarbons (PFCs), and
- sulfur hexafluoride (SF₆).

For the Project the GHG species of concern are CO₂, CH₄ and N₂O.

GHG emissions are generally reported in terms of carbon dioxide equivalent (CO₂-e). This is to provide a standardised unit for reporting due to different gases having varying effects on global warming impacts, known as global warming potential (GWP).

The GWP refers to the GHGs potential to trap heat in the atmosphere for a certain period (generally 100 years), relative to CO₂ (which has a GWP of one). CH₄ has a GWP of 28, which means for every tonne of CH₄ emitted, it has the same global warming effect as 28 tonnes of CO₂. As a result, GHGs such as CH₄ and N₂O have a higher potential to affect global warming.

Table 5-6 presents the GWP for the key GHGs that are anticipated to be emitted as a result of the construction and operation of the Project as advised by Department of Agriculture, Water and the Environment (DAWE) (2021).

Table 5-6 GWP of Key GHGs

Gas	Chemical formula	GWP
Carbon dioxide	CO ₂	1
Methane	CH ₄	28
Nitrous oxide	N ₂ O	265

A brief description of the NGER Act is provided in Section 5.5.1.2.1. Reporting under the NGER Act requires that GHG emissions are separated into three categories referred to as emission scopes. This is the internationally accepted method of reporting on GHG emissions. The three scopes of emissions as per the *National Greenhouse and Energy Reporting (Measurement) Determination 2008* (NGER (Measurement) Determination) are described in Figure 5-8.

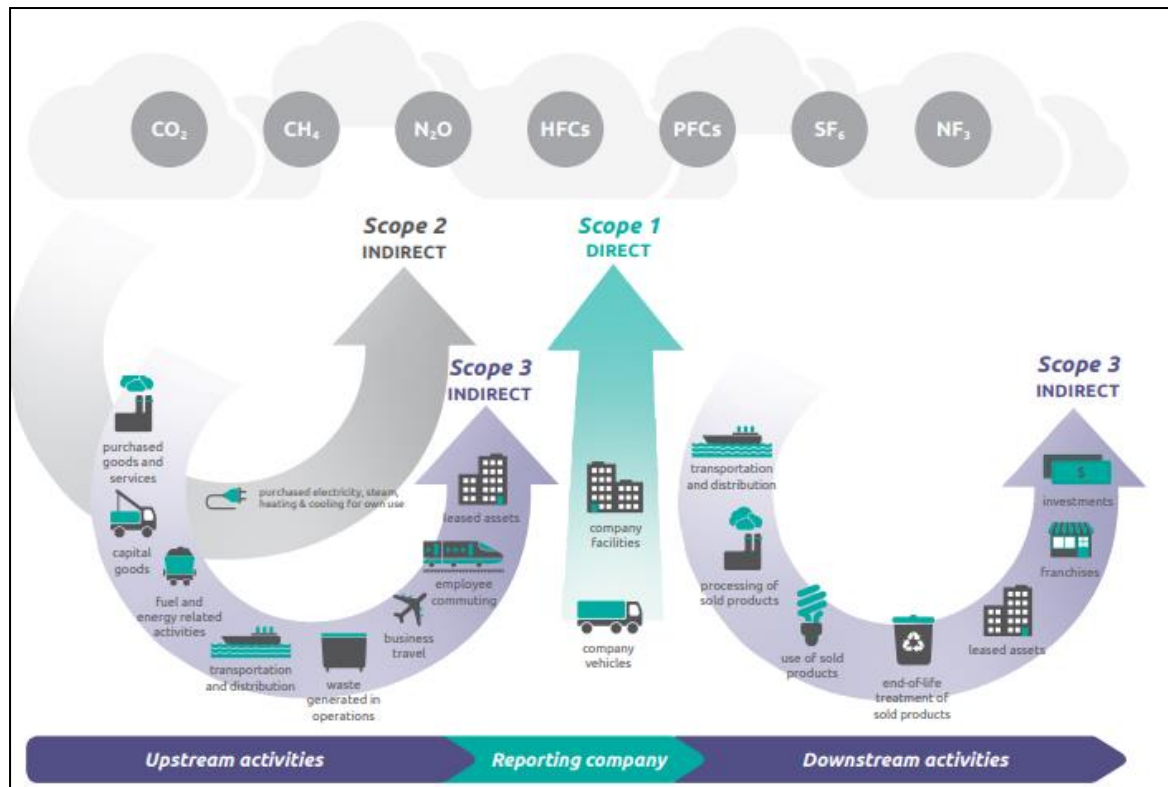


Figure 5-8 Overview of scope and emissions flow across reporting entity (GHG Protocol, 2013)

Reporting under the NGER Act requires that organisations report Scope 1 and Scope 2 emissions, but not Scope 3 emissions, which can be reported voluntarily. This assessment has developed an emissions inventory for Scope 1 and Scope 2 emissions only.

