2 CLIMATE AND CLIMATE CHANGE

This chapter provides an overview of the existing climate and predictions of climate change in the area of the LNG Component of the Queensland Curtis LNG (QCLNG) Project. It describes the potential impacts of climate change on the LNG Facility and associated works.

This chapter does not describe the impact on climate change from the production of greenhouse gases and the release of these gases to the environment from LNG Component of the Project. Greenhouse gas emissions, their impacts and mitigation strategies to curb these impacts are discussed in detail in *Volume 7*: *Greenhouse Gas Management*.

2.1 CLIMATE

2.1.1 Description of Project Environmental Objectives

The Project environmental objective for climate and climate change is: to ensure that Project infrastructure design and proposed management strategies incorporate consideration for climatic extremes and future climate change

2.1.2 Rainfall Patterns

The Gladstone region has a sub-tropical climate, averaging 267 days of sunshine per year and a mean annual rainfall of approximately 750mm[1]. The heaviest rainfall occurs during summer (December to February) in the northern tropical monsoon season *(Figure 5.2.1 and Figure 5.2.2*). From 1994 to 2008 almost 50 per cent of the region's total annual rainfall occurred during summer. *Table 5.2.1* highlights monthly rainfall figures for the region based on climate data collected at the Gladstone Airport from 1994 to 2008.

1 Gladstone Area Promotion and Development Limited (GAPDL), (2006) *Gladstone Regional Overview, September Quarter 2006*

Table 5.2.1 Minimum, Average and Maximum Monthly Averaged Rainfall at Gladstone Airport, 1994-2008

Month	Minimum (mm)	Average (mm)	Maximum (mm)	Average rainfall (%)
January	3.6	113.7	269.2	15.3
February	19.8	141.3	657.4	19.0
March	6.8	46.2	135.4	6.2
April	5.6	37.9	214.2	5.1
May	3.8	37.5	135.2	5.0
June	0.4	50.6	166.6	6.8
July	0	13.7	50.4	1.8
August	0	39.8	136.8	5.4
September	0	32.6	81.2	4.4
October	2.4	66.7	167.6	9.0
November	11.4	56.3	160.2	7.6
December	22.4	106.4	327.2	14.3

Figure 5.2.1 Mean Number of Days with Rain >=1mm and Mean Monthly Rainfall at Gladstone Airport from 1994 to 2008.

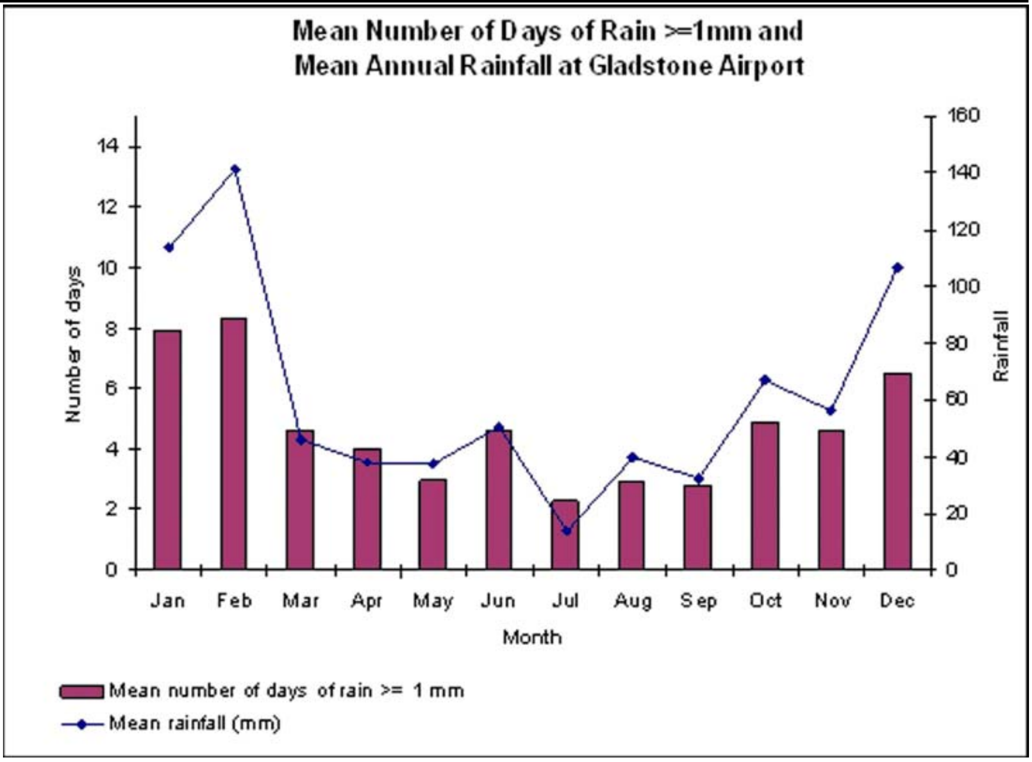
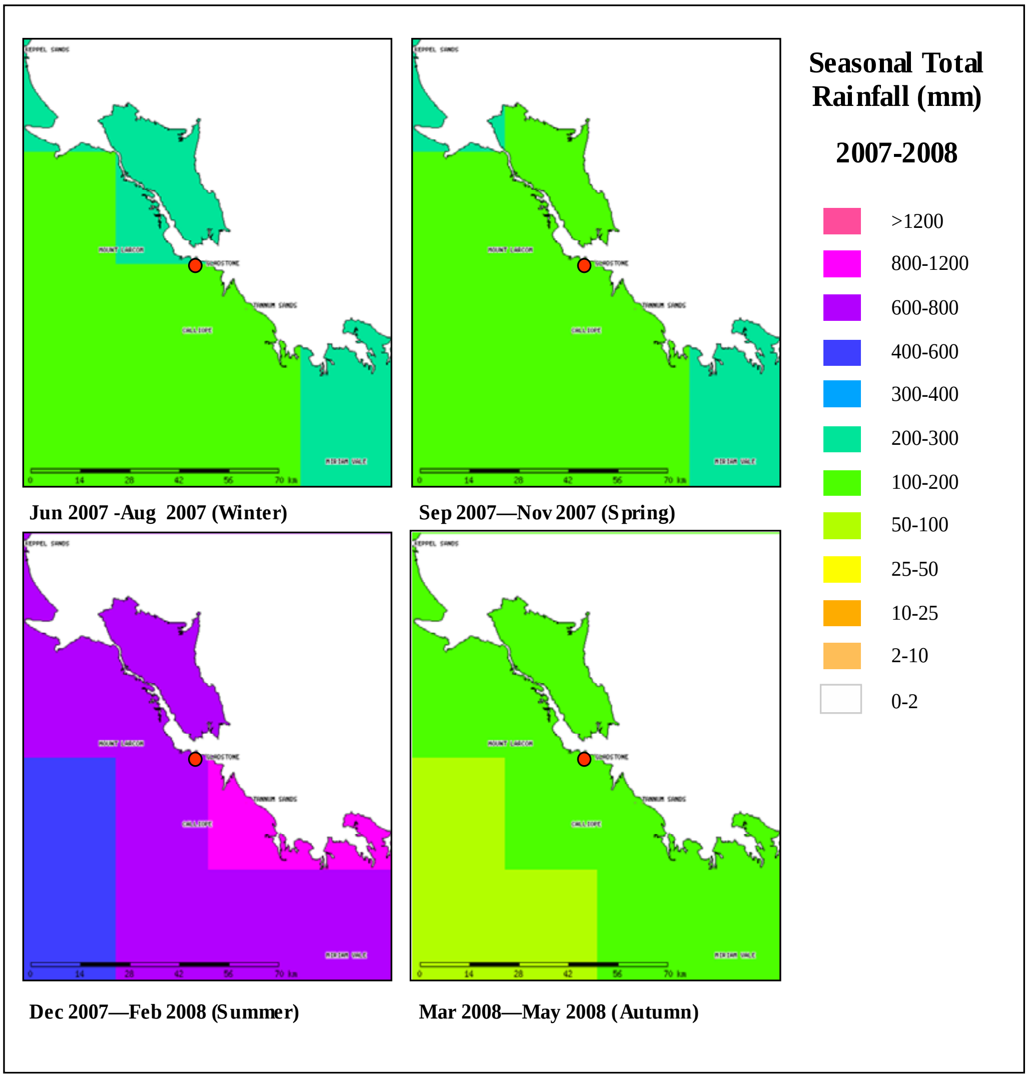


