11. CLIMATIC ADAPTATION

This chapter provides a summary of the existing climate and climate extremes in the vicinity of the project development area in terms of rainfall, air temperature, wind and other factors that potentially affect the management of the project. An assessment of the project's vulnerabilities to climate change is also provided. Prediction of climate change and its effect have inherent uncertainties and best efforts to incorporate adaptation to climate change are included.

For the detailed findings on climate change adaptation refer to Appendix D, Greenhouse Gas Impact Assessment. Environmental protection objectives have been developed and the avoidance, mitigation and management measures to achieve these objectives identified.

11.1 Legislative Context and Standards

The following legislation, policy and guidelines are relevant to identifying climate change and adaptive strategies during construction, operation and decommissioning of the project.

11.1.1 National Framework for Climate Change Adaptation

Climate change adaptation is one pillar of the Australian Government's three-pillar strategy to address climate change, with the other pillars being emissions reduction (e.g., the introduction of the Australian Government's Climate Change Plan (Australian Govt., 2011) and carbon pricing) and Australia's participation in developing a global response. As such, the government is progressing a number of actions specifically focused on climate change adaptation separate to the emissions reductions initiatives described in Chapter 10, Greenhouse Gas Emissions. Key milestones for climate change adaptation to date are outlined below.

National Climate Change Adaptation Framework (COAG, 2007). In 2007, the Council of Australian Governments (COAG) endorsed the National Climate Change Adaptation Framework. Recognising climate change adaptation is a long-term agenda, the framework established targeted, medium-term strategies to guide actions by governments for the period 2007 to 2014. Strategies aim to support informed decisions on adaptation and include identifying sectors and regions especially vulnerable to climate change impacts, with Australia's coast being a particular focus.

Adapting to Climate Change in Australia (DCCEE, 2010c). In early 2010, the Department of Climate Change and Energy Efficiency released its position paper on adapting to climate change in Australia. The position paper sets out the Australian Government's vision for adapting to the impacts of climate change, and expresses the Australian Government's desire to work through COAG to develop a national adaptation agenda.

Climate Change Adaptation Actions for Local Government (DCCEE, 2010d). Building the capacity of local governments to identify and implement climate change adaptation actions has also been an area of Australian Government focus. In 2010, the Department of Climate Change and Energy Efficiency re-issued a report, first published in 2007, on climate change adaptation actions for local government, which considers, along with other matters, climate change adaption in the context of local government planning and development approval functions.

The Garnaut Climate Change Review (Garnaut, 2008). This report was commissioned by the Commonwealth, state and territory governments in 2007 and examines the impacts on the Australian economy from climate change. Policies and policy frameworks to improve sustainable prosperity are also recommended.

11.1.2 State Policies and Action Plans

The Queensland Government's focus on climate change adaptation is governed through state planning policies, as well as climate and community action plans and planning schemes. Those relevant to the project include:

- **ClimateSmart Adaptation 2007-2012.** An action plan for managing the impacts of climate change, originally prepared by the Queensland Government Department of Natural Resources and Water (DNRW, 2007a). Containing 62 actions across sectors, including business and industry, the five-year plan was developed as part of Queensland's broader ClimateSmart 2050 strategy. The Office of Climate Change now has responsibility for implementing the plan.
- **State Planning Policy: Mitigating the Adverse Impacts of Flood, Bushfire and Landslide 1/03.** Made under the *Integrated Planning Act 1997*, which has since been replaced by the *Sustainable Planning Act 2009*, this state planning policy requires likely impacts of climate change on natural hazards to be incorporated into hazard assessment studies. Suitable data sources for climate change predictions must be used.
- **ClimateQ: Toward a Greener Queensland** (DERM, 2009b). This report outlines Queensland's response to climate change, following a review of Queensland's climate change strategies in 2008 based on national and international developments.
- **Western Downs 2050 Community Plan** (WDRC, 2011). This report includes mention of discussing and addressing climate change in future planning and works to limit impacts.
- **Toowoomba Regional Council's 2009-2014 Corporate Plan** (TRC, 2009). This plan states that the Toowoomba region is responsive to climate change and that the council will develop and implement a response to climate change, will encourage environmentally sustainable choices and encourage resource-use efficiency for developments.
- **Goondiwindi Regional Council's 2009-2014 Corporate Plan** (GRC, 2009). This plan mentions the council will 'liaise with stakeholders and other levels of government to identify the local impacts of climate change' and 'consider, evaluate and communicate the impacts of climate change to our communities'.