5.5.1 Legislation and policy

The following sections describe the international, Australian and Queensland legislation, policy, and management frameworks applicable to the Project with respect to GHG.

5.5.1.1 International

Australia has committed to two key international agreements, the Kyoto Protocol (1997) and the Paris Agreement (2016). These overarching international agreements target GHG emission reduction and limiting this century's global temperature rise to under 2°C above pre-industrial levels.

5.5.1.1.1 Kyoto Protocol

The Kyoto Protocol was concluded and agreed in 1997 by the United Nations Framework Convention on Climate Change (UNFCCC) and enforced in 2005. Australia ratified the Kyoto Protocol in 2007. The Kyoto Protocol aims to reduce the impact of human-induced climate change by setting nation-specific GHG emissions targets.

The Kyoto Protocol involves the reduction of emissions of six specific GHGs; CO₂, CH₄, N₂O, HFCs, PFCs and SF₆.

The Protocol designated two commitment periods for emissions targets; the first commitment period started in 2008 and ended in 2012 and the second commitment period (Doha Amendment) began in 2013 and ended in 2020. In the second commitment period Australia set a target to reduce GHG emissions to five per cent below 2000 levels by the end of 2020, and this emissions reduction target was achieved. Australia's commitments to the Kyoto Protocol are no longer current as the second commitment period has ended. The current international commitment is the Paris Agreement.

5.5.1.1.2 Paris Agreement

The Paris Agreement was finalised and entered into force in 2016, with the objective to build upon the mechanisms and targets put forward by the Kyoto Protocol. The Paris Agreement has been ratified by 189 of the 197 Parties to the UNFCCC and has effectively replaced the Kyoto Protocol

The goal of the Paris Agreement is to limit the increase in the global average temperature to below 2°C above pre-industrial levels and reduce GHG emissions by encouraging technological innovation and clean energy.

5.5.1.2 Commonwealth Government

5.5.1.2.1 National Greenhouse and Energy Reporting Act 2007

The NGER Act introduces a single national framework for reporting and disseminating company information about GHG emissions, energy production, and energy consumption. The NGER Act was most recently updated in 2019.

The NGER Act requires that individuals or corporations who exceed certain GHG emission thresholds publicly report their GHG emissions, energy consumption and energy production each financial year.

The current GHG reporting thresholds for corporations are as follows:

- emission of more than 50,000 tonnes (t) of carbon dioxide equivalent (CO₂-e)
- production of 200 terajoules (TJ) or more of energy
- consumption of more than 200 TJ of energy.

5.5.1.2.2 Emissions Reduction Fund

To meet its targets set under the Kyoto Protocol and Paris Agreement, the Department of Agriculture, Water and Energy (DAWE) has commissioned the Emissions Reduction Fund (ERF). The ERF is a voluntary scheme which provides incentives for Australian businesses, farmers, land holders and citizens to reduce their GHG emissions by adoption of more efficient practices and technologies.

Key elements of the ERF are as follows:

- crediting emissions reductions that go beyond business as usual standards
- selling emission reductions in the form of Australian Carbon Credit Units (ACCU)
- a Safeguard Mechanism that provides a framework for Australia's largest emitters to measure, report and manage emissions.

5.5.1.2.3 Direct Action Plan

The Commonwealth Government's policy, the Direct Action Plan, targets to reduce GHG emissions by 26 to 28 per cent below 2005 levels by 2030. This builds on previous targets set out by the Kyoto Protocol to reduce emissions by five per cent below 2000 levels by 2020.

5.5.1.3 State Government

The Queensland Climate Change Response sets out the Queensland Government's strategy to transition to a low carbon economy and address the impacts of climate change. The Queensland Climate Change response includes the Queensland Climate Transition Strategy and the Queensland Climate Adaptation Strategy.

5.5.1.3.1 Queensland Climate Transition Strategy

The Queensland Government has set a state target to reach zero net emissions by 2050, along with the interim target aligned with the Australian Government's target for at least a 30% reduction in emissions on 2005 levels by 2030.

5.5.1.3.2 Queensland Climate Adaptation Strategy

Queensland Climate Adaptation Strategy (Q-CAS) aims to address the impacts of climate change and build an innovative and resilient Queensland by understanding risks, providing information, integrating climate adaptation into policy, and collaborating with stakeholders.

5.6 Project GHG Emission Sources

Potential GHG emission sources for all phases of the Project and their corresponding emissions scope are listed in Table 5-7. The construction phase of the Project will generate the highest quantity of GHG emissions. Emissions from the operation and maintenance phase are expected to be significantly lower. Emissions from the decommissioning phase are also expected to be lower than during the construction phase.

