Australia Pacific LNG Project

Volume 2: Gas Fields

Chapter 4: Climate and Climate Change Adaptation

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4. Climate and climate change adaptation

4.1 Introduction

This chapter provides information on the existing climate of the south central Queensland region and explores predictions of climate change in the region in which the Australia Pacific LNG Project (the Project) gas fields will be located. It describes the potential impacts of climate change on the Project's gas fields and associated works, based on current knowledge.

Greenhouse gas emissions, their impacts and mitigation strategies specific to the gas fields are discussed in detail in Volume 2 Chapter 14.

Sections 4.2 and 4.3 of this chapter address the environmental impact statement (EIS) terms of reference sections 3.1.1 Climate and 3.1.2 Climate change adaptation, respectively.

Throughout the Project life, including site preparation, construction, operation, decommissioning and rehabilitation, the Project will be influenced by the climate. The Australia Pacific LNG's sustainability principles will be applied to the development of strategies for the gas fields to ensure that climate-induced impacts do not cause conditions which adversely impact the Project or the environment. Of Australia Pacific LNG's 12 sustainability principles, as discussed in the sustainability chapter Volume 1 Chapter 3, the relevant sustainability principles for climate in the gas fields are as follows:

- Minimising adverse environmental impacts and enhancing environmental benefits associated with Australia Pacific LNG's activities, products or services; conserving, protecting, and enhancing where the opportunity exists, the biodiversity values and water resources in its operational areas
- Identifying, assessing, managing, monitoring and reviewing risks to Australia Pacific LNG's workforce, its property, the environment and the communities affected by its activities.

Under these principles, climate and climate change values are addressed through the identification and assessment of climate change risks and the mitigation of impacts on project assets and activities through climate change strategies.

4.2 Climate

4.2.1 Climate over the gas fields' area

Information in this section is for climate in the south central Queensland region and is based on long term monitoring information. Meteorological monitoring data from the Bureau of Meteorology (BOM) stations located at Roma, Dalby and Miles have been used to characterise the climate in the Australia Pacific LNG gas fields' development area (BOM 2009a).

The Roma, Dalby and Miles monitoring stations have been selected for their close proximity to the proposed gas fields and processing facilities and the availability of data. These monitoring stations have been selected to provide a summary of the regional climate, where data collection has been carried out for between 12 to 114 years. The meteorological parameters measured at the Roma, Dalby and Miles monitoring stations include long term temperature, solar radiation, atmospheric pressure, rainfall, relative humidity and wind speed and direction. The parameters used from each site are summarised in Table 4.1. Refer to Volume 5 Attachment 28 for more details.

Table 4.1 Summary of Bureau of Meteorology monitoring sites and parameters

Region	Location	Latitude/ longitude	Record period	Parameters
Roma	Airport	26.54 °S 148.78 °E	1985 – 2009	Temperature, solar exposure, relative humidity, rainfall, surface pressure, wind speed and wind direction
Miles	Post Office	26.66 °S 150.18 °E	1885 – 2009	Temperature, solar exposure, relative humidity and rainfall
	Constance St	26.66 °S 150.18 °E	1997 – 2009	Surface pressure, wind speed and wind direction
Dalby	Airport	27.16 °S 151.26 °E	1992 – 2009	Temperature, solar exposure, relative humidity and rainfall

The more extreme weather events include big storms, floods, heat waves and bushfires which may cause impacts such as sedimentation, erosion, stormwater management, containment of waste in bunding and tailings dams, health and safety risks to personnel and interruption to transportation.

These impacts are discussed further in Volume 2 Chapter 11 – Surface water and watercourses, Volume 2 Chapter 5 – Topography, geomorphology, geology, soils and land contamination, and Volume 2 Chapter 17 – Traffic and transport.

The construction methods and management strategies for these issues are dealt with in Volume 2 Chapter 24. These include plans for sediment and erosion control, geology and soils, transport, surface water and health and safety.

4.2.2 Wind speed and direction

The wind fields in the Project area of southern central Queensland reflect the geographic situation and physical environment of the region. The environment consists of relatively flat terrain on the lee side of the Great Dividing Range, dry to semi-arid conditions with a mixture of agricultural, pastoral, and forest land uses, dispersed with small rural towns and industries, all located a significant distance from the Queensland coast. Consequently, the winds across the region are largely driven by synoptic scale influences such as pressure gradients, convergence and convection, and subsidence of cool air from aloft, rather than orographic affects and ocean-land interactions such as land-sea breezes.

The distributions of wind speed and direction observed at Roma and Miles have been used to characterise the wind fields in the Project area.