Figure 5.2.2 Total Seasonal Rainfall (mm) in the Gladstone Region from 2007 to 2008



2.1.3 Temperature

From 1994 to 2008, the mean annual maximum and minimum temperatures recorded at Gladstone Airport were 27.2°C and 12.7°C respectively. During this time the temperature exceeded 30°C for approximately 80 days of the year.

Diurnal variation in air temperature was greatest in winter (June to August), with average daily minimum and maximum temperatures varying by approximately 11°C from 12°C to 23°C. During the summer months the average daily temperature ranged from 23°C to 30°C.

The mean minimum and maximum daily temperatures at the Gladstone Airport from 1994 to 2008 are presented in *Figure 5.2.3.* The range of seasonal daily average minimum and maximum temperatures and the highest and lowest daily temperatures by season as observed at Gladstone Airport for the period 1993 to 2008 are presented in *Table 5.2.2* [2].

Figure 5.2.3 Mean Minimum and Maximum Daily Temperatures (°C) at Gladstone Airport from 1994-2008

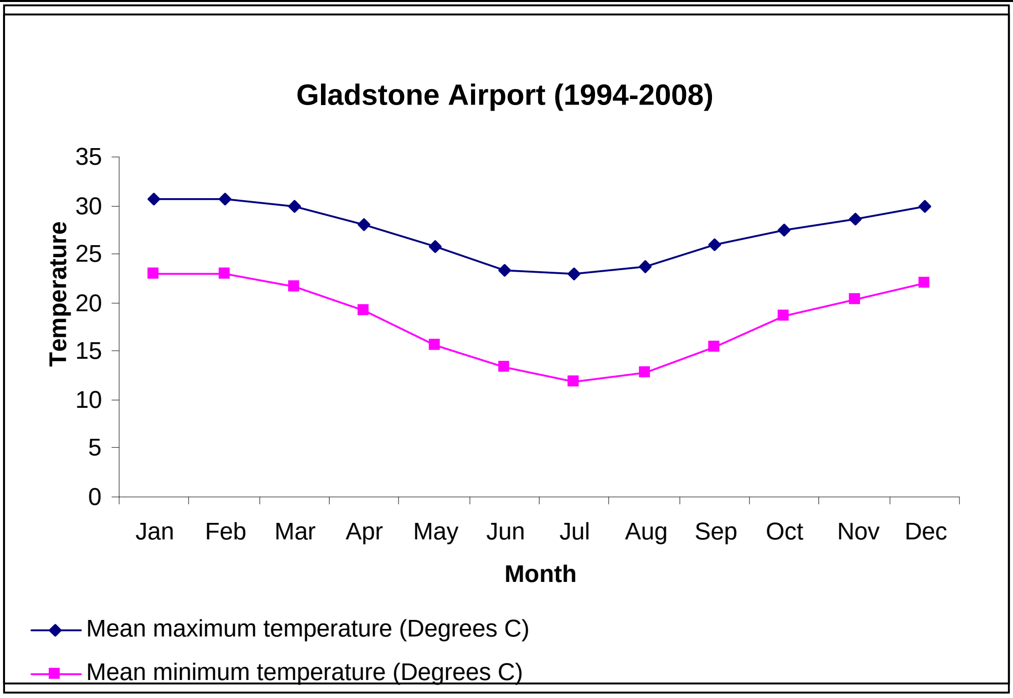


Table 5.2.2 Summary of Seasonal Temperatures (in °C) as Observed at Gladstone Airport for the Period 1993 to 2008

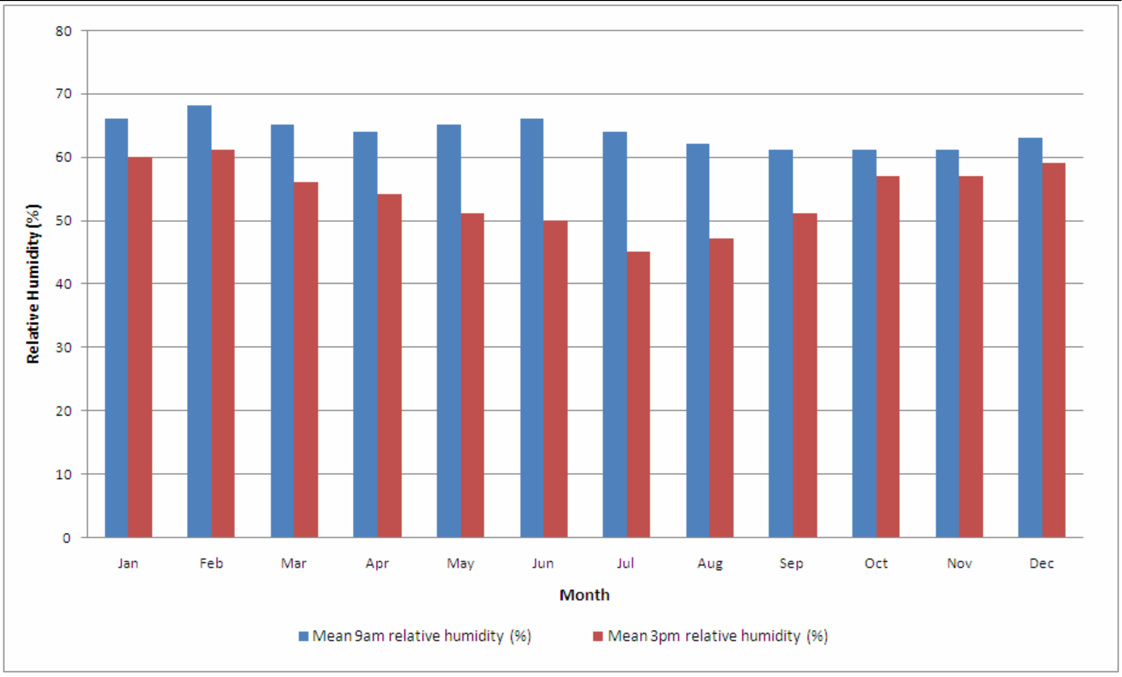
Season	Average Daily Maximum Temperature	Average Daily Minimum Temperature	Maximum Temperature	Minimum Temperature
Summer	30.3	22.7	39.3	16.7
Autumn	27.8	18.7	41.0	4.9
Winter	23.2	12.6	30.8	3.5
Spring	27.3	18.2	36.7	7.2

2 Bureau of Meteorology as referenced in Katestone Environmental (2009) *Air Quality Impact Assessment of the QCLNG Project, Gladstone, Queensland.*

Relative Humidity

Figure 5.2.4 highlights the monthly averaged relative humidity at 9am and 3pm at Gladstone Airport from 1993 to 2008[3]. During this period there was little variation in the 9am relative humidity figures between each season. The mean relative humidity at 3pm was lower in winter than summer, signifying slightly drier afternoons in the colder months.