11.1.3 Australian Standards

Australian standards that address climatic factors in design (but not specifically climate change) include:

- AS/NZS 1170.2:2011 Structural Design Actions – Part 2: Wind Actions (Standards Australia, 2011).
- AS 3959-2009 Construction of buildings in bushfire-prone areas (Standards Australia, 2009b).

11.2 Assessment Methods

The objective of the study was to identify the project's vulnerability to changing climate patterns and describe climate change adaptation strategies that may be adopted for the design, construction and operation of the project. The study involved:

- Summarising the climate parameters and climatic extremes presently experienced within the project development area.
- Reviewing emerging Australian and Queensland government frameworks that deal with climate change adaptation.

- Reviewing projections for various climate parameters reported by the Intergovernmental Panel on Climate Change (IPCC), the Australian Government and the Queensland Government.
- Assessing project-related risks associated with projected climate change.
- Developing a climatic adaptation strategy for the project that is consistent with emerging frameworks.

More specifically, the Garnaut Climate Change Review (Garnaut, 2008) was used to predict the potential impacts that may arise due to changes in climate. The climate change predictions were based on three global emission scenarios, as described below:

Scenario 1. No action is taken to mitigate climate change resulting in a continuation of increasing emissions throughout the twenty-first century, accelerating the rate of increase in atmospheric concentrations of greenhouse gases. Greenhouse gas concentrations are predicted to reach 1,565 ppm CO_2 equivalent, which is more than 3.5 times higher than pre-industrial concentrations, by 2100.

Scenario 2. Emissions peak and decline steadily, so that atmospheric concentrations stop rising in 2060 and stabilise around 550 ppm CO_2 equivalent (one third the concentration reached in Scenario 1).

Scenario 3. Emissions are reduced immediately and decline more sharply than in Scenario 2. Atmospheric concentrations overshoot to 530 ppm CO_2 equivalent mid century and decline toward stabilisation at 450 ppm CO_2 equivalent early in the twenty-second century.

The Garnaut review details Australian emission trajectories for each of the three global emission scenarios, within the context of Australia playing a fair and proportionate part to constrain greenhouse gas emissions through an effective global agreement. The trajectories give an indication of the greenhouse emission cuts required in Australia to achieve the 550 ppm (Scenario 2) and 450 ppm CO_2 equivalent (Scenario 3) stabilisation goals.

11.3 Existing Environment

The information presented below has been drawn from Appendices A, Planning Assessment; C, Air Quality Impact Assessment; E, Geology, Landform and Soils Impact Assessment; G, Groundwater Impact Assessment; H, Surface Water Part A: Fluvial Geomorphology and Hydrology Impact Assessment; O, Economic Impact Assessment; and S, Preliminary Hazard and Risk Assessment.

11.3.1 Climate

Temperatures within the project development area are typical of subtropical regions, with mean monthly minimum temperatures ranging from 3.6^{o}C in winter to 21^{o}C in summer and maximums ranging from 17^{o}C in winter to 35^{o}C in summer. Rainfall displays a consistent pattern across the project development area and ranges from a long-term monthly average of 20 to 40 mm in winter to 70 to 100 mm in summer. Evaporation rates are approximately five times higher in summer months than in winter months.

Wind patterns differ across the northern, central and southern parts of the project development area (see Figure 4.4). The central area has winds characterised by an east to west flow in the afternoons. The northern and southern areas show a more even spread of wind direction.

The project development area experiences approximately 20 thunderstorm days per year, which can result in strong winds, heavy rainfall and flash flooding.