The analysis of the distribution of winds across the Project Area has identified two dominant features of the regional wind fields:

a) A large proportion of the winds blow from the north-eastern sectors (between the north and east). These winds tend to be moderate (approximately 30% of the time) or strong (approximately 3% to13% of the time).

b) There is a significant amount of calms (less than 2m/s) in the region, particularly at Miles.

The seasonal distribution of winds at Roma and Miles indicates that the winds from the northeast quadrant, and in particular from the north and north-northeast direction, dominate all year round. The

seasonal distribution also shows that winds from the south to southwest also make up another significant proportion of the winds across the region, particularly during the autumn and winter months, and to a lesser extent during the spring.

The diurnal distribution of winds also illustrates the dominance of the winds from the northeast quadrant, and in particular from the north and north-northeast direction, and show that the wind blows from this direction at all times of the day. However, the north and north-northeasterly winds are particularly prevalent during the night and early morning periods and slightly less frequent during the late evening. The diurnal profile also indicates that the winds during the afternoon, the warmest time of the day, are more evenly distributed from all directions, particularly at Roma, with a higher proportion of the higher winds from the southwest occurring at that time.

4.2.3 Temperature and solar radiation

The average maximum daily temperature recorded at the sites during summer ranges from 31.8°C at Dalby to 33.4°C at Roma. The average minimum daily temperature recorded at the sites during winter ranges from 4.5°C at Miles to 4.8°C at Dalby. On average, daily temperatures tend to increase to the west across the gas fields' development area, with Roma typically recording higher temperatures throughout the year than Miles to the east, and Dalby further to the east.

The analysis identifies a seasonal temperature profile typical of the sub-tropical Queensland climate, with cooler winter months of June, July and August and warmer summer months of December, January and February.

The amount of solar radiation at the surface is a primary driver for the weather patterns and climatic cycles that influence the Darling Downs and central Queensland region. The analysis illustrates the seasonal pattern whereby summertime solar exposure is twice that of the wintertime. As evident in the higher temperatures at Roma, solar exposure at Roma is marginally higher than at Miles and Dalby.

4.2.4 Rainfall

The annual pattern of rainfall illustrates the sub-tropical climate in the region, where 50% (Roma), 51% (Miles) and 57% (Dalby) of the annual precipitation occurs during the monsoonal months of November to February. The annual average rainfall across the region ranges between 558mm at Roma and 649mm at Miles, with the maximum monthly average rainfall occurring in December, January and February for Dalby (99 mm), Miles (95 mm) and Roma (83 mm), respectively. While rainfall predominantly occurs during the monsoonal summer period illustrating its sub-tropical climate, the relatively low amount of annual rainfall shows that the region is still quite dry due to its inland, semi-arid setting, when compared to the tropical north of Australia. On average, the total rainfall during the monsoonal months is slightly more than twice that of the drier months. In comparison in Darwin, approximately ten times as much rainfall occurs during the monsoonal months (November to March) than in the drier months (April to October).

4.2.5 Relative humidity

The seasonal availability of moisture is another important factor in influencing the climate, by affecting the transfer of heat in the atmosphere through the balance between sensible and latent heat fluxes, and the occurrence of precipitation. Relative humidity is one of several measures used to describe the amount of moisture in the atmosphere, and is the ratio of the actual amount of moisture in the atmosphere to the maximum amount that could be held, at a given temperature.

Relative humidity has been analysed from long-term averages based on daily measurements collected at 9am and 3pm at Roma, Miles and Dalby.

The analysis indicates that the cooler late autumn and winter months (May to July) tend to be relatively more humid than the warmer spring and summer months (September to January). While this may appear to contradict the suggestion that the summer months are wetter than the winter months in terms of precipitation, it is an artefact of the measure of relative humidity, where it is the ratio of the actual water vapour content and the maximum capacity of the atmosphere to hold water, at a given temperature.

Considering the significant number of drought affected years during the recent measurement period, rainfall has not significantly varied between seasons, while the amount of solar heating of the surface, and subsequent temperature, has continued in its typical summer-winter cycle. As the air temperature increases so too does its ability to hold water. However, if the amount of available water remains relatively constant, the relative humidity is reduced.

Consequently, the seasonal temperature variation influences the atmosphere's ability to hold water and, therefore, the relative humidity. As discussed in the rainfall section above, only twice the amount of rainfall occurs in the wet season in comparison to the dry season, while twice the amount of solar radiation occurs in the summer to that in the winter.

In regard to average daily variations, the analysis indicates that relative humidity is 60% higher at 9am than at 3pm across the region on average.

4.2.6 Surface pressure

Long and short-term fluctuations in atmospheric pressure are important when describing climatic patterns across the region. Monitoring data from Roma and Miles have been used to characterise the mean sea-level pressure in the region during the period 2002 to 2009.