Figure 5.2.4 Monthly Averaged 9am and 3pm Measurements of Relative Humidity for Gladstone



2.1.4 Wind (Direction and Speed)

2.1.4.1 Regional Data

Meteorological data[4] collected at the Gladstone Airport referenced in this section illustrate that winds predominantly flow between northeast and south-southeast with 62.2 per cent of winds blowing from this direction (refer *Figure 5.2.5*). These winds normally dominate daytime and early evening flows, with winds strongest between midday and 6pm (refer *Figure 5.2.6*). Winds tend to be strongest in an easterly direction during the summer months (refer *Figure 5.2.7*).

The high percentage of easterly daytime flows indicates that the Gladstone

3 Bureau of Meteorology as referenced in Katestone Environmental (2009) *Air Quality Impact Assessment of the QCLNG Project, Gladstone, Queensland.*

4 Bureau of Meteorology as referenced in Katestone Environmental (2009) *Air Quality Impact Assessment of the QCLNG Project, Gladstone, Queensland.*

region is strongly influenced by sea breezes. The sea breeze generally develops around 10am to 11am each day and is often preceded by a significant shift in wind direction from the more southerly and westerly nighttime flows. The distribution of wind speeds at Gladstone Airport for the period 1996 to 2009 is summarised *in Table 5.2.3*[5].

Table 5.2.3 Summary of the Distribution of Wind Speeds at Gladstone Airport for all Directions and for the Dominant Easterly Sector

Direction	Wind speed	Wind speed range (m/s)	Percent (%)
All	Calm to light	0 – 1.99	8.5
All	Moderate	2.0 – 4.99	61.6
All	Strong	>5.0	29.8
Easterly sector	Calm to light	0 – 1.99	3.5
Easterly sector	Moderate	2.0 – 4.99	25.7
Easterly sector	Strong	>5.0	42.8

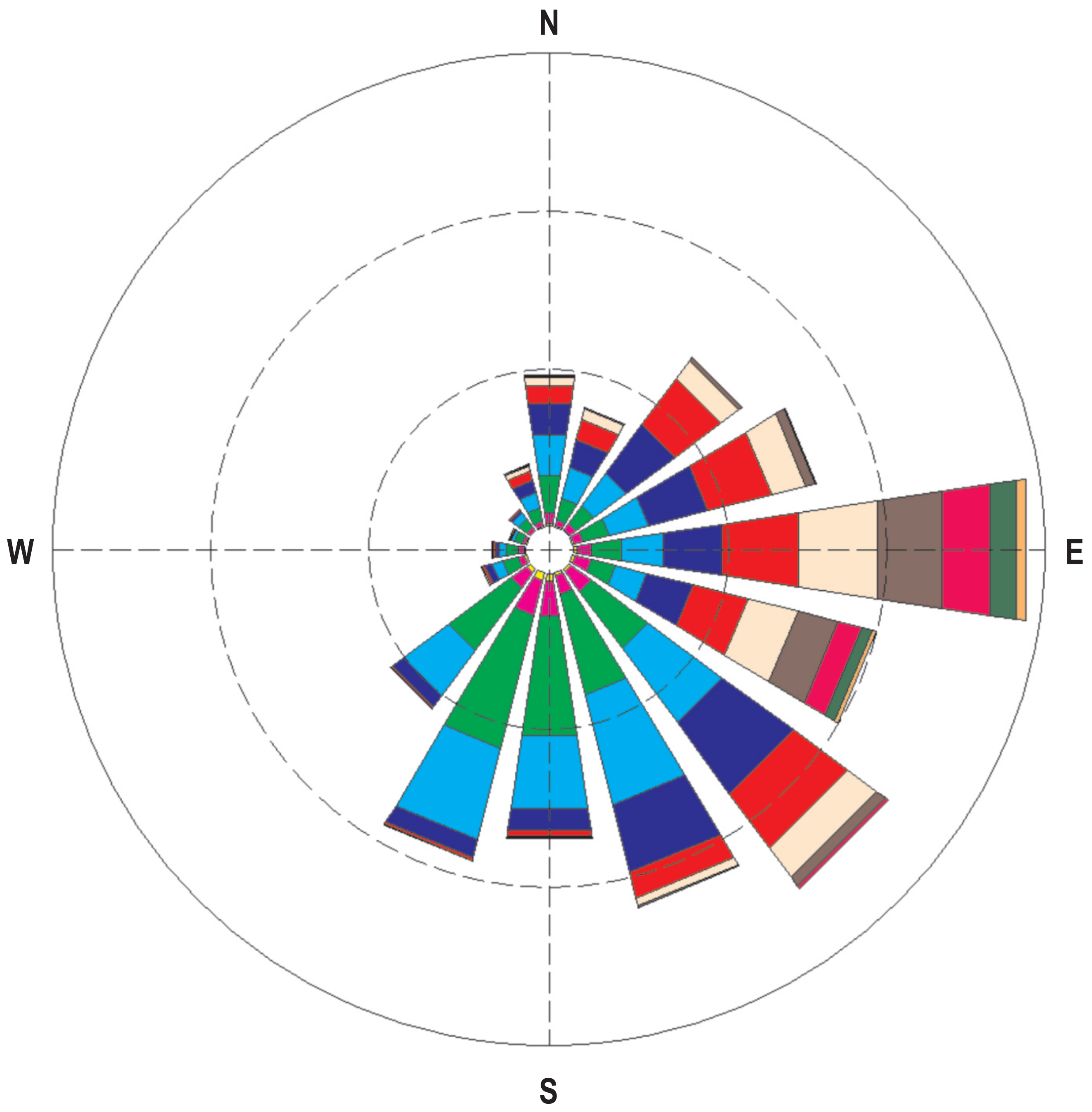
2.1.4.2 Site Modelling Data

CALMET (an advanced non-steady-state diagnostic three-dimensional meteorological model) has been used to simulate meteorological conditions around Curtis Island.

Winds on the east coast of Curtis Island can be expected to be significantly stronger than those on the sheltered west coast. Morning winds are predominantly offshore while afternoon winds are onshore and strongest during the summer months. Winds are projected to be highest between midday and 6pm (refer *Figure 5.2.8 and Figure 5.2.9).*

Curtis Island primarily experiences winds from the east to southeast, with maximum sustained speed of 9 metres per second (m/s). The seasonal distribution of winds is influenced by monsoonal winds and precipitation patterns. The diurnal wind pattern is dominated by the southeast trade winds, which usually begin to intensify by 9 am as a south-easterly flow and gradually rotates counter clockwise to a north-easterly flow by the mid afternoon. Nighttime flows predominantly consist of very light westerly flows from the surrounding terrain and the ever-present trade winds.

