



# APPENDIX X – Environmental Impact Statement

## Climate change risk assessment

Prepared for Lake Lyell Project Pty Ltd



# Lake Lyell Pumped Hydro Energy Storage Project

## Climate change risk assessment

Lake Lyell Project Pty Ltd

E221111 RP18

November 2025

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## Executive Summary

EnergyAustralia Renewables Pty Ltd (EnergyAustralia) in partnership with EDF power solutions (EDFA), referred to as Lake Lyell Project Pty Ltd (LLP), is developing the Lake Lyell Pumped Hydro Energy Storage (PHES) Project (the project). The project will have the capacity to store up to 3,080 megawatt hours (MWh) of energy and generate at 385 megawatts (MW) for 8 hours or generate up to around 440 MW for a shorter period. At a basic level, it will consist of upper and lower water reservoirs, a pipeline connecting them, and a hydro-electric power station connected to the national energy grid that is capable of generating or consuming electricity.

This report presents a climate change risk assessment (CCRA) for the project. The report briefly describes the project, identifies assessment guidelines, and contains the CCRA itself.

The climate in the area of the project in the near future (2030) and far future (2070) was characterised using a range of data sources, and notably the projection data from the NSW and Australian Regional Climate Modelling (NARClIM) project. Climate was characterised using information on temperature, rainfall, drought, fire danger and storms.

A climate risk and adaptation workshop was held with EnergyAustralia. The effects of the future changes in climate were considered in relation to potential impacts on the construction and operation of the project, including areas such as physical structures, transport and worker safety. In total, 10 potential construction impacts and 28 potential operational impacts were identified. In the workshop, the potential risks were discussed with the project team.

Construction risks were only assessed for the near-future scenario. Initially, a mixture of low, medium and high risk ratings were obtained. High initial risks were associated with delays to construction as a result of bushfires and flooding. Operational risks were assessed for the near-future and far-future scenarios. All of the initial risk ratings were either 'low' or 'medium'.

Planned and additional measures – including design measures, operational measures and plans – were then considered.

The final step was the assessment of residual risks once all measures had been applied. For most potential climate change impacts during construction, the residual risk was determined to be 'low'. Three impacts (relating to delays caused by bushfires and storms) had a medium residual risk. For project operation, and for all potential climate change impacts, the residual risk was determined to be 'low'. For these residual risks, it is therefore considered that additional mitigating contingencies would not need to be considered.

# TABLE OF CONTENTS

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<b>Executive Summary</b>	<b>ES.1</b>	
<b>1 Introduction</b>	<b>1</b>	
1.1 Background	1	
1.2 Assessment guidelines and requirements	1	
<b>2 Project description</b>	<b>5</b>	
<b>3 Climate change risk assessment</b>	<b>7</b>	
3.1 Scope of the assessment	7	
3.2 Past and future climate	8	
3.3 Initial risk rating with no measures	19	
3.4 Identification of current/proposed and additional measures	20	
3.5 Residual risk	21	
3.6 Review	21	
<b>4 Summary and conclusions</b>	<b>22</b>	
<b>References</b>	<b>24</b>	
<b>Abbreviations</b>	<b>25</b>	
<b>Annexures</b>		
Appendix A	Risk rating method	A.1
Appendix B	Climate change risk register	B.1
<b>Tables</b>		
Table 3.1	Overview of NARClIM data	9
Table 3.2	Temperature statistics for Lithgow (2007-2023)	10
Table 3.3	Summary of temperature projections – Low emissions scenario (SSP1-2.6) (4 km grid cell containing project)	11
Table 3.4	Summary of temperature projections – High emissions scenario (SSP3-7.0) (4 m grid cell containing project)	11
Table 3.5	Rainfall statistics for Lithgow (2007-2023)	13
Table 3.6	Summary of rainfall projections – Low emissions scenario (SSP1-2.6) (4 km grid cell containing project)	13
Table 3.7	Summary of rainfall projections – High emissions scenario (SSP3-7.0) (4 km grid cell containing project)	13
Table 3.8	Summary of maximum rainfall projections (East Coast cluster)	13

Table 3.9	Summary of time in drought (East Coast cluster; RCP8.5)	14
Table 3.10	FFDI at locations in the region (DPIE 2019)	15
Table 3.11	Summary of fire danger projections – Low emissions scenario (SSP1-2.6) (4 km grid cell containing the project)	15
Table 3.12	Summary of fire danger projections – Low emissions scenario (SSP1-2.6) (4 km grid cell containing the project)	15
Table 3.13	Summary and interpretation of climate projections	17
Table 3.14	Initial risk profile for the project	20
Table 3.15	Climate change impacts with high risk (construction)	20
Table 3.16	Climate change impacts with residual risk above ‘low’ (construction)	21
Table A.1	Likelihood criteria	A.1
Table A.2	Consequence criteria	A.1
Table A.3	Risk matrix	A.2
Table B.1	Climate change risk register – construction	B.2
Table B.2	Climate change risk register – operation	B.5