The longer term cycles are evident in the seasonal fluctuations of mean sea-level pressure, which fluctuates around an average pressure of 1,020hPa during the drier winter months (May to August), and 1,010hPa during the wetter summer months (November to February). Within this seasonal cycle, mean sea-level pressure fluctuates on a diurnal basis between 3 to 4hPa, with solar heating of the ground during the midday-afternoon period reducing the atmospheric pressure above the ground. At night when the temperature falls, atmospheric pressure increases again.

The seasonal fluctuations are generated by the passage of high pressure systems across the low to mid latitudes during the winter months and tend to produce relatively dry, clear, stable synoptic conditions due to the subsidence of cool air from aloft. Conversely during the summer months, the passage of low pressure systems across the low to mid latitudes associated with the development of the Queensland trough and southward shift in the inter-tropical convergence zone, along with more intense solar heating, tend to produce warmer conditions and the development of afternoon thunderstorms.

4.2.7 Climate extremes

Droughts

Periodic drought is part of the Australian weather pattern. Major Australian droughts have included 1963–68, 1972–73, 1982–83 and 1991–95 (BOM 2009b).

Western Downs Regional Council, which includes Miles, and the Maranoa Regional Council, which includes Roma, has been 'drought declared' with some areas drought declared since 2001 (Department of Primary Industries and Fisheries 2009).

Floods

The Condamine River is the major watercourse within the tenement study area. As a result, there is significantly more information available with respect to historical flooding and stream flow data. 'Records of large floods along the Condamine extend back as far as 1887 at Warwick with extensive records at several other locations on the mainstream. Major floods occur regularly, on average every two years. The worst flooding recorded occurred in 1942, 1950, 1956, 1975, 1976, 1983 (twice), 1988 and 1996. Major floods generally only occur in the first half of the year although records indicate that they may also occur in late spring' (BOM 2009c). For more information, refer to Volume 2 Chapter 11 – Surface Water and watercourses.

Tropical cyclones

Queensland is susceptible to cyclones which develop over tropical waters in northern Australia. The gas fields region is within a 200km radius of Roma in south central Queensland. While there are more cyclones over the coast, there were 11 tropical cyclones within a 200km radius of Roma from 1906 to 2006 (BOM 2009d). Figure 4.1 includes notable events such as cyclones Althea, Wanda, Cliff and Gertie.

In the summer months, from January to March, tropical cyclones and tropical lows have an influence on central Queensland weather patterns. These systems often interact with regions of high pressure over southern Australia to produce strong pressure gradients over the whole of eastern Australia. Cyclones occur rarely (<0.1 per annum) in the gas fields' development area (BOM 2009e).

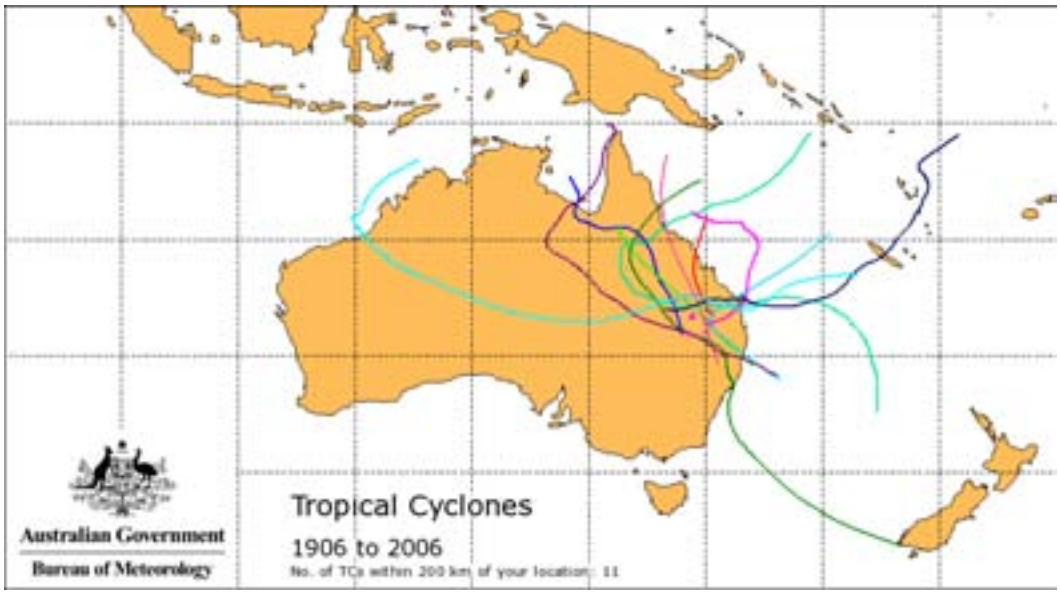

Figure 4.1 Tropical cyclones within 200km of Roma from 1906 to 2006 (BOM 2009d)

Frequency of thunderstorms and lightning strikes

The frequency of thunderstorms has been estimated from maps developed by the BOM for Australia. BOM has analysed ten years (1990 to 1999) of records of thunder-days, from 300 monitoring sites around Australia, to produce a map of average annual thunder-days. A thunder-day is defined as 'an observational day...during which thunder is heard at the station. Precipitation need not occur' (Huschke 1959). An observational day is defined from midnight to midnight, local standard time.