5 Katestone Environmental (2009) *Air Quality Impact Assessment of the QCLNG Project, Gladstone, Queensland.*



Legend

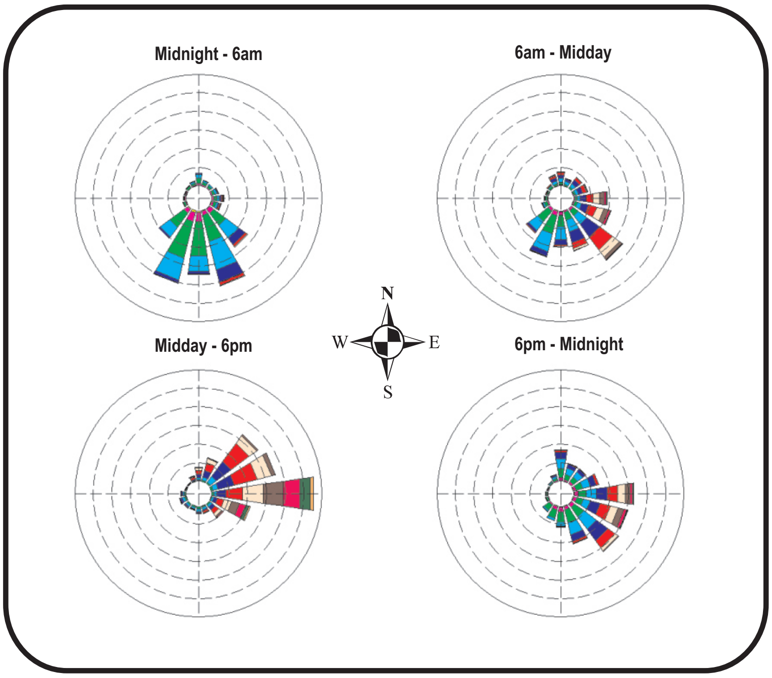
Each ring is 5.0%
Wind Speed (m/s)

- >= 10.0
- 9.0 to < 10.0
- 8.0 to < 9.0
- 7.0 to < 8.0
- 6.0 to < 7.0
- 5.0 to < 6.0
- 4.0 to < 5.0
- 3.0 to < 4.0
- 2.0 to < 3.0
- 1.0 to < 2.0
- 0.0 to < 1.0

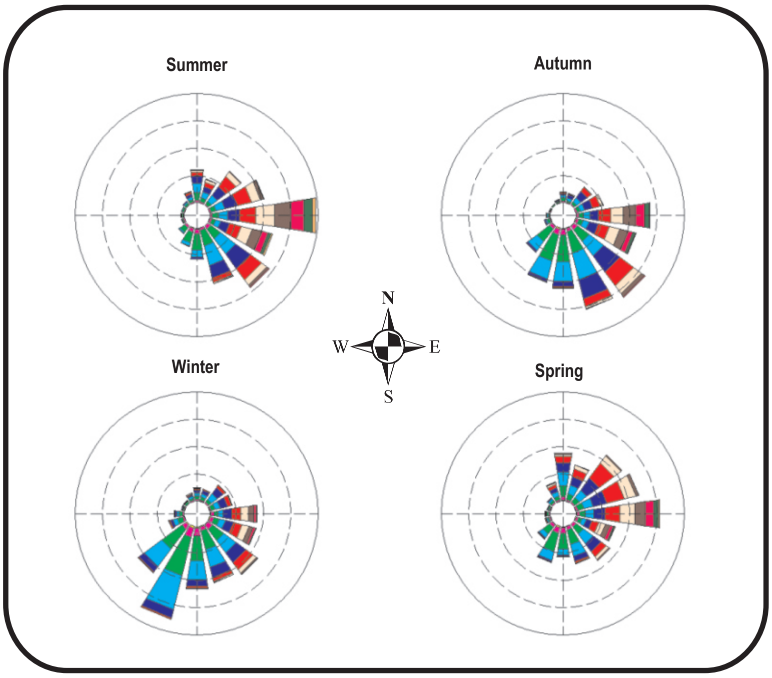
Source:
Bureau of Meteorology as referenced in Katestone Environmental (2009)
Air Quality Impact Assessment of the QCLNG Project, Gladstone, Queensland.
Unpublished report for BG International Limited, Report Reference KE0810645 Air, June 2009

QUEENSLAND CURTIS LNG A BG Group business	Project: Queensland Curtis LNG Project Client: QGC - A BG Group business	Title: **Annual Wind Rose for Gladstone Airport January 1996 - January 2009**
ERM Environmental Resources Management Australia Pty Ltd	Drawn: JB — Volume 5 — Figure 5.2.5 Approved: KR — File No: 0086165b_EIS_CL_CDR001_F5.2.5 Date: 18/05/09 — Revision 2	Disclaimer: Maps and Figures contained in this Report may be based on Third Party Data, may not to be to scale and are intended as Guides only. ERM does not warrant the accuracy of any such Maps and Figures.

DAILY WIND ROSE FOR GLADSTONE
JANUARY 1996 - JANUARY 2009
Figure 5.2.6



SEASONAL WIND ROSE FOR GLADSTONE
JANUARY 1996 - JANUARY 2009
Figure 5.2.7



Legend

Each ring is 5.0%
Wind Speed (m/s)

Wind Speed (m/s)	
>= 10.0	orange
9.0 to < 10.0	dark green
8.0 to < 9.0	crimson
7.0 to < 8.0	brown
6.0 to < 7.0	cream
5.0 to < 6.0	red
4.0 to < 5.0	dark blue
3.0 to < 4.0	light blue
2.0 to < 3.0	green
1.0 to < 2.0	magenta
0.0 to < 1.0	yellow

Source:
Bureau of Meteorology as referenced in Katestone Environmental (2009)
Air Quality Impact Assessment of the QCLNG Project, Gladstone, Queensland.
Unpublished report for BG International Limited, Report Reference KE0810645 Air, June 2009

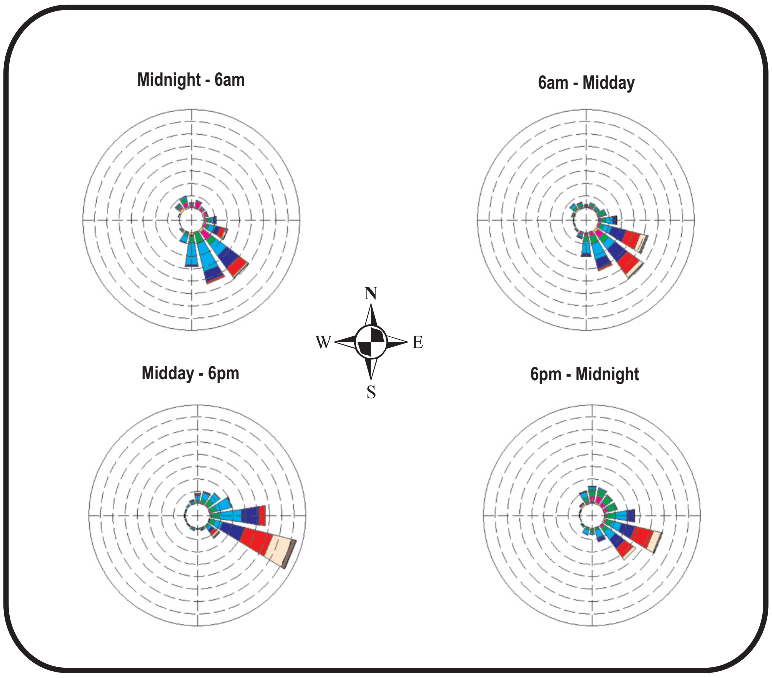
QUEENSLAND CURTIS LNG
A BG Group business