11.3.2 Extreme Climatic Events

Flood records for the project development area extend back to 1862 (see Figure 4.6 for the flooding extents from 1956 to 1988 and Figure 4.7 for the extent of the 31 December 2010 flooding event). Floods can be described as minor, moderate and major, with major floods occurring on average every two years for the Condamine River and generally in late spring, summer and autumn. The worst floods in the Condamine River Catchment were reported in 1942, 1956, 1976, 1983, 1996, 2001, 2004, 2010 and 2011. The Border Rivers Catchment recorded its worst flooding in 1956, 1976, 1996, 1998, 2010 (twice) and 2011.

In the past decade, the region has been severely affected by drought conditions. Between 2000 and 2009, parts of Toowoomba, Western Downs and Southern Downs regional councils were either partially or fully drought declared, while parts of the Goondiwindi Regional Council were drought declared between 2002 and 2009. Figure 4.12 shows the drought-declared areas in Queensland in 2009 and 2010.

The existing environment contains areas of natural bushland and grassland. The hot summers, prolonged cycle of drought and drought-breaking rains mean that bushfires, as well as floods, may affect the area. The project development area has both low and medium bushfire hazard areas (see Figure 4.5). There are no areas of high-risk bushfire hazard. Increased bushfire hazard areas generally correspond with the state forests and other vegetated areas within the project development area (Appendix A, Planning Assessment).

In the past 100 years (from 1906 to 2006), tropical cyclones have passed through the immediate vicinity of the project development area (i.e., within 200 km of Dalby) 15 times (Figure 11.1) (BOM, 2011a).

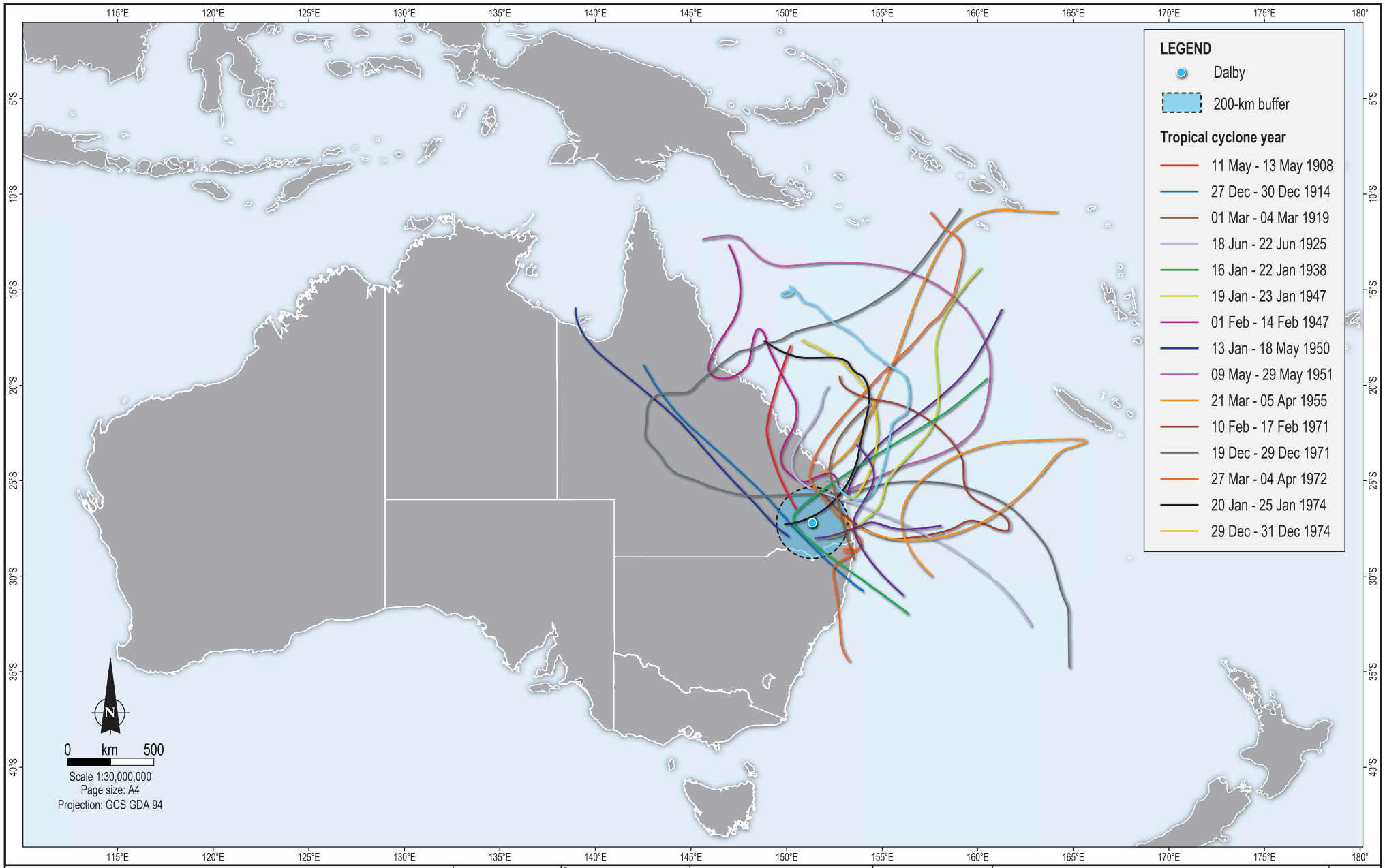
In the project development area, landslides are considered unlikely due to the limited extent of steep slopes and the material properties of the rock and soil.