The frequency of lightning activity has been estimated from maps of lightning flash density developed by the BOM. Eight years of data has been analysed (1995 to 2002) from ground-based lightning detectors and NASA satellite-based instruments. The lightning flash density is defined as the number of flashes of a specific type occurring over unit area in unit time (Kuleshov et al. 2006). Total flash density is made up of cloud-to-ground flashes and intracloud flashes. Total flash density and cloud-to-ground flash densities are presented here.

Table 4.2 summarises the thunder-day and lightning flash density information for the Australia Pacific LNG gas fields and gas pipeline.

Table 4.2 Project gas fields and gas pipeline areas – annual average thunder days, total lightning flash density and cloud-to-ground flash density

Parameter	Australia Pacific LNG gas-field and pipeline
Thunder days (annual average – 1990-1999)	10 to 30 thunder-days per year
Total lightning flash density[1] (annual average – 1995-2002)	5 to 10 flashes per km^2 per year
Cloud-to-ground lightning flash density[2] (annual average – 1995-2002)	1 to 3 flashes per km^2 per year

[1] Total lightning flash density: flashes per square kilometre per year

[2] Cloud-to-ground flash density: flashes per square kilometre per year

4.2.8 Impacts of weather patterns and extremes of climate on project

When designing and constructing the gas fields particular regard has been given to the historical weather patterns and climate extremes. The south central Queensland region has a sub-tropical climate, which is characterised by a moderately distinctive wet and dry season, high temperatures and humidity.

Historical weather patterns show that summertime weather activity generates the wetter spring and summer months, relative to the drier autumn and winter months, when the solar incidence is less intense.

Construction methods and scheduling will be implemented to ensure personnel and the environment are protected. Methods and timing of construction include ensuring erosion and sediment control measures and stormwater management measures are appropriately constructed and sized to deal with anticipated amount of rainfall, and that appropriate shelter is available for the workforce in chances of severe weather. Appropriate weather protection will be provided for personnel.

Overall, south central Queensland does not experience a typical weather pattern that will restrict construction or operation. The inclusion of appropriate measures, such as site stormwater management systems and waste containment systems, will ensure personnel and the environment are protected. Further information regarding mitigation measures can be found in Volume 2 Chapter 5, Volume 2 Chapter 9, and Volume 2 Chapter 11.

4.3 Climate change

While the inherent uncertainties surrounding predicted impacts are recognised, this section discusses the gas fields' vulnerabilities to climate change and possible adaptation strategies.

4.3.1 Methodology

Effective climate change adaptation requires an awareness of the risks posed by climate change, and an understanding of the relative significance of those risks.

A climate change adaptation risk assessment was conducted to assess how alterations to weather patterns and rising sea level have the potential to impact on the gas fields. The climate change predictions from Commonwealth Scientific and Industrial Research Organisation (CSIRO), which has published the most comprehensive data to date, were compiled ahead of a climate change adaptation risk assessment workshop.

The risk assessment process was conducted in accordance with the Risk Management Standard AS/NZS ISO 31000:2009 and the Australian Government publication Climate Change Impacts and Risk Management – A Guide for Business and Government (2006). Attendees at the workshop included key decision makers on the Project, engineers and environmental specialists. Risks identified were analysed and assessed using the Australia Pacific LNG risk matrix (refer Volume 1 Chapter 1) and then screened for identification of mitigation measures. Existing measures were explored during the risk assessment process and further mitigation actions were brought forward to be included into the design criteria and operating strategies.

The climate change risk assessment process was conducted, as required by the EIS terms of reference Section 3.1.2 Climate change adaptation, to assess the Project's vulnerabilities to climate change and describe possible and preferred adaptation strategies. The climate projections used in the risk assessment are provided in Section 4.3.2. Section 4.3.3 provides the risk mitigation measures which treat the identified risks and have been incorporated into the design criteria and operating strategies. Australia Pacific LNG cooperative approach to adaptation to climate change is described in Section 4.3.4.

4.3.2 Climate projections

To assess the Project's vulnerability to climate change, predictions were gathered from the CSIRO and the Queensland Government. These are referenced in the sections below.