ERM
Environmental Resources Management Australia Pty Ltd

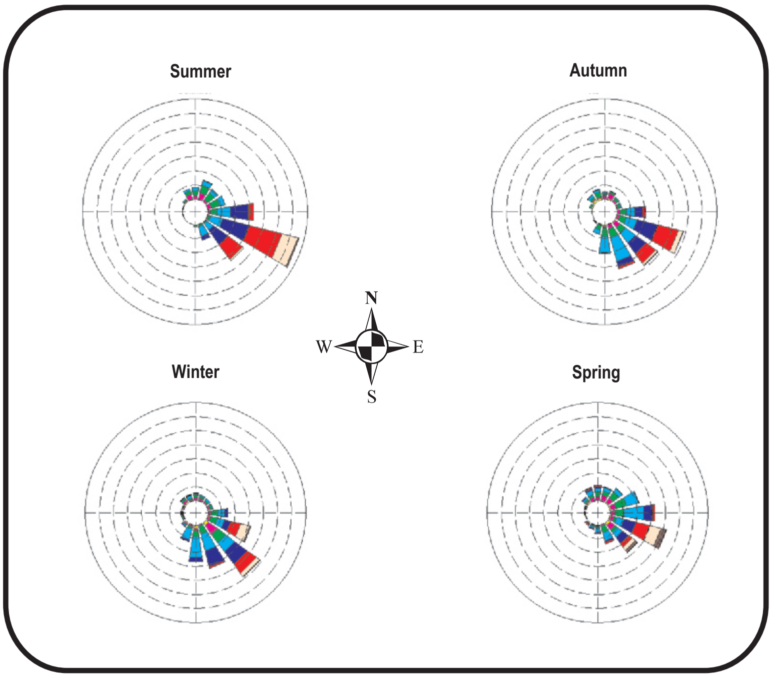
Project	Queensland Curtis LNG Project		
Client	QGC - A BG Group business		
Drawn	JB	Volume 5	Figure 5.2.6 & 5.2.7
Approved	KR	File No: 0086165b_EIS_CL_CDR002_F2.6_F2.7	
Date	08/08/09	Revision 2	

Title **Daily and Seasonal Wind Rose for Gladstone Airport January 1996 - January 2009**

DAILY WIND ROSE
FOR PROPOSED SITE
Figure 5.2.8



SEASONAL WIND ROSE FOR
PROPOSED SITE
Figure 5.2.9



Legend

Each ring is 5.0%
Wind Speed (m/s)

Wind Speed (m/s)	
>= 10.0	orange
9.0 to < 10.0	dark green
8.0 to < 9.0	crimson
7.0 to < 8.0	brown
6.0 to < 7.0	cream
5.0 to < 6.0	red
4.0 to < 5.0	dark blue
3.0 to < 4.0	light blue
2.0 to < 3.0	green
1.0 to < 2.0	magenta
0.0 to < 1.0	yellow

Source:
Generated data by CALMET v6.3 as referenced in Katestone Environmental (2009) Air Quality Impact Assessment of the QCLNG Project, Gladstone, Queensland. Unpublished report for BG International Limited, Report Reference KE0810645 Air, Draft Report March 2009

QUEENSLAND CURTIS LNG
A BG Group business

ERM
Environmental Resources Management Australia Pty Ltd

Project	Queensland Curtis LNG Project		
Client	QGC - A BG Group business		
Drawn	JB	Volume 5	Figure 5.2.8 & 5.2.9
Approved	KR	File No: 0086165b_EIS_CL_CDR003_F2.8_2.9	
Date	08/07/09	Revision 2	

Title **Daily and Seasonal Wind Rose for Proposed Site**

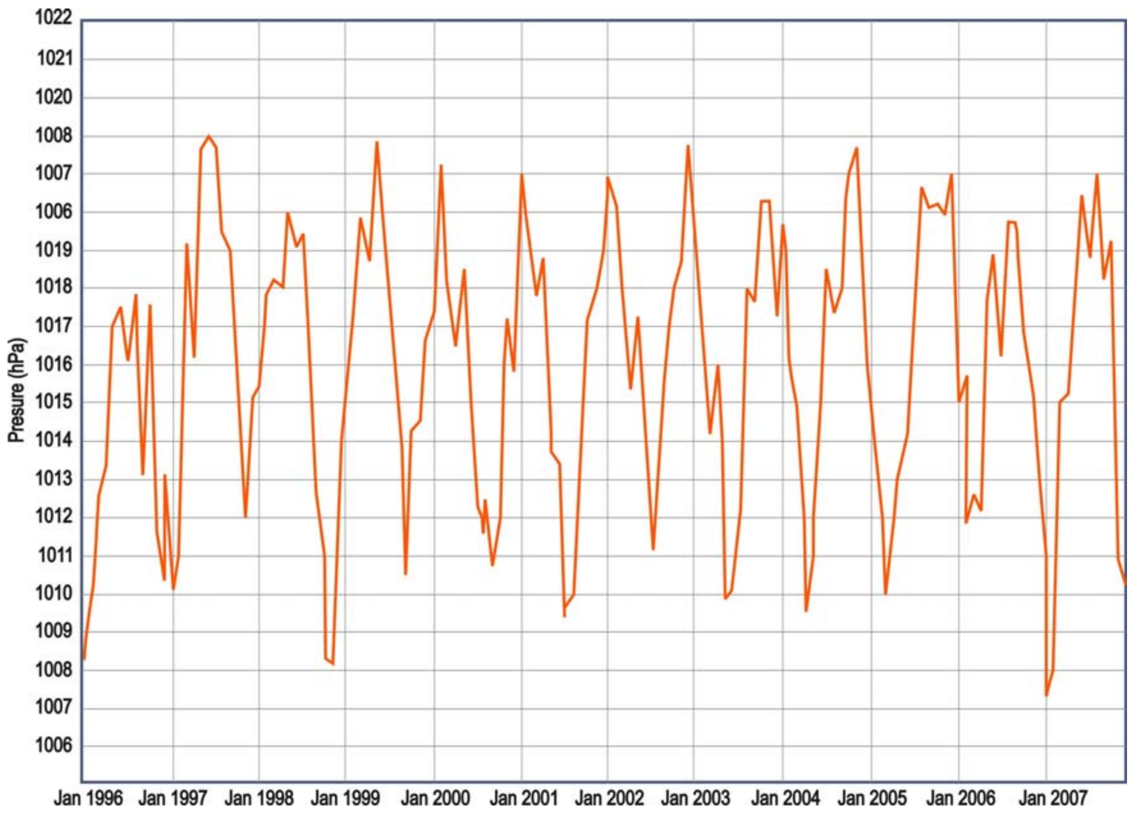
2.1.4.3 *Other Factors (e.g. Temperature Inversions) That May Affect Air Quality*

Special factors that may affect air quality are addressed in *Volume 5, Chapter 12.*

2.1.4.4 *Surface Pressure*

Biannual patterns of peaks and troughs in the monthly averaged pressure field indicates that the months of January and July are generally dominated by low pressure features that are typically associated with either wetter (summer) and/or colder (winter) conditions. The months of April and October are generally dominated by high pressure features that are typically associated with clear, drier and warmer conditions[6]. The monthly averaged surface pressure at Gladstone is presented in *Figure 5.2.10.*[7]

Figure 5.2.10 Monthly Averaged Surface Pressure for Gladstone Airport (hPa)