## Figures

Figure 1.1	Regional context	3
Figure 1.2	Local context	4
Figure 2.1	Project overview	6
Figure 3.1	Historical temperature data for Lithgow	10
Figure 3.2	Historic rainfall data for Lithgow	12

# 1 Introduction

## 1.1 Background

EnergyAustralia Renewables Pty Ltd (EnergyAustralia) in partnership with EDF power solutions (EDF), referred to as Lake Lyell Project Pty Ltd (LLP), is developing the Lake Lyell Pumped Hydro Energy Storage (PHES) Project (the project). The project will have the capacity to store up to 3,080 megawatt hours (MWh) of energy and generate at 385 megawatts (MW) for 8 hours or generate up to around 440 MW for a shorter period. At a basic level, it will consist of upper and lower water reservoirs, a pipeline connecting them, and a hydro-electric power station connected to the national energy grid that is capable of generating or consuming electricity.

The project is located approximately 5 kilometres (km) west of Lithgow and 110 km west of the Sydney central business district, shown in Figure 1.1 and Figure 1.2. The project takes advantage of existing infrastructure (i.e. Lake Lyell) associated with Mt Piper power station which will be decommissioned in the coming decades and allows Lake Lyell to continue to serve a specific purpose in electricity generation (consistent with its existing use).

In June 2024, the Minister for Planning and Public Spaces declared the project to be Critical State Significant Infrastructure (CSSI). Accordingly, approval for the project is required under Part 5, Division 5.2 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). This requires the preparation of an environmental impact statement (EIS) for the project in accordance with Secretary's environmental assessment requirements (SEARs) and the approval of the Minister. EMM Consulting Pty Limited (EMM) has been engaged by EnergyAustralia to prepare the EIS.

This climate change risk assessment (CCRA) is an appendix to the project's EIS and should be read in conjunction with it.

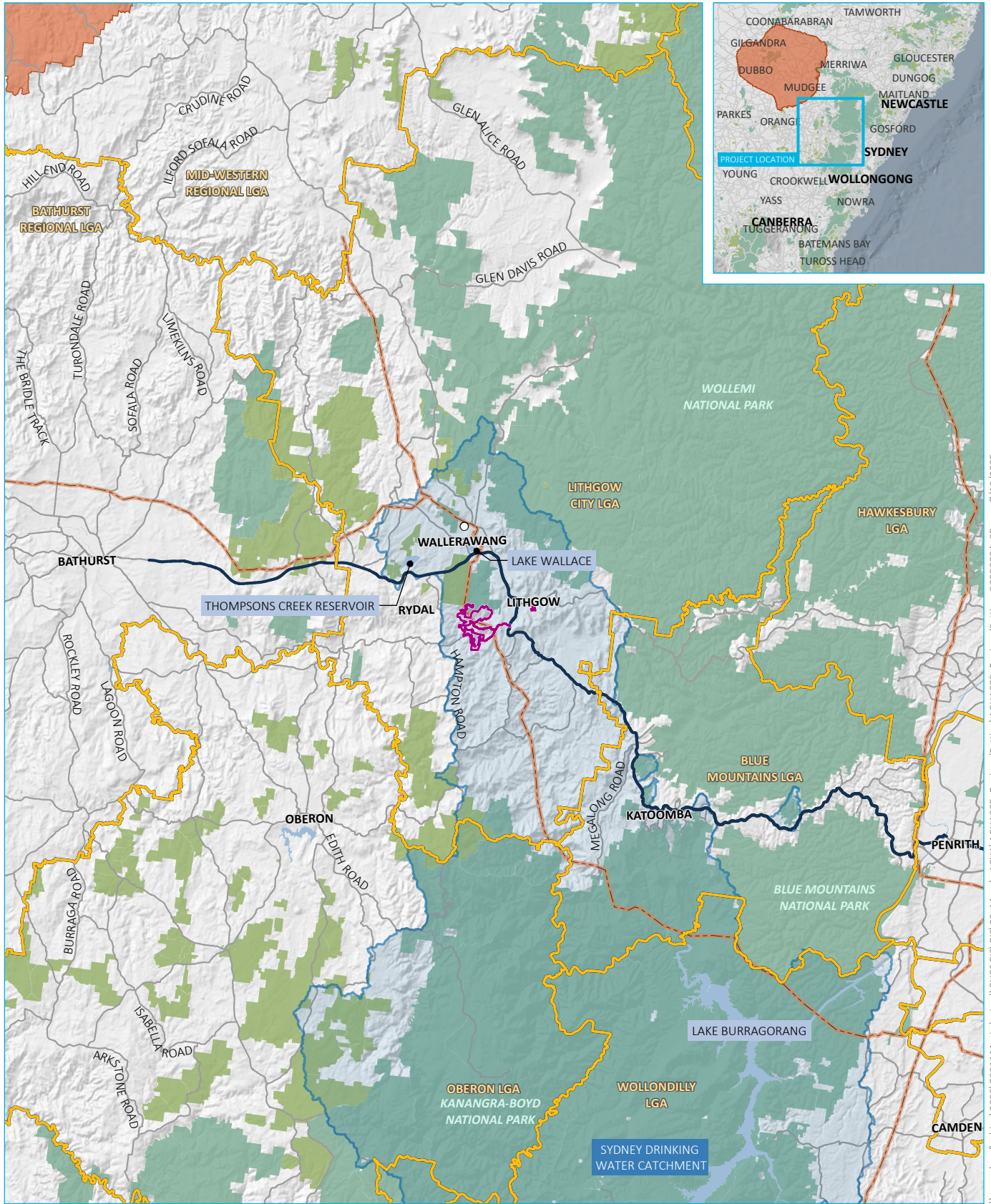
## 1.2 Assessment guidelines and requirements