CSIRO projects are available for years 2030, 2050 and 2070. The Project is estimated to operate for 30 years, starting in 2014 for LNG production train 1, making projections for 2050 the most appropriate scenario. Where appropriate, 2050 projections have been used, but where predictions figures are published only for 2030 and 2070 time horizons, both have been reported and used in the assessment process.

The emissions scenarios referred to in this document include A1B, B1 and A1FI (CSIRO 2008), where:

- The B1 scenario refers to a global agreement that brings about dramatic reductions in global emissions
- The A1B scenario refers to mid-range levels of global emission
- The A1FI scenario refers to high levels of emissions, in line with recent global emissions.

Changes in the climate of Australia by 2030 do not vary greatly from one emission scenario to another. However, changes by 2070 are heavily dependent on the chosen emission scenario,

because the scenarios are highly divergent beyond 2030. The best projections for the region have been sought, but models are not all based upon the same emissions scenarios.

Several cities have climate change predictions presented in the Climate Change in Australia Cities Summaries (CSIRO 2007) including St George, approximately 150km south of Roma, and Brisbane as shown in Figure 4.2. For this study, predictions for St George have been considered as representative of the geographical region of central south Queensland while predictions for Brisbane, Rockhampton and Gladstone have been considered as representative of the region of the east coast of Queensland.

Temperature change

The information in Table 4.3 summarises the predicted mean temperature change for St George (in the south central Queensland region). The table provides the 10th, 50th and 90th percentiles of the likely change in the mean temperature. By 2050, the predicted increase in mean temperature is 3.6°C, which was chosen as the basis for determining climate change impacts in the risk assessment. In order to predict the average temperature in 2050, the predicted mean temperature change of 3.6°C is added to the historical average temperature.

Table 4.3 Mean temperature change for St George (°C)[1]

	2030			2050		
	Average (50%)	Range (10%-90%)		Average (50%)	Range (10%-90%)	
Annual	1.1	0.7	1.6	3.6	2.4	5.2
Dec-Feb	1.1	0.7	1.7	3.6	2.2	5.5
Mar-May	1.1	0.7	1.7	3.5	2.1	5.3
Jun-Aug	1.0	0.7	1.5	3.3	2.1	4.8
Sep-Nov	1.2	0.8	1.8	3.9	2.6	5.7

[1] A1B predictions (2030) and A1FI (2050), 50% percentile and range (CSIRO 2007)

LEGEND

- Major town
- Cities with climate change predictions
- Major drainage and waterbodies
- Major road

SOURCE INFORMATION

Major drainage and waterbodies (based on 250k topography)
Commonwealth of Australia (Geoscience Australia) 2009

Roads and Towns
Department of Main Roads 2009

0 50 100km

SCALE - 1 : 2,750,000 (at A4)
Latitude/Longitude
Geocentric Datum of Australia 1994

N

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Volume 2 Chapter 4
Figure 4.2 - Cities for which climate change predictions are presented by CSIRO

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Precipitation change

The information in Table 4.4 summarises the predicted percentage of rainfall change for St George, in the south central Queensland region. The table provides the 10 th, 50 th and 90th percentiles of the likely change in precipitation. By 2070, the predicted decrease in mean rainfall is 10% annually, which has been chosen as the basis for determining climate change impacts in the risk assessment. In order to predict the average precipitation in 2050, the predicted mean precipitation change 10% is subtracted from the historical average precipitation (CSIRO 2007).

As well as a decrease in annual rainfall, an increase in daily precipitation intensity (rain per rain-day) and the number of dry days is also predicted. The future precipitation regime will have longer dry spells interrupted by heavier precipitation events. Changes to extreme events would have the potential to increase erosion and flood frequency, with implications for agriculture, forestry, river flow, water quality, and the design standards of infrastructure. Drought occurrence is projected to increase over most of Australia (CSIRO 2007).

Table 4.4 Mean rainfall change for St George (%)[1]

	2030			2050		
	Average (50%)	Range (10%-90%)		Average (50%)	Range (10%-90%)	
Annual	-3	-12	5	-10	-35	17
Dec-Feb	-1	-12	10	-3	-33	33
Mar-May	-3	-16	10	-11	-44	32
Jun-Aug	-6	-19	6	-17	-49	18
Sep-Nov	-6	-18	5	-18	-47	17

[1] A1B Predictions (2030) and A1FI (2050), 50% percentile and range (CSIRO 2007)

Sea level rise

Sea level rise is not anticipated to affect the gas fields, as they are around 400km inland and 200 metres above sea level.