6 Katestone Environmental (2009) *Air Quality Impact Assessment of the QCLNG Project, Gladstone, Queensland.*

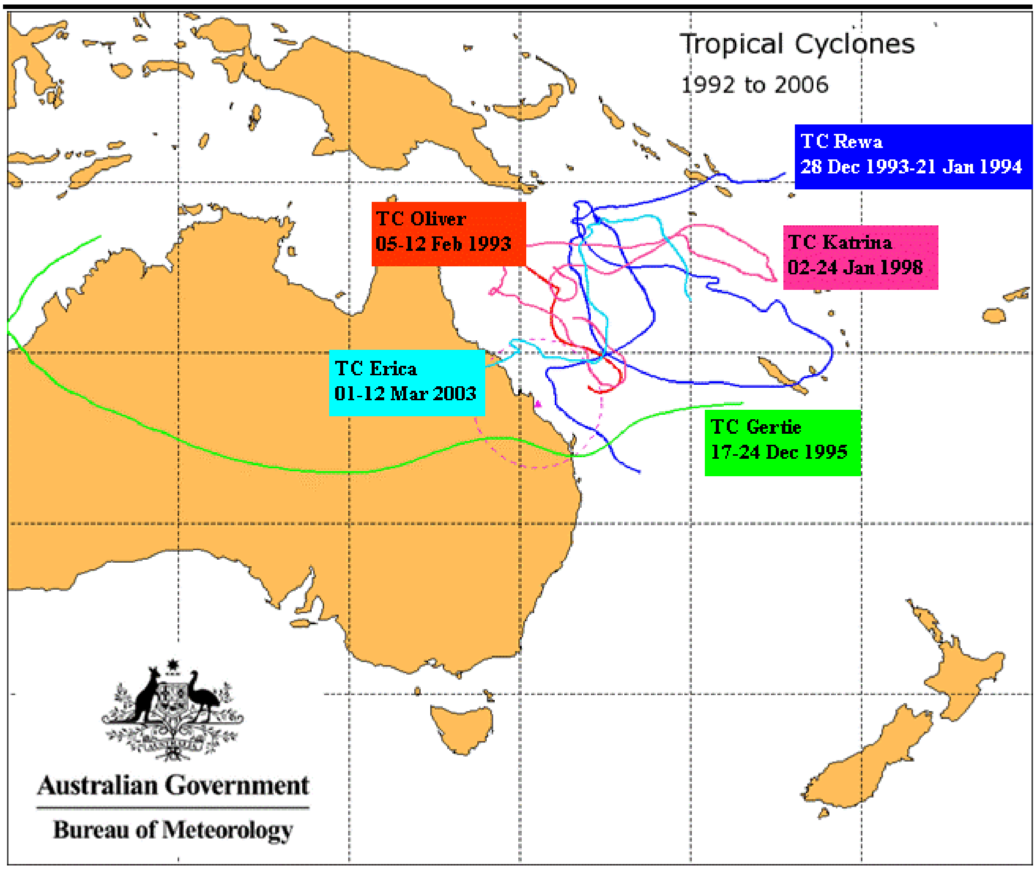
7 Bureau of Meteorology as referenced in Katestone Environmental (2009) *Air Quality Impact Assessment of the QCLNG Project, Gladstone, Queensland.*

2.1.5 Extremes of Climate

The Gladstone region experienced long-term droughts from 1964 to 1967, 1969 to 1970, 1984 to 1985, 1993 to 1995, and 1996 to 2003. The drought between 1996 and 2003 was particularly significant because it resulted in the introduction of water restrictions for the first time and contributed to the region being identified as being "partly drought declared" on January 1st, 2007.[8]

Gladstone is susceptible to cyclones that develop over tropical waters in Northern Australia. There were eight tropical cyclones within a 400 km radius of Gladstone from 1986 to 2006. *Figure 5.2.11* highlights the cyclone tracks of five tropical cyclones that occurred within a 400 km radius of Gladstone from 1992 to 2006[9].

Figure 5.2.11 Tropical Cyclone Tracks Within 400 km of Gladstone - 1992 to 2006



Source: BoM, 2008.

8 Department of primary Industries and Fisheries (2008) *Queensland Drought Situation* , and Gladstone City Council & Calliope Shire Council,(2005) *Joint Local Disaster Management Plan*

9 Bureau of Meteorology (2008)

Tropical cyclones generally occur during the warmer months (November to April) and pose a threat to communities due to the destructive weather patterns they create, including heavy rainfall, flooding, and damaging winds (BoM 2008). Cyclones can also cause storm surges which have the potential to cause flooding in Gladstone when coupled with high tides. [10]

The most significant floods in Gladstone occur in summer or early autumn when rainfall is at its heaviest. The region's highest flood event was recorded in the Fitzroy River in 1918 when flood waters reached 10.1 m. The most recent major flood event for the Fitzroy River occurred in 2008 and resulted in flood waters reaching heights of more than 7 m. Minor floods were reported in February 2003 and January 2004.[11]

The Gladstone Regional Council has developed a scale to highlight the effect that natural hazards and risks present to the community. The scale is presented below, identifying the likelihood and consequences associated with a particular event.

Table 5.2.4 Natural Hazards and Risks that Might Affect Gladstone Community[12]

	Likelihood	Consequences
Cyclone	B	5
East coast low	B	3
Storm tide	B	3
Severe storms	B	3
Flood	B	2
Earthquake	D	4

Likelihood rating scale	Consequences rating scale
A - Almost certain	1 - Insignificant
B - Likely	2 - Minor
C - Possible	3 - Moderate
D - Unlikely	4 - Major
E - Rare	5 - Catastrophic

Impacts of climates extremes and management and mitigation measures for both existing climate extremes and potential future climate change are described in *Section 2.2.3*.

10 Environmental Protection Agency (EPA) (2008) *Queensland Storm Tide Information Resource*

11 Gladstone City Council & Calliope Shire Council (2005) *Joint Local Disaster Management Plan*

12 Gladstone City Council (2008) *Gladstone Joint Local Disaster Management Plan*

2.2 CLIMATE CHANGE

There is intrinsic uncertainty in making climate change projections. However, consideration of climate change projections has been incorporated in the technical design of the QCLNG Project.

In addition, the EIS Terms of Reference (ToR) require that impacts of, and adaptation to, climate change are built into considerations on soil erosion, waste and water containments, temperature as it impacts power generation systems and wind/rain/humidity and temperature as these elements impact on air quality.

This chapter outlines the latest climate change projections for the area around Gladstone. Based on this data, the sensitivity of the technical design to predicted changes in climate has been analysed and LNG Component design modified where necessary.

2.2.1 Natural and Induced Hazards

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) has published the most comprehensive data on climate change predictions for Australia to date.

The following base assumptions have been made following a review of CSIRO's 2007 modelling data of climate change predictions:

- In general, projections are given to 2030 because the lifespan of the QCLNG Project is expected to be 20 years for each LNG train.
- Climate change predictions to 2030 are broadly similar under different emissions scenarios. Therefore, scenario A1B is used as it is a middle emissions scenario and is readily available.
- For those aspects of the LNG Facility where retrofitting is difficult and/or adaptation is not easy, such as the base height of the LNG Facility above sea level, the sensitivity of the design to 2050 projections and to A1F1 emissions scenario has been undertaken, where data was available.

2.2.2 Climate Projections

2.2.2.1 Mean Temperature Change

Table 5.2.5 summarises the predicted mean annual temperature change for the Gladstone region. Additional time horizons and emission scenarios are given in *Annex 5.1*.

Table 5.2.5 Mean Temperature (A1B1 Predictions in 2030 for the Gladstone Region)[13]

Mean Temperature Change (°C)	P10	P50	P90
Annual	0.6	0.8	1.2
Dec – Feb	0.5	0.8	1.2
Mar – May	0.6	0.8	1.2
Jun – Aug	0.6	0.8	1.2
Sep – Nov	0.6	0.8	1.2

The sensitivity analysis will consider a temperature rise of 0.6ºC to 1.2°C.

2.2.2.2 Mean Precipitation Change

Table 5.2.6 summarises predicted percentage rainfall change for the Gladstone region. Additional time horizons and emission scenarios are given in *Annex 5.1.*

Table 5.2.6 Mean Percentage Precipitation Change (A1B1 Predictions in 2030 for Gladstone Region)[14]

% Rainfall change	P10	P50	P90
Annual	-10.1	-3.2	4.2
Dec – Feb	-9.9	-1.8	7.0
Mar – May	-14.9	-4.9	7.2
Jun – Aug	-10.8	-1.7	8.8
Sep – Nov	-13.0	-5.3	4.1

The sensitivity analysis will consider a change in precipitation of -10.1 percent to +4.2 per cent.