The CCRA was informed by the following guidelines, standards and data:

- Climate Change Impacts and Risk Management – A Guide for Business and Government (AGO 2006)
- National Climate Risk Assessment Methodology (DCCEEW 2023)
- Hydropower Sector Climate Resilience Guide (IHA 2019)
- AS/NZS 31000:2018 Risk Management – Principles and Guidelines
- Australian Standard 5334-2013, Climate change adaptation for settlements and infrastructure – A risk-based approach
- International Standard ISO/TS 14092:2020, Adaptation to climate change — Requirements and guidance on adaptation planning for local governments and communities
- NSW and ACT Government Regional Climate Modelling climate change projections (NARCLiM) (DCCEEW 2024).

### 1.2.1 SEARs

The SEARs for the project were revised on 17 November 2025 and no longer included the requirement for consideration of climate change adaptation. However, the CCRA has still been completed and provided with the EIS as it supports the consideration of hazards and risks in the long term, given the project's lifespan over 80 to 100 years. It also demonstrates the project's resilience to climate change and identifies additional measures that could be incorporated into the project's design, if needed.



Source: EMM (2025); Lake Lyell Project Pty Ltd (2025); ABS (2021); DCSSS (2024); GA (2009); ESRI (2025)



- KEY**
- ▭ Project area
  - ▭ Local government area
  - ▭ Sydney Drinking Water Catchment
  - ▭ Central West Orana Renewable Energy Zone
  - Mt Piper Power Station
  - Major road
  - Great Western Highway
  - 330 kV transmission line
  - ▭ Named waterbody
  - ▭ NPWS reserve
  - ▭ State forest
  - ▭ Central West Orana Renewable Energy Zone
- INSET KEY**
- Major road
  - ▭ NPWS reserve
  - ▭ State forest
  - ▭ Central West Orana Renewable Energy Zone