11.4 Issues and Potential Impacts

Regarding climate change, the Bureau of Meteorology (BOM, 2011b) states:

> A cooler-than-average global mean temperature has not been recorded since 1985 (for the last 25 years). The past 10 years have been the globe's hottest on record with an anomaly of +0.46°C. Increasing global mean temperatures derived from instrumental measurements are consistent with other independent indicators of climate change, such as reductions in ice and snow cover, and rises in global sea levels.

Considering this, the effect of climate change on weather patterns may alter the frequency and intensity of weather-related disasters. Climate change impacts may also affect the project adversely or have negative impacts on agricultural productivity and biodiversity in the region; however, directly linking these adverse impacts on climate change poses challenges.



Source:
Tropical cyclones from Bureau of Meteorology.
Countries from ESRI.

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Date: 28.11.2011
MXD: 7040AC_04_GIS195_v1_1
File Name: 7040_04_F11.01_GIS_GL

Arrow Energy

Surat Gas Project

arrow energy go further

Tropical cyclones within 200 km of Dalby from 1906 to 2006

Figure No: **11.1**

Predicted climate change impacts presented in the Garnaut review (Garnaut, 2008) are shown in Table 11.1. Based on the information provided in the review, the climate change predictions and impacts have been made as specific to the project's location as possible.

Table 11.1 Climate change impacts predicted by the Garnaut Review

Aspect	Location	Year	Scenario 1	Scenario 2	Scenario 3
Temperature	Global	2030	Predicted increase in average temperature 1.3°C	Predicted increase in average temperature 1.2°C	Predicted increase in average temperature 1.2°C
		2070	Predicted increase in average temperature 3.5°C	Predicted increase in average temperature 2°C	Predicted increase in average temperature 2°C
		2100	Predicted increase in average temperature 4.5°C	Predicted increase in average temperature 1.5°C	Predicted increase in average temperature 2°C
Precipitation	Queensland	2030	Decrease from 1990 level by 2.4%	Not specifically determined	Not specifically determined
		2070	Decrease from 1990 level by 8.6%	Not specifically determined	Not specifically determined
		2100	Decrease from 1990 level by 12.7%	Not specifically determined	Not specifically determined
Cyclones and storms	Global	NA	Increased intensity		
		NA	Frequency same or decreased		
Bushfires	Australia	2013	5 to 25% increase in number of days with extreme fire weather	Not specifically determined	Not specifically determined
		2034	15 to 65% increase in number of days with extreme fire weather	Not specifically determined	Not specifically determined
		2067	100 to 300% increase in number of days with extreme fire weather	Not specifically determined	Not specifically determined
Heatwaves	Brisbane	2008	0.9 days over 35°C	Not specifically determined	Not specifically determined
		2030	1.7 days over 35°C	Not specifically determined	Not specifically determined
		2070	8 days over 35°C	Not specifically determined	Not specifically determined
		2100	21 days over 35°C	Not specifically determined	Not specifically determined
Agriculture	Australia	NA	Crop production affected by changes in average rainfall and temperature. Livestock affected by quantity and quality of pastures. Severe weather events (bushfire, flooding) reduce production. Increased temperature alters occurrence of pests and disease. Potential for carbon fertilisation if crop growth is not restricted by temperature and rainfall.		