2.2.2.3 Sea level rise

Global warming is predicted to cause the sea level to rise as increasing temperatures lead to thermal expansion of the world's oceans and melting of glaciers and land ice. An estimate of regional sea level rise relative to the land may be obtained by adding the globally averaged sea level projections, the projections for regional departures from the global average and local estimates of vertical land motion. Local estimates of vertical land motion are not included in this analysis.

It should be noted that there is great uncertainty on sea level predictions, as

13 Unpublished data extracted from the "Climate Change in Australia" projections by Leanne Webb (CSIRO Division of Marine and Atmospheric Research).

14 Unpublished data extracted from the "Climate Change in Australia" projections by Leanne Webb (CSIRO Division of Marine and Atmospheric Research).

indicated by the scatter of model results in *Climate Change in Australia*, pp 93[15]. Moreover, recent data suggest that sea level rise will err towards the higher end of the model ranges. Therefore, this analysis will take a precautionary approach and consider A1B and A1F1 projections to both 2030 and to 2070.

Table 5.2.7 summarises the predicted average global sea level rise.

Table 5.2.7 Global Average Sea Level Rise (mm)[16]

Year	A1B		A1F1	
	5% minima	95% maxima	5% minima	95% maxima
1990	0	0	0	0
2000	10	27	9	28
2010	21	59	19	60
2020	35	96	32	99
2030	55	143	48	146
2040	77	200	69	204
2050	102	266	96	278
2060	126	337	130	368
2070	150	413	165	471

It is projected that sea level rise offshore the Gladstone region will be greater than predicted global levels[17].

Unpublished data from CSIRO indicates that the regional increase at Gladstone is in fact the highest on the Queensland coast. The closest point on the model, located 45 km north-east of Gladstone, gives the following regional values[18]:

- 2030: +16.5 mm
- 2070: +32.8 mm

15 Commonwealth Government of Australia (2009) *Climate Change in Australia*

16 CSIRO (2009) *Sea Levels*

17 CSIRO (2009) *Sea Levels*

18 Unpublished data from Siobhan O'Farrell at CSIRO

Therefore, for the purposes of this EIS, the sensitivity of the QCLNG Project Components to a predicted rise in sea level has been considered for:

- 2030:

  Scenario A1B: 71.5 to 159.5 mm

  Scenario A1F1: 64.5 to 162.5 mm

- 2070:

  Scenario A1B: 182.8 to 445.8 mm

  Scenario A1F1: 197.8 to 503.8 mm

Note that sea surface temperature and changes in sea water pH are not considered in this analysis because water will not be required for cooling[19] . Sea water will feed into the reverse osmosis (RO) plant, but it is anticipated that any potential impact from changing sea surface temperature will be easily mitigated.

2.2.2.4 *High Intensity Rainfall Events and Cyclones*

There is an emerging consensus that maximum tropical cyclone wind speeds are likely to increase by 5 per cent to 10 per cent, by some time after 2050. This will be accompanied by increases of 20 per cent to 30 per cent in peak tropical cyclone precipitation rates[20].

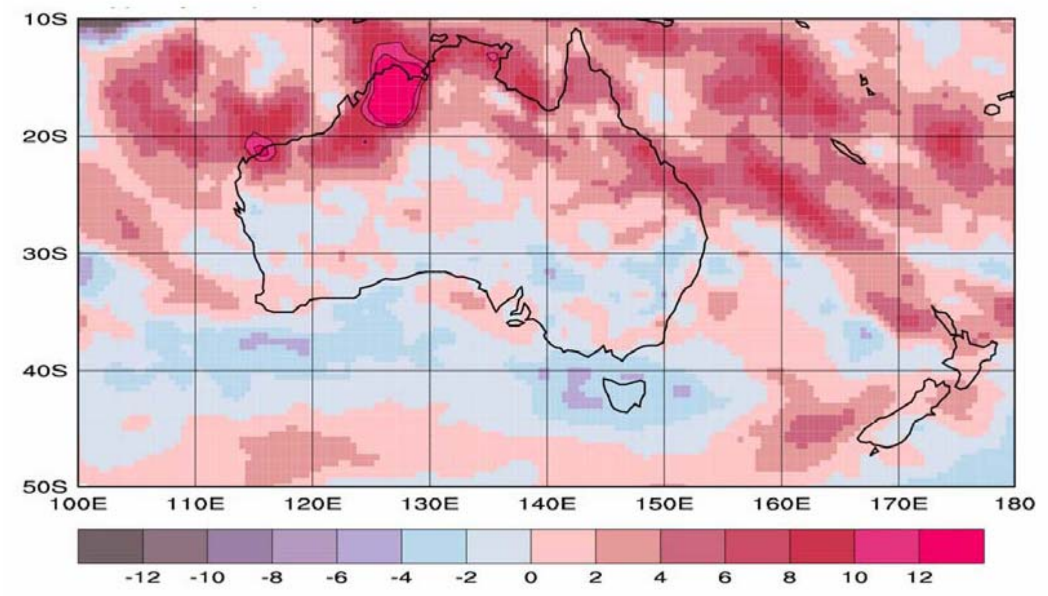
Figure 5.2.12 below shows the per cent changes in December to February extreme wind speeds (top 1 per cent each summer) between the period 1961 to 2000 and 2010 to 2050[21].

19 In the event this design assumption changes, several environmental studies (including this one) will need to be redone.

20 Acclimatise (2008) quoting K Walsh et al (2002)

21 Acclimatise (2008) quoting from the CSIRO high resolution DAR125 climate model, K. Hennessy et al, 2004

Figure 5.2.12 Changes in Extreme Wind Speeds (per cent)



It is expected that extreme wind speeds at Gladstone will increase by 4 per cent to 6 per cent.

2.2.2.5 Storm Surge and Storm Tides

Storm Surge

A storm surge is an offshore rise in water over several hours, typically associated with a cyclone. Most casualties from a tropical cyclone occur during a storm surge.

The Queensland Government commissioned Connell Wagner to undertake the concept design for the Curtis Island Bridge and associated road[22]. This report included consideration of predicted changes in storm tide and extreme wave conditions along the eastern Australian coastline, based on a study *Queensland Climate Change and Community Vulnerability to Tropical Cyclones: Ocean Hazards Assessment – Stage 3 Report* (Queensland Government 2004). Relevant aspects of the Connell Wagner report are summarised below[23].

The predicted storm tide levels for 2003 in the region are given in *Table 5.2.8*.

22 Connell Wagner 2008 Curtis Island Road / Bridge Concept Design

23 Extract from Connell Wagner 2008 gives sea level rise predictions to 2100. These data are not used here as the time horizon is too long for the LNG plant lifespan and predicted sea level rises are not linear.

Table 5.2.8 Peak Storm Tide Levels at Gladstone 2003

Location	Storm Tide Level (m AHD)		
	100 year ARI	500 year ARI	1000 year ARI
Gladstone	2.82	3.51	3.80

Source: Queensland Government (2004) Queensland Climate Change and Community Vulnerability to Tropical Cyclones: Ocean Hazards Assessment – Stage 3 Report

The Queensland Government (2004) then considered the implications for storm tide statistics in the event of

1. a combined effect of an increase in Maximum Potential Intensity (MPI) of 10 per cent and a poleward shift in tracks of 1.3° south
2. an increase in frequency of topical cyclones of 10 per cent
3. a mean sea level rise of 0.3 m

Table 5.2.9 and *Table 5.2.10* give the predicted peak storm tide levels for Gladstone in 2030 and 2070.