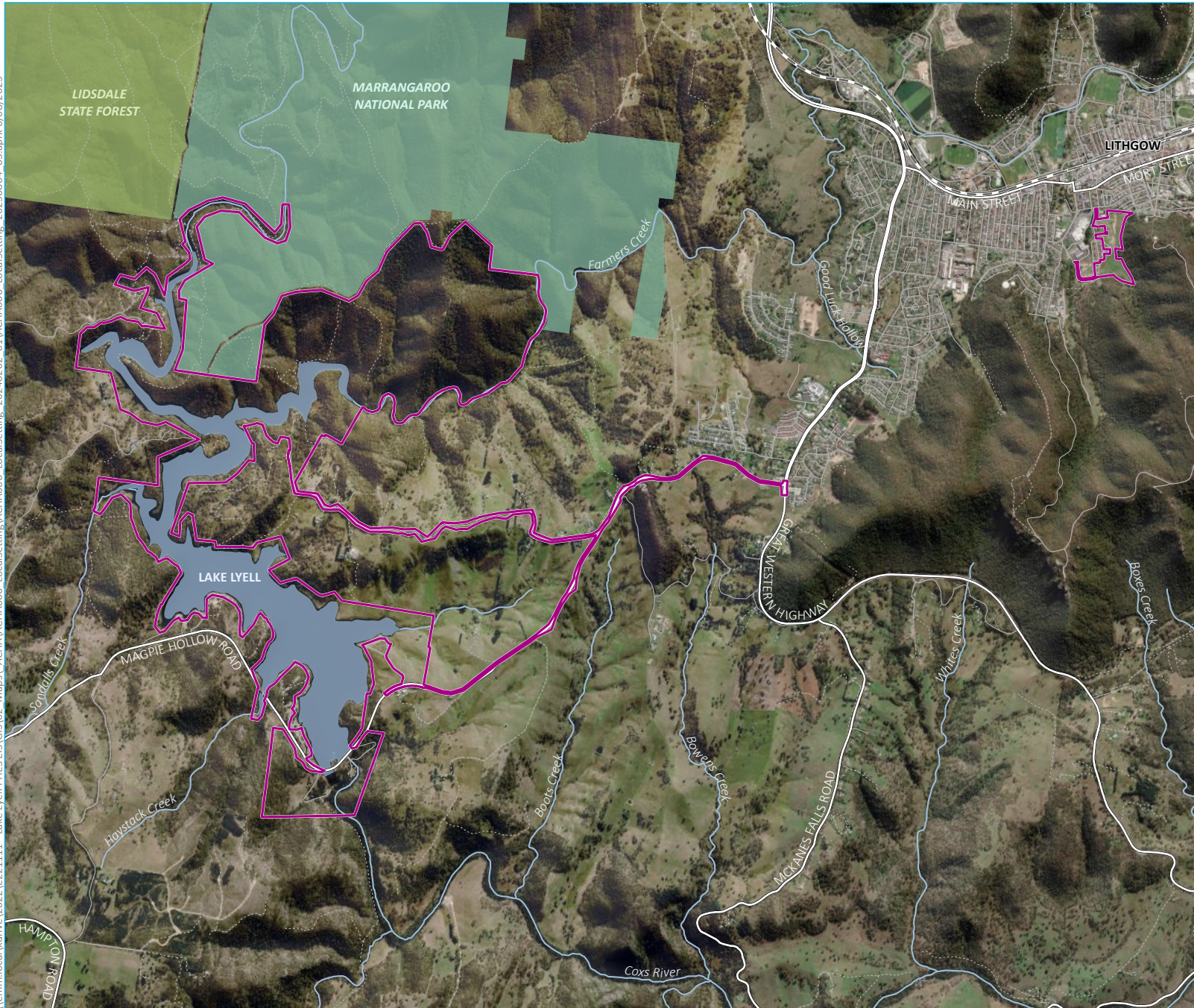
Regional context

Lake Lyell PHES  
Climate Change Risk Assessment  
Figure 1.1



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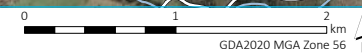
- KEY**
- Project area
  - Existing environment
  - - - Rail line
  - == Major road
  - Minor road
  - ..... Vehicular track
  - Named watercourse
  - Named waterbody
  - NPWS reserve
  - State forest

Local context

Lake Lyell PHES  
Climate Change Risk Assessment  
Figure 1.2



Source: EMM (2025); Lake Lyell Project Pty Ltd (2025); DCSSS (2024); GA (2009); ESRI (2025)



## 2 Project description

A detailed description of the project, including an overview of its design, construction and operation is provided in the project's environmental impact statement (EIS). The EIS (specifically Chapter 3 and Appendix B) should be read in conjunction with this report. A summary of the project's key elements is provided below.

The project design, as shown in Figure 2.1, can be broadly categorised into:

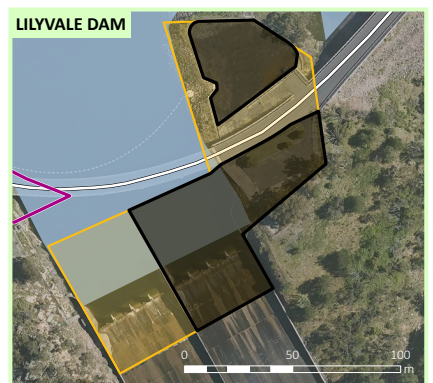
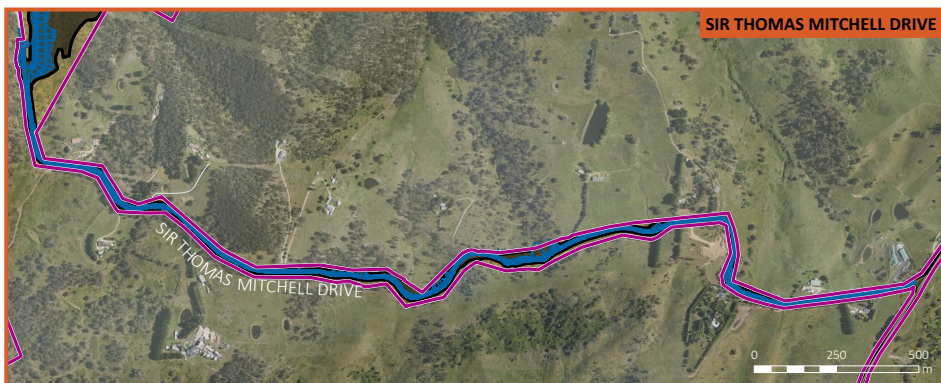
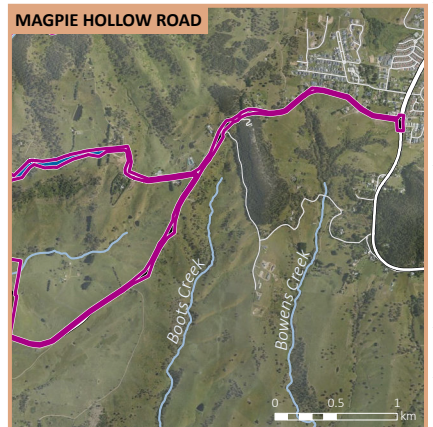
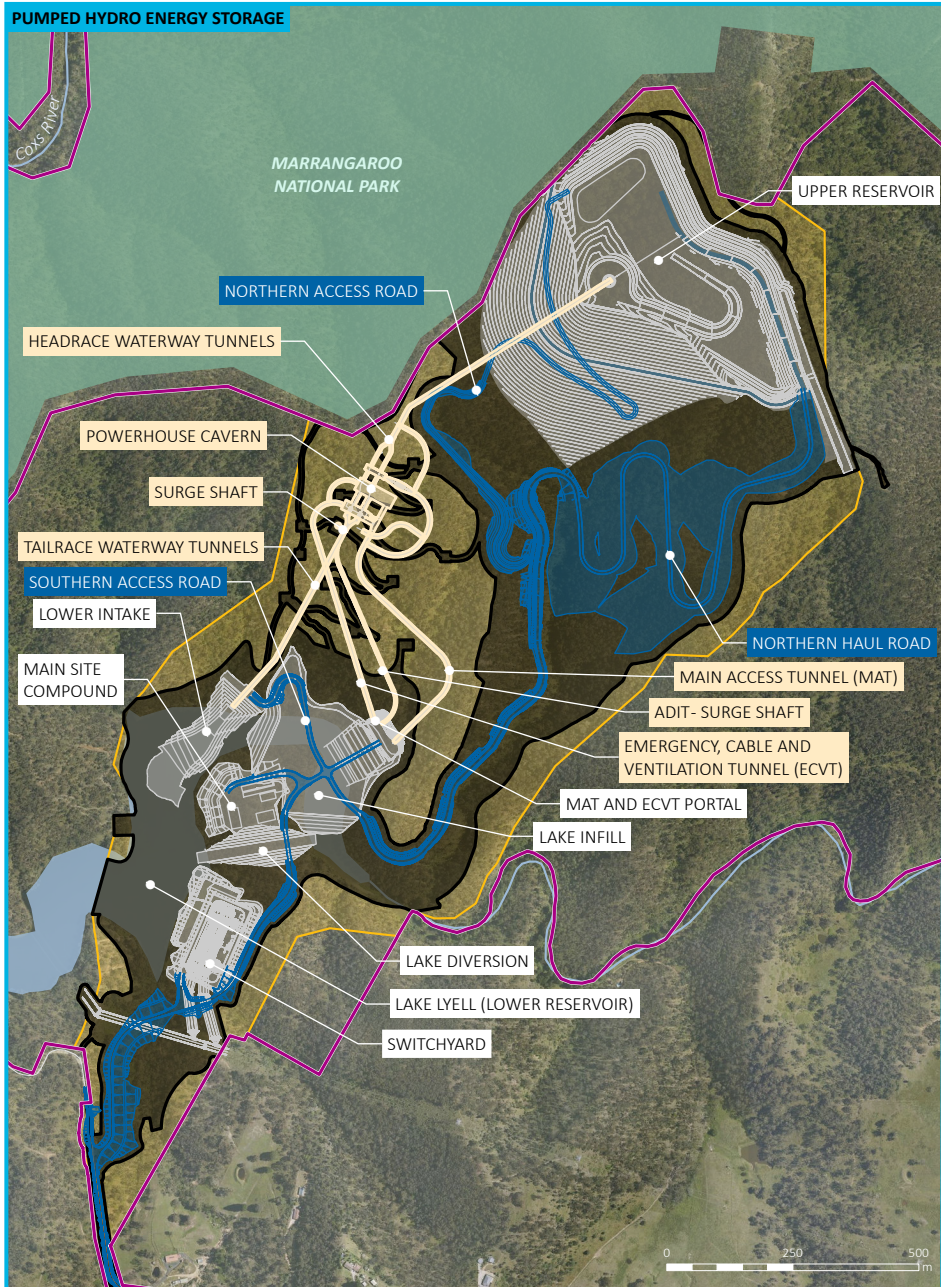
- pumped hydro generation components – including a 5.3 gigalitre (GL) upper reservoir to be constructed behind the southern ridge of Mount Walker, a 33.5 GL lower reservoir (existing Lake Lyell), inlet/outlet structures, and an underground powerhouse, surge shaft and waterway tunnels
- transmission connection components – including a new high voltage switchyard and connection to the existing 330 kilovolt (kV) transmission line that runs through the site
- site access and ancillary facilities – including upgrade of existing and construction of new access roads and bridges, a diversion and infill of a section of Lake Lyell, administration and utilities
- other construction components or works – including geotechnical investigations, temporary workforce accommodation, site work pads, laydown areas and facilities, and spoil management.

Construction will be completed in stages, including:

- pre-construction / enabling works – consisting of initial access works (internal and external roads), geotechnical investigations, site establishment and preparation of the worker's accommodation camp
- main works – consisting of all other construction activities needed to enable operation of the project.

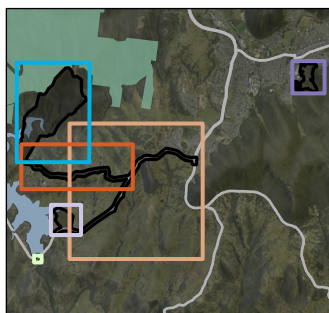
During operation, the project will act as an electrical energy storage system through the conversion of electrical to kinetic energy to gravitational energy and back via water as it is transferred from the elevated upper reservoir to a lower reservoir. The project will provide services to the wholesale 'spot' market on the National Electricity Market (NEM), and support ancillary services used to manage the power system reliably.