Table 11.1 Climate change impacts predicted by the Garnaut Review (cont'd)

Aspect	Location	Year	Scenario 1	Scenario 2	Scenario 3
Dryland cropping - wheat	Dalby, Queensland	2030	8.2% cumulative yield change	1.6% cumulative yield change	4.8% cumulative yield change
		2100	-18.5% cumulative yield change	-3.7% cumulative yield change	-1.0% cumulative yield change
Dryland cropping - wheat	Emerald, Queensland	2030	7.2% cumulative yield change	1.8% cumulative yield change	4.4% cumulative yield change
		2100	-10.1% cumulative yield change	-2.5% cumulative yield change	0% cumulative yield change
Irrigated agriculture	Murray Darling	2030	12% decline in economic value of production	3% decline in economic value of production	3% decline in economic value of production
		2050	49% decline in economic value of production	6% decline in economic value of production	6% decline in economic value of production
		2100	92% decline in economic value of production	6% decline in economic value of production	20% decline in economic value of production
Water supply infrastructure	Australia	2100	34% increase in cost of supplying water	4% increase in cost of supplying water	5% increase in cost of supplying water
Temperature-related deaths	Queensland	2100	Over 4,000 additional heat-related deaths relative to no climate change	Fewer deaths relative to no climate change	Fewer than 80 additional heat-related deaths relative to no climate change
Geopolitical stability in Asia-Pacific	Asia Pacific	2100	Displacement of people from Southeast Asian cities (sea rise)	Less displacement (lower sea rise)	Less displacement (lower sea rise)
Ecosystems	Global	NA	Loss of biodiversity in high altitudes, wet tropics, coastal freshwater wetlands, coral reefs increasing with higher impact scenarios.		
International trade	Global	NA	Affected economies (China, India, Indonesia) reducing demand for Australian goods.		

In comparison, Table 11.2 presents a summary of the Queensland Government's predicted impacts of climate change by 2070 (as shown in Appendix D, Greenhouse Gas Impact Assessment).

Table 11.2 Queensland Government's climate change predictions

	Queensland Average	Eastern Downs	Maranoa and District	Central Queensland
Temperature				
Change previous decade*	0.4°C	0.5°C	0.5°C	0.5°C
Predicted change by 2070	4.4°C	4.5°C	5°C	4.5°C
Predicted number of days above 35°C (% change)	437%	300%	200 to 300%	400%

Table 11.2 Queensland Government's climate change predictions (cont'd)

	Queensland Average	Eastern Downs	Maranoa and District	Central Queensland
Rainfall				
Change in last decade in comparison with previous 30 years**	-8%	-12%	-8%	-14%
Predicted change (% change)***	-4.3%	-32 to +16%	-34 to +17%	-35 to +17%
Evaporation				
Predicted change (% change)	10.5%	7 to 15%	6 to 15%	7 to 15%

Note: 1. The project development area spans across the Eastern Downs, Maranoa and District, and Central Queensland regions. 2. The predictions are based on a high emissions scenario – fiftieth percentile projection.

* Some variation can be expected between decades due to the effects of longer-term cycles such as La Nina and El Nino events.