Table 5.2.9 Peak Storm Tide Levels at Gladstone in 2030

Emission Scenario	Storm Tide Level (m AHD) (low – high)		
	100 year ARI	500 year ARI	1000 year ARI
A1B	3.10 – 3.19	3.95 – 4.04	4.28 – 4.37
A1F1	3.09 – 3.19	3.94 – 4.04	4.27 – 4.37

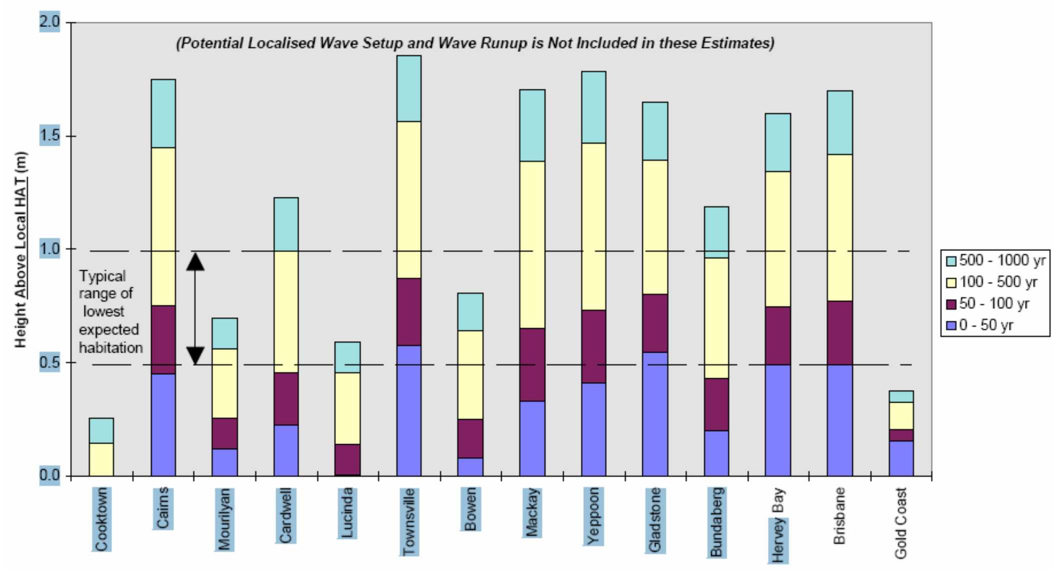
Table 5.2.10 Peak Storm Tide Levels at Gladstone in 2070

Emission Scenario	Storm Tide Level (m AHD) (low – high)		
	100 year ARI	500 year ARI	1000 year ARI
A1B	3.21 – 3.48	4.06 – 4.33	4.39 – 4.66
A1F1	3.23 – 3.53	4.08 – 4.38	4.41 – 4.71

Storm Tides

Storm tide statistics studies have been undertaken along the Australian east coast. *Figure 5.2.13* summarises the storm tide statistics for various locations, including Gladstone. As illustrated, Gladstone has a higher storm tide risk profile when compared to other locations across Australia's eastern coastline.

Figure 5.2.13 Storm Tide Statistics for Various Locations on Queensland Coastline



Source: Worley Parsons (2008) Gladstone LNG Project – Fisherman's Landing. Environmental Impact Assessment.

2.2.2.6 Bushfires

A decrease in rainfall leading to drier conditions and a change in vegetation, as a result of climate change, are two factors that could increase the frequency and intensity of bushfires.

Proposed bushfire buffer zones are outlined in *Volume 5*, *Chapter 18* of this EIS. If the increased frequency and intensity of bushfires does not raise the community bushfire risk category then it would have no effect on the recommended buffer zone.

Based on results of rainfall patterns and the 20-year lifespan per LNG train, climate change impacts are not anticipated to increase the risk of bushfires in the area.

2.2.3 Impact Assessment and Mitigation Measures

The implications of potential climate change within the lifetime of the QCLNG Project as outlined above have been or will be taken into consideration in detailed design of the LNG Component. A summary of measures taken to address climate change implications for the LNG Component includes the following:

2.2.3.1 Mean Temperature Rise

Based on preliminary studies, the estimated LNG production at the selected temperature ranges are outlined in *Table 5.2.11*.

Table 5.2.11 Estimated LNG Production Rate Based on Ambient Temperature

Ambient Temperature (°C)	Production Rate (%)
23	100
13.5	110
31	96

However, use of inlet air chilling (IAC) for refrigeration turbines means that increases in average temperature anticipated over the life of the QCLNG Project will not significantly impact on refrigeration turbine efficiency or LNG production.

For compressor air coolers, exchangers are designed with 110 per cent surface area capacity which provides sufficient buffer for the anticipated mean temperature rise.

2.2.3.2 Mean Precipitation Change

The change in precipitation is not expected to significantly impact operations given the LNG Facility will be self sufficient in water supply, with its needs met by seawater desalination using RO. While to some degree rainwater captured on site may augment RO, the LNG Facility will not depend upon rainfall. Therefore, changes in rainfall patterns should not impact on-site water supply.

2.2.3.3 High Intensity Rainfall Events and Cyclones

Structural elements for the LNG Facility will be designed and constructed in accordance with AS/NZS1170: Part II: Wind Actions, taking into consideration the appropriate designed cyclonic regional wind speeds applicable to Gladstone.

2.2.3.4 Storm Surge and Storm Tide

Maximum projected storm surge level (by 2070) is 4.71 m AHD (refer *Table 5.2.10)*, which takes into account the combined effect of an increase in Maximum Potential Intensity of cyclones by 10 per cent, a poleward shift in tracks of 1.3° south, increase in frequency of topical cyclones 10 per cent and mean sea level rise of 0.3 m. The current LNG Facility design is for an onshore plant located at or above 6 m AHD.

For marine facilities and especially the LNG loading jetty, consideration has been given to storm surge (as outlined above) plus allowance for a 200 year wave height of 2 m, plus an air gap, safety factor and rounding, to derive a jetty design height of 9.0 m AHD (above lowest astronomical tide or LAT). The top of the jetty head platform is at elevation 12.5 AHD.

2.2.3.5 *Bushfires*

Bushfire buffer zones proposed in *Volume 5*, *Chapter 18* are anticipated to be sufficient to mitigate any increased likelihood of bushfires as a result of climate change.

2.3 CONCLUSION

Potential changes in climatic conditions and associated environmental risks that may occur during the life of the QCLNG Project include changes in mean temperature, precipitation, high intensity rainfall events and cyclones, storm surges and storm tides. Climatic extremes as well as these potential changes have been, and will continue to be, considered during detailed design for the LNG Component, in particular the LNG Facility and associated infrastructure.

These potential climatic changes have been considered for their impacts on operating/production efficiency of the LNG Facility, water availability for the LNG Facility, structural integrity of infrastructure and bushfire risk. Climate change considerations have influenced the choice of technology used within the LNG Facility, the location and design of infrastructure and stormwater systems and the extent of the buffer zone around the LNG Facility proposed as mitigation against increased bushfire risks. A summary of the impacts outlined in this chapter is provided in *Table 5.2.12*

Table 5.2.12 Summary of Impacts for Climate and Climate Change

Impact assessment criteria	**Assessment outcome**
Impact assessment	Negligible
Impact type	Direct
Impact duration	Short-term for impacts associated with extreme events and bushfires Long-term for impacts associated with changes in temperature and precipitation
Impact extent	Local
Impact likelihood	Unlikely

<u>Overall assessment of impact significance:</u> negligible to minor as mitigation measures have been, and will continue to be, incorporated into detailed design to reduce potential risks from climatic extremes and climate change to the LNG Component, including the LNG Facility and associated infrastructure.