After the 80 to 100-year design life of the project, the asset may remain viable for a plant refurbishment and extension of life as has been seen for other older assets globally. Following the plants final refurbishment or once it has reached the end of its serviceable life then the project would look to return the site to a more natural state and encourage community beneficial use.



Source: EMM (2025); Lake Lyell Project Pty Ltd (2025); DCSSS (2024); GA (2009); MetroMap (2025)

GDA2020 MGA Zone 56



**KEY**

- Project area
- Permanent road
- Above ground design
- Underground design
- Construction envelope
- Disturbance footprint
- Existing environment
- Major road
- Minor road
- Named watercourse
- Named waterbody
- NPWS reserve

**Project overview**

Lake Lyell PHES  
Climate Change Risk Assessment  
Figure 2.1



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## 3 Climate change risk assessment

### 3.1 Scope of the assessment

A CCRA was conducted to determine the resilience of the construction and operation of the project to the likely future impacts of climate change.

#### 3.1.1 Main steps

The steps involved in a CCRA are well-established (e.g. AGO 2006, DCCEEW 2023). The main steps are typically:

1. Characterisation of the climate in the area, including:
  - a) identification of key climate variables and metrics; the climate variables and metrics considered in the assessment were temperature, rainfall and droughts, fire danger and storms
  - b) characterisation of the past climate, based on observations
  - c) climate change projections, which describe how each variable may change over the design life of a project.
2. Identification of the broad impacts of the changes in the climate variables on the operation of the project, and also the impacts on the environment where appropriate.
3. The risk assessment itself, taking into account the following for each identified impact:
  - a) the likelihood of the impacts occurring
  - b) the consequences of the impacts occurring
  - c) the combination of the likelihood and consequences to define a risk rating.
4. Identification of measures to mitigate, adapt or build resilience to the identified risks.
5. Assessment of residual risks for the project once the measures have been applied.

For the project, these steps are addressed in Sections 3.2 to 3.5.

Both quantitative and qualitative data has been gathered to inform the assessment in line with the Australian Government's Climate Change Impacts and Risk Management – A Guide for Business and Government (AGO 2006) and the National Climate Risk Assessment Methodology (DCCEEW 2023).

A climate risk and adaptation workshop was held in August 2024, involving EnergyAustralia and EMM (see Section 3.3.1).

#### 3.1.2 Definitions

The terms that are used in this report are defined as follows:

- **Climate hazard:** This is a physical event that can harm human health, livelihoods, or natural resources. A climate hazard can be direct (such as flooding that releases pollution into nearby waterways) or indirect (such as a drought, where water is not available for dust suppression).
- **Impact:** This is the likely effect of a change in a climate change variable on an element of the project (e.g. damage to equipment due to high temperature, destruction of a facility by bushfire).

- **Likelihood:** This is the likelihood of a climate change impact occurring. Some impacts might happen only once, whereas others may be recurring.
- **Consequence:** This is the consequence of a climate change impact occurring.
- **Climate risk:** This is the potential for adverse consequences for human or ecological systems from climate hazards. It can be viewed as the product of the consequences of climate change and the likelihood of those consequences. In the context of this report climate risk refers to the potential negative impacts of climate change on the project, and in particular the environmental performance of the project. The report focuses on physical<sup>1</sup> risks, which can be event-driven (acute), such as increased severity of extreme weather events (e.g. cyclones, droughts, floods, heatwaves and fires), or can relate to longer-term shifts (chronic) in precipitation and temperature and increased variability in weather patterns (Ramboll 2023).

## 3.2 Past and future climate

### 3.2.1 Data sources

The project is located in the Central Tablelands region of NSW. The past climate in the area around the project was characterised using long-term temperature and rainfall data from the Bureau of Meteorology (BoM) monitoring station at Lithgow (Coerwull) (ID: 63226). The Lithgow monitoring station is approximately 4.6 km to the east-north-east of the centre of the project area, and at a similar elevation to the project (around 900 metres (m)).

For the future climate, the collection and processing of data was more involved. CSIRO & BoM (2015) note that impact assessment in a region should consider the risk of both a drier and wetter climate.

The NSW Government provides climate projection data from the NSW and Australian Regional Climate Modelling (NARClIM) project<sup>2</sup>. The third generation of NARClIM projections (known as NARClIM 2.0) was released in 2025. NARClIM 2.0 provided an improved, more comprehensive dataset for studying climate change compared with the previous versions, NARClIM 1.0 and NARClIM 1.5 (Di Virgilio et al. 2025).

The NARClIM 2.0 projections were generated from five global climate models (GCMs) run by climate modelling research centres around the world, including CSIRO in Australia. These GCMs informed the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6, published in 2021). NARClIM 2.0 uses the GCM runs for the same emissions scenario, a low emission scenario (SSP1-2.6) and a high emission scenario (SSP3-7.0). These emissions scenarios are representative of a future climate with carbon dioxide (CO<sub>2</sub>) emissions cut to net zero by around 2075 (SSP1-2.5) and a future climate with CO<sub>2</sub> emissions doubled by around 2100 (SSP3-7.0). In the NARClIM project, the data from the five GCMs were 'dynamically downscaled'<sup>3</sup> for south-east Australia using regional climate models (RCMs). NARClIM generated data for over 100 weather and climate variables, including temperature, number of hot days and cold nights, rainfall and average forest fire danger index (FFDI), and at 4 km grid square resolution.