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

*** The 'best estimate' of projected rainfall change shows a decrease under all emissions scenarios.

For the Eastern Downs, Maranoa and District, and Central Queensland regions, it is also projected there will be an increased risk and intensity of bushfires (DERM, 2010c).

Potential climate change impacts on the geopolitical stability in Asia Pacific and international trade are not considered relevant within the lifespan of the project. Potential implications to the project (i.e., design, construction and operation) from the climate change impacts described in Table 11.1 are detailed in the following sections.

11.4.1 Rainfall, Evaporation and Drought

Predicted changes relating to reduced rainfall, higher rates of evaporation and subsequently more prevalent drought conditions could potentially affect the Surat Gas Project through:

- Increased bushfire risk arising from drier conditions caused by decreased rainfall, increased evaporation and higher temperatures.
- Increased evaporation rates from dams, which are not expected to impact the project adversely.
- Increased costs associated with purchase of potable water as water supplies are affected and water infrastructure becomes more costly.

11.4.2 Air Temperature

The predicted increase in global temperatures for the three scenarios developed as part of the Garnaut review ranges from 2°C to 3.5°C by 2070. Predictions specific to the project development area, however, show potential for a 4.6°C increase in air temperature over the next 60 years, with the potential for:

- Increasing the operational temperature range over which project infrastructure, equipment and construction materials must withstand.
- Decreasing efficiency of power generation through gas engines, which can be adversely affected by increasing ambient temperatures.
- Altered risks to the health of workers, in particular incidence of heat stress and insect-borne diseases. Tropical diseases such as Ross River virus and dengue fever, for which temperature is a key determinant, are expected to increase under climate change (DERM, 2009b).

11.4.3 Severe Weather Events

The Garnaut review predictions for the patterns of extreme weather events that have potential impact on the project include:

- Increased intensity of cyclones and storms.
- Increase in the number of days with extreme fire weather.
- Stronger winds arising from more frequent and severe weather events, which could increase wind shear stresses on the production facilities.
- More frequent flood events.

11.5 Management Objective

The environmental protection objective for climatic adaptation is to minimise the project's vulnerability to climate change.

11.6 Avoidance, Mitigation and Management Measures

A proactive approach will be taken to ensure that effects of climate change are considered in the planning and design, construction, operations and decommissioning phases of the project. The actions forming the project's proposed climate change adaptation strategy are set out below:

- Ensure maximum design temperatures of infrastructure, equipment and materials are sufficient to account for future increases in ambient air temperature. [C025]
- Design and construct the production facilities in accordance with current Australian standards addressing climatic factors including wind, bushfires and floods. [C026]
- Deploy preventive and responsive measures for bushfire management and flooding, as set out in Chapter 25, Preliminary Hazard and Risk. [C027]
- Incorporate climate change-induced health risks into future workplace health, safety and environmental management plans, as set out in Chapter 25, Preliminary Hazard and Risk. [C028]
- Estimate and include climate change costs in business cost projection and consider emerging business opportunities that climate change may generate. [C029]
- Engage in government or industry climate change programs as set out in Chapter 10, Greenhouse Gas Emissions. [C030]

In addition to the proposed measures that will ensure the safe and efficient operations of the project, Arrow will seek ways to lower water consumption through water-efficient technologies and practices and/or by installation of water-efficient devices in recognition of the importance of this valuable resource and its potential to be affected by changes in our current climate. Additional detail on water-related management measures, including those for beneficial use of coal seam gas water, are provided in the avoidance, monitoring, mitigation and management sections of Chapter 14, Groundwater and Chapter 15, Surface Water.

11.7 Residual Impacts

There is significant uncertainty associated with climate change projections.

Based on the current understanding of predicted changes to climate across the project development area and Arrow's proposed climate adaptation strategy, the significance of any residual impacts that climate change may pose on the project, is considered to be low.

11.8 Inspection and Monitoring

Arrow will monitor emerging opportunities to manage potential changes in climate that may have an impact on the project. [C513]