Cyclones

There are three components of tropical cyclones that combine to make the total hazard – strong winds, intense rainfall and induced ocean effects including extreme waves. Climate change may affect the frequency, severity and position of cyclones. There is some indication that precipitation rates may increase by 20% to 30% during tropical cyclones (CSIRO 2007). Precipitation change has been discussed in Section 4.3.2, exhibiting similar effects as during existing cyclonic events. Extreme waves will have no material impact on the gas fields region of the Project.

Projections of tropical cyclones in the Australian region are limited, but the available studies suggest there maybe an increase in the number of tropical cyclones in the more intensive categories (categories 3-5) but a possible decrease in the total number of cyclones (Department of Climate Change 2009).

Bushfires

Projections of fire risk have been undertaken for the gas fields region (Charleville) for 2020 and 2050. Fire risk is a rating calculated based on observations of temperature, relative humidity and wind speed combined with an estimate of the fuel state to predict the fire behaviour (Lucas et al. 2007). Changes in the risk of fire are summarised as percentile differences from 1974 to 2007 levels in Table 4.5. The authors of this study have used two global warming scenarios, low (Mark2) and high (Mark3). These scenarios are consistent with, but not the same as, Intergovernmental Panel on Climate Change models (B1, A1B and A1FI) (CSIRO 2008).

Projections for 2050 indicate that when the global warming scenario is low, the fire risk rises +39% above 1974–2007 levels. When the global warming scenario is high, the fire risk increases by 205% above 1974–2007 levels. These percentage changes are relative to small baseline frequencies, where at present (1973–2007) the annual average number of extreme fire danger days at Charleville is 6.8 days and in a high global warming scenario the prediction is 20.9 days by 2050.

Table 4.5 Percentile change in fire risk from average 1974-2007 levels*

Global warming scenario	2020	2050
Low (Mark2)	19.0	39.4
High (Mark3)	49.6	204.9

*Source: Lucas et al. 2007

4.3.3 Climate change adaptation

The following sections describe the climate change risk mitigation measures that have been incorporated into the design criteria and operating strategies. Alternative and further adaptation measures have been considered and documented in the risk assessment process and will be taken forward into the design phases of the Project. Climate change risk will continue to be reviewed during project implementation.

Elevated temperatures

Design for flexibility in relation to operating temperatures is part of the design considerations. Higher temperatures will affect the energy demand for cooling and compressor efficiency. Compressor operating ranges will be designed for predicted higher ambient temperatures.

Air conditioning and shading of work areas, critical plant and equipment, and temporary accommodation facilities has been, and will continue to be, included in the design of the gas fields' construction and to protect against elevated temperatures. Water pipes will be buried, preventing temperatures increasing beyond desirable levels.

These measures, which are included in the design of the gas fields and associated infrastructure, assist in adapting to climate change. The residual risk to the gas fields component of the Project was determined to be negligible.

Precipitation change

During heavy rainfall intensity events, safe systems of work are to be implemented. This will include managing travel plans, considering the storm warning and weather forecasts of BOM, and providing safe driver training to personnel. Design of water crossing, pond walls, roads and other water affected

infrastructure will be designed to standards which include safety contingencies for increased intensity of precipitation events.

Changes in precipitation frequency may cause groundwater levels to decrease. The use of treated associated water is designed to be used by the Project for all project water needs where possible, to prevent increased pressure on groundwater resources.

Erosion which may result from precipitation intensity and frequency change will be treated with engineering solutions, in accordance with erosion control guidelines. These measures, which are included in the design of the gas fields and associated infrastructure, assist in adapting to climate change.

The residual risk to the gas fields and associated infrastructure was determined to be negligible.

Humidity

The impacts of changed humidity are considered to be low, because the decrease is still well within the operating range of the equipment. Any impacts due to changes in humidity will be mitigated by a maintenance program and use of corrosion inhibitors.

The residual risk to the gas fields and the associated infrastructure was determined to be negligible.

Cyclones

Interruptions to normal business operation may occur during cyclone events, if wind and dust storms occur in the vicinity of the gas fields. Back up control systems and uninterrupted power supply will be included in the project design. Back up diesel supplies will be provided for the temporary accommodation facilities to maintain emergency power generation.

Structural elements for the gas fields will follow the building code for the appropriate cyclonic activity applicable to the gas fields' geographical region and the predicted change due to climate change.

To preserve the health and safety of project personnel, the implementation of a journey management system, emergency response plans, safe driver training and storm warnings will be included in the operations systems.

These measures, which are included in the design of the gas fields, assist in adapting to climate change. Further alternative adaptation measures which may be considered include extended journey management plans to include contact with onsite personnel about weather warnings and maintain updates to BOM weather forecasts, and design temporary accommodation facilities and enclosures for extreme wind events.

The residual risk to the gas fields and the associated infrastructure was determined to be low. This is due to the potential for more intense cyclones to present a health and safety risk to personnel.