For this assessment, climate parameters were taken from an interactive map on the AdaptNSW website<sup>4</sup>, which presents the climate information from NARClIM 2.0 in a simplified form.

<sup>1</sup> Climate-related risks can also be associated with the transition to a lower-carbon economy ('transition risks'), the most common of which relate to policy, regulation, technology changes, market responses and reputational considerations (Ramboll 2023).

<sup>2</sup> NARClIM is led by the NSW Government in partnership with the ACT and South Australian governments, with input from the University of New South Wales's Climate Change Research Centre (UNSW CCRC).

<sup>3</sup> Dynamic downscaling is a climate modelling technique where an RCM uses physical principles to determine how the climate system behaves over a particular region of the globe. RCMs rely on input data from GCMs at their boundaries to perform this dynamical downscaling.

<sup>4</sup> <https://www.climatechange.environment.nsw.gov.au/projections-map>

The simulations are for four distinct 20-year periods:

- an historical (baseline) period (1990 to 2009 for NARClIM 2.0)
- a near-future period (2020 to 2039) (also represented in the CCRA as 2030)
- a far-future period (2060 to 2079) (also represented in the CCRA as 2070)
- a second far-future period (2080 to 2099) (not used in the CCRA).

The values in the interactive map are stated as changes in the near-future and far-future periods, relative to the baseline period, based on the results from the RCMs. Each of the different models produced a range of different projections or outcomes. To reduce the bias and uncertainty from looking at a single model prediction, the approach for this analysis is to combine data from the RCMs to produce a ‘model ensemble average’.

The climate projections can be viewed in a ‘region view’ or ‘grid view’. The grid view presents values for each 4 km grid square, and on both an annual basis and by season. The projections for temperature, rainfall and fire danger were extracted for the 4 km grid cell in which most of the project would be located. Given that the project would actually cover several different grid cells in the interactive map, the temperature projections (annual values only) for the eight grid cells around the central grid cell were obtained to understand the potential variability across the project.

An overview of the data collected from the AdaptNSW portal is provided in Table 3.1.

**Table 3.1 Overview of NARClIM data**

Content	NARClIM 2.0
Climate parameters	<ul style="list-style-type: none"> <li>• Average temperature<sup>(a)</sup></li> <li>• Daily maximum temperature</li> <li>• Daily minimum temperature</li> <li>• Accumulated precipitation</li> </ul>
Years simulated	<ul style="list-style-type: none"> <li>• Baseline (1990 to 2009)</li> <li>• Near-future (2020 to 2039)</li> <li>• Far-future (2060 to 2079)</li> </ul>
Models	<ul style="list-style-type: none"> <li>• CSIRO ACCESS-ESM1-5</li> <li>• EC-Earth3-Veg</li> <li>• MPI-ESM1-2-HR</li> <li>• NorESM2-MM</li> <li>• UKESM1-0-LL</li> </ul>
Downscaling approaches <sup>(b)</sup>	<ul style="list-style-type: none"> <li>• R1</li> <li>• R2</li> </ul>

(a) Referred to as ‘near surface temperature’.

(b) Further details of the downscaling approaches are provided by DCCEEW (2024a).

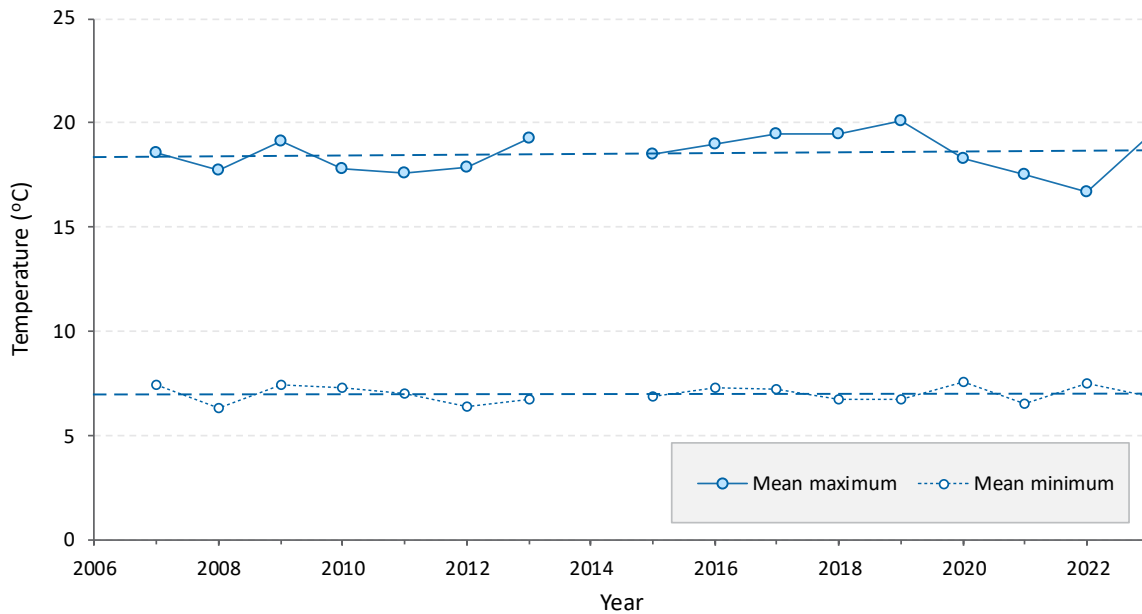
In addition, the Climate Change in Australia project (CSIRO & BoM 2015) developed projections of basic climate change variables. The corresponding website<sup>5</sup> provides climate change projections of Australia’s future climate at a national level, and associated work. The projections that are most relevant to this report are those for the ‘East Coast’ cluster and the ‘East Coast South’ sub-cluster, which comprises regions in the central part of the eastern seaboard of Australia (Dowdy et al. 2015).