Table 5-7 Emission sources associated with the Project

Project Phase	Category	Source of Greenhouse Gas Emissions
Construction	Scope 1	<ul style="list-style-type: none"> Vegetation clearing Diesel fuel consumption by site vehicles Diesel fuel consumption by equipment and plant Diesel fuel consumption for power generation for diesel generator sets, which will provide power to equipment and site offices
	Scope 3	<ul style="list-style-type: none"> Transportation of vehicles and equipment to site Diesel fuel consumption during transportation of transmission structures conductors and steel by sea from China/India Diesel consumption in light vehicles for transportation of workforce
Operation and maintenance	Scope 1	<ul style="list-style-type: none"> Diesel consumption in light and heavy vehicles for general maintenance of transmission structures and lines Aviation fuel consumption in helicopters for maintenance of transmission lines Diesel consumption in light and heavy vehicles for switching station facility operation and maintenance Vegetation maintenance
	Scope 2	<ul style="list-style-type: none"> Grid electricity consumption through power loss via the transmission lines
	Scope 3	<ul style="list-style-type: none"> Diesel consumption in light vehicles and machinery used to maintain easements and access tracks (undertaken by 3rd party contractor)
Decommissioning	Scope 3	<ul style="list-style-type: none"> Diesel fuel consumption by vehicles, equipment and plant to support decommissioning and transport of material

5.6.1 Key assumptions in GHG emission estimations

As discussed in Section 5.6, construction of the Project has potential to generate significant GHG emissions. Emissions generated during the operation and maintenance phase of the Project are expected to be significantly lower than the construction phase, with the majority of emissions relating to fuel combustion for mobile equipment and vehicles, which will be much less than during the construction phase. At this stage, due to the timeline and available information, it is not possible to accurately estimate GHG emissions from the decommissioning phase.

On this basis, and as the construction phase is expected to have the highest emissions, GHG emission estimates have been prepared for the construction phase only. Scope 1 GHG emissions during the construction phase expected to be the largest contributor to total GHG emissions from the Project (all phases).

While multiple potential GHG emission sources will exist within the construction phase of the Project, only those which are considered significant have been included in this assessment. The determination of source significance itself required the use of assumptions. Assumptions that have been used in this assessment are intended to be conservative due to the high level nature of input data currently available.

The following conservative assumptions were made to estimate GHG emissions from the construction phase of the Project.

- GHG emissions have been estimated for an annual (12 month) period.
- The approximate Project disturbance area of 1,704 hectares (ha) has been assumed to be cleared of vegetation.
- Potential maximum biomass for the Project area is between 50-100 tonnes dry matter/ha.
- The Project area is generally comprised of 85% remnant vegetation (open woodland) and 15% non-remnant vegetation (grasslands).
- Temporary construction camps and contractor site offices are likely to be erected during construction of the Project due to its rural location. Diesel generators will be used to provide electricity at these locations for a period likely greater than 12 months.
- Due to the size and linear nature of the Project, material transportation distances are likely to change per worksite and over time. For the construction phase of the Project, it has been assumed material will travel up to 200 km from the material source.
- Although both diesel and unleaded petrol fuel is likely to be used, for the purposes of the GHG calculations it has been assumed that only diesel is used by equipment and vehicles.
- Concrete will be used to lay foundations.
- Heavy vehicles will be used to transport cement, concrete and steel.

5.6.2 Estimated Project GHG emissions

The New South Wales (NSW) Government Department of Roads and Maritime Services (RMS) provides a workbook developed by the Transport Authorities Greenhouse Group (TAGG) for the estimation of GHG emissions. Although the workbook was designed primarily for use on road projects, it has been utilised to estimate Project emissions as it is designed for linear infrastructure projects.

GHG emissions for the Project are presented in Table 5-8. As discussed in Section 5.6.1, GHG emission estimations have been completed for the construction phase of the Project only.

The construction phase of the Project is estimated to result in approximately 240,582 t CO₂-e of GHG during construction of the Project. The annual GHG emissions for the Project (construction phase) represent 0.05% of Australia's 2019 GHG emissions (529.3 Mt CO₂-e) and 0.15% of Queensland's 2019 GHG emissions (164.54 Mt CO₂-e) (National Greenhouse Accounts, 2019).

Table 5-8 Annual GHG emissions by Project source for the construction phase

Emission Source	Scope 1 Emissions (t CO ₂ -e)	Scope 3 Emissions (t CO ₂ -e)	Total Emissions (t CO ₂ -e)
Fuel combustion for on-site electricity	100	8	107
Fuel combustion by site vehicles	109	8	118
Fuel combustion by plant and equipment	564	43	606
Fuel combustion for earthworks activity	209	16	225
Fuel combustion for vegetation removal	3,053	233	3,286
Vegetation removal	220,943	-	220,943
Material usage – aggregate, concrete, cement, steel	-	15,298	15,298
Total	224,977	15,605	240,582