Flooding

The change in precipitation intensity may result in increased localised flooding.

Water ponds and watercourse crossings will be designed to include a safety factor for the contingency of higher water levels.

Pipes and critical power cables will be buried to accommodate erosion.

To preserve the health and safety of personnel, the implementation of a journey management system, emergency response plans, safe driver training and storm warnings will be included in the operations systems.

These measures, which are included in the design of the gas fields, assist in adapting to climate change. Further alternative adaptation measures which may be considered include multiple exit roads for critical plant and infrastructure to prevent road closures affecting access.

The residual risk to the gas fields and the associated infrastructure was determined to be low. This is due to the potential for flooding to affect access to critical plant and infrastructure.

Bushfires

Bushfire breaks have been designed to maintain clearance around the well heads and surrounding plant and equipment. Emergency shutdowns will be employed and sprinkler systems will be designed for the temporary accommodation facilities. For more detail refer to Volume 2 Chapter 22 – Hazard and risk.

Weather forecasting services and bushfire warnings will inform the withdrawal of personnel from unsafe areas. It is also the intention to continue to work cooperatively with the rural fire service to share information and receive advice. Controlled burning will be used where appropriate.

These measures, which are included in the design of the gas fields, assist in adapting to climate change. Further alternative adaptation measures which may be considered include multiple exit roads for critical plant and infrastructure to prevent road closures effecting access and extended journey management plans to include a fire danger strategy.

The residual risk to the gas fields and the associated infrastructure was determined to be low. This is due to the potential for bushfires to affect infrastructure in the gas fields or personnel working in the gas fields.

4.3.4 Cooperative approach to climate change adaptation

Both Origin and ConocoPhillips work through the Australian Petroleum Production & Exploration Association (APPEA) as an industry body. APPEA aims to work with governments to achieve credible industry actions and governmental greenhouse policies that address greenhouse concerns in an economically and commercially viable way. APPEA and its member companies are committed to taking action on climate change, including the promotion of natural gas as apart of the Asia-Pacific Economic Cooperation energy work.

APPEA member companies are also committed to reviewing (and if necessary adapting) their risk management strategies (encompassing engineering design, safety and environmental assessments) to reflect new learnings on the likely impacts of climate variability, to complement government action, to give the community greater confidence about how the greenhouse issue is being addressed (APPEA 2003).

Australia Pacific LNG is involved in regular engagement with key governmental agencies. The aim of meeting with these stakeholders is to share project information as it comes to hand, seek guidance about regulators' requirements and expectations for the EIS and approvals process, and to achieve the proposed project assessment and approval schedule.

As part of this dialogue, the Project has met with the Gladstone Ports Corporation and Maritime Safety Queensland. A cooperative relationship has been established and will continue with these organisations and, where relevant, will involve discussions on climate change adaptation.

Australia Pacific LNG actively engaged with Department of Infrastructure and Planning (DIP) and Department of Employment, Economic Development and Innovation (DEEDI) through a number of forums, including:

- LNG Executive Group (DEEDI) – meetings, approximately bi-monthly, with other LNG proponents and senior departmental officers to discuss strategic policy matters
- Common Issues Forum (DEEDI) – fortnightly meetings with other LNG proponents to discuss operational issues of a common nature to the industry, such as co-location of gas pipeline common-user corridors established by the Queensland Government
- LNG Industry Unit (DEEDI) – separate meetings with proponents are organised where instances of commercial confidentiality is required
- Australia Pacific LNG EIS Project Group Meeting – EIS facilitation is provided through a DIP project manager and DERM representative each fortnight, to ensure that industry is provided with prompt advice on any issues raised
- Input into DIP's Water Futures for the CSG water management policy being developed by the Coal Taskforce Unit.

Australia Pacific LNG undertakes to continue its cooperative approach with government, other industry and other sectors to address adaptation to climate change. Australia Pacific LNG will take into account climate change risks of flooding, temperature change and sea level rise in the design process.

4.4 Conclusion

4.4.1 Assessment outcomes

Based on the currently available data, climate change during the lifespan of the Project is expected to be minor, in the context of the extremes in climate already experienced within the south central Queensland region.

Gas fields' infrastructure will be designed and constructed to cope with the existing climate and future potential climate change. Predicted changes in temperature, precipitation, cyclones and bushfires have been considered, and the vulnerabilities of the gas fields have been assessed using the appropriate risk assessment process.

Potential consequences of climate change that have been considered include:

- Exposure to higher temperatures
- Flooding from intense rainfall
- Reduction in rainwater availability
- Erosion
- Damage from cyclonic conditions
- Damage from bushfires.

Design features for wind action, flooding and bushfires have been incorporated into the design criteria and will continue to be considered during the detailed design phase. Strategies to mitigate climate change impacts during the construction and operation phases of the Project have been identified.

It was concluded from the risk assessment discussed above that there is currently adequate design controls and strategies in place or planned for to adequately mitigate climate change risk. Climate change risk will continue to be assessed during further stages of project implementation.

A summary of the environmental values, sustainability principles, potential impacts and mitigation measures in relation to climate and climate change associated with the gas fields are presented in Table 4.6.

This table also includes the residual risk levels for climate and climate change. A risk assessment has been undertaken to identify the potential risks, causes and consequences from the climate and climate change. Mitigation measures to reduce the risk have been nominated and the residual risk has been calculated. Further details on the risk assessment methodology are provided in Volume 1 Chapter 4.

Table 4.6 Summary of environmental values, sustainability principles, potential impacts and mitigation measures

Environmental values	Sustainability principles	Potential impacts	Possible causes	Mitigation and management measures	Residual risk level
Life, health and well-being of people. Diversity of ecological processes and associated ecosystems.	Minimising adverse environmental impacts and enhancing environmental benefits associated with Australia Pacific LNG's activities, products or services; conserving, protecting, and enhancing where the opportunity exists, the biodiversity values and water resources in its operational areas.	Sedimentation, erosion, stormwater management, containment of waste in bunding and tailings dams, health and safety risks to personnel and interruption to transportation	Extreme climate events: Droughts Floods Tropical Cyclones	Refer to construction methods as outlined in Volume 2 Chapter 11 – Water Resources and Volume 2 Chapter 5 – Topography, geomorphology, geology, soils and land contamination and Volume 2 Chapter 17 – Traffic and transport.	Low
Life, health and well-being of people. Diversity of ecological processes and associated ecosystems.	Identifying, assessing, managing, monitoring and reviewing risks to Australia Pacific LNG's workforce, its property, the environment and the communities affected by its activities	Increased health and safety risk to personnel Heat damage to infrastructure Higher cooling and energy demand	Elevated Temperatures	Shading and air-conditioning of work areas, critical plant and equipment, temporary accommodation facilities and waiting areas. Safe work procedures for hot conditions. Water pipes buried to prevent unnecessary temperature increase. Design for increased cooling loads.	Low
Life, health and wellbeing of people. Diversity of ecological processes and associated ecosystems.		Drought Decreased water quality Impacts on rivers and wetlands	Precipitation Change	Allowance for increased precipitation intensity in the existing design of water affected infrastructure. Erosion management measures.	Low

Environmental values	Sustainability principles	Potential impacts	Possible causes	Mitigation and management measures	Residual risk level
		Dust due to dry windy conditions Erosion and sedimentation Increased overland flow runoff		Journey management plans incorporating storm warnings and weather forecasts. Safe driver training.	
Life, health and wellbeing of people. Diversity of ecological processes and associated ecosystems.		Impact on corrosion rates Increase risk of heat stress and dehydration	Humidity	Gas fields inspection and maintenance program. Safe work procedures for hot conditions.	Low
Life, health and wellbeing of people. Diversity of ecological processes and associated ecosystems.		High wind speeds effecting structures Tree fall impact on structures Health and safety risk to personnel	Cyclones	Operational systems to include journey management plans, safe driver training and storm warnings. Follow the building code for appropriate cyclone category. Back up control systems and uninterrupted power supply. Back up diesel supply in permanent and temporary accommodation facilities for emergency power generation.	Low

Environmental values	Sustainability principles	Potential impacts	Possible causes	Mitigation and management measures	Residual risk level
Life, health and wellbeing of people. Diversity of ecological processes and associated ecosystems.		Loss of site access Erosion and sedimentation Wash away of personnel, pipelines or associated infrastructure	Flooding	Water storage ponds and water course crossings will be designed to include a safety margin for climate change. Operations systems to include journey management plans, safe driver training and storm warnings. Pipes and critical power cables will be buried to accommodate erosion.	Low
Life, health and wellbeing of people. Diversity of ecological processes and associated ecosystems. .		Bushfire encroaching on the gas fields or personnel	Bushfires	Bushfire buffer areas. Emergency response plan to address bushfire risk. Bushfire warnings incorporated in journey management plans. Australia Pacific LNG will continue to work cooperatively with the rural fire service to share information and receive advice.	Low

4.4.2 Commitments

In order to manage potential impacts of climate and climate change associated with the gas fields and associated infrastructure, Australia Pacific LNG will:

- Incorporate adaptive management approach to climate change throughout the life of the Project
- Incorporate the agreed preferred climate change strategies which resulted from the risk assessment into the design process
- Cooperate with government, other industry and other sectors to address adaptation to climate change.

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