<sup>5</sup> <https://www.climatechangeinaustralia.gov.au/en/overview/>

### 3.2.2 Temperature

The Central Tablelands region has a temperate climate with mild to warm summers and no dry season. The region contains high elevation landscapes which provide a predominantly mild climate. Being inland, there is a marked seasonal and diurnal variation in temperature (NSW Government 2016).

Historical temperature data were obtained from the BoM monitoring station at Lithgow. Temperature has been measured here since mid-2006. Figure 3.1 shows the annual mean maximum and minimum temperatures at Lithgow between 2007 and 2023. The values are calculated from the monthly mean maximum and minimum temperatures. The record shows that, at this location, there has been a gradual increase in temperature over the period. However, in some recent years there has been a notable decrease in maximum temperature. This is likely linked to the onset of the La Niña phenomenon<sup>6</sup> in eastern Australia during this period.



**Figure 3.1** Historical temperature data for Lithgow

The baseline temperature projections from AdaptNSW are for the period 1990 to 2009. The Lithgow data only covers the last three years of this period (2007 to 2009), and therefore the statistics for the more extensive period between 2007 and 2023 are given in Table 3.2. The overall average maximum and minimum temperatures at Lithgow for the period 2007 to 2023 were similar to those for 2007 to 2009.

As noted above, the area has mild to warm summers, with a mean maximum temperature of around 26°C. Winters are cold, with a mean minimum temperature of around 1°C.

**Table 3.2** Temperature statistics for Lithgow (2007-2023)

Statistic	Jan	Feb	May	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean maximum (°C)	26.3	24.2	22.0	18.7	14.8	11.3	10.9	12.5	16.1	19.5	22.2	24.2	18.5
Mean minimum (°C)	13.6	13.0	11.0	7.4	3.4	2.1	1.1	1.4	3.7	6.6	9.3	11.3	7.0

<sup>6</sup> La Niña is the counterpart to the El Niño Southern Oscillation (ENSO) - one of Australia’s major climate drivers.

Table 3.3 and Table 3.4 provide summaries of the temperature projections for the low and high emissions scenarios from the AdaptNSW interactive map, and for the 4 km grid cell containing the project. On an annual basis, average, maximum and minimum temperatures are all projected to increase by around 0.7°C in the near future for both emissions scenarios, and by around 1.2°C under the low emissions scenario and 2.6°C under the high emissions scenario in the far future. The increases are generally largest in summer and smallest in winter. The projections indicate that there would be an increase of around one hot day (>35°C) per year in the near future for both emissions scenarios, two hot days per year under the low emissions scenario and six hot days per year under the high emissions scenario in the far future. There would also be marked reductions in the number of cold nights (<2°C) per year.

**Table 3.3 Summary of temperature projections – Low emissions scenario (SSP1-2.6) (4 km grid cell containing project)**

Parameter/statistic	Near future (2020-2039), rel. to baseline					Far future (2060-2079), rel. to baseline				
	Spring	Summer	Autumn	Winter	Annual	Spring	Summer	Autumn	Winter	Annual
<b>Change in temperature</b>										
Daily average (°C)	+0.78	+0.94	+0.73	+0.57	+0.75	+1.23	+1.49	+1.27	+1.00	+1.25
Daily maximum (°C)	+0.89	+1.05	+0.75	+0.66	+0.84	+1.38	+1.75	+1.31	+1.14	+1.40
Daily minimum (°C)	+0.70	+0.89	+0.72	+0.50	+0.70	+1.10	+1.29	+1.26	+0.90	+1.14
<b>Change in cold nights</b>										
Cold nights <2°C (days)	-3.19	-0.15	-2.40	-5.90	-11.65	-4.59	-0.13	-3.73	-11.14	-19.59
<b>Change in hot days</b>										
Hot days >35°C (days)	+0.01	+1.01	+0.04	0	+1.05	+0.10	+1.94	+0.04	0	+2.08

**Table 3.4 Summary of temperature projections – High emissions scenario (SSP3-7.0) (4 m grid cell containing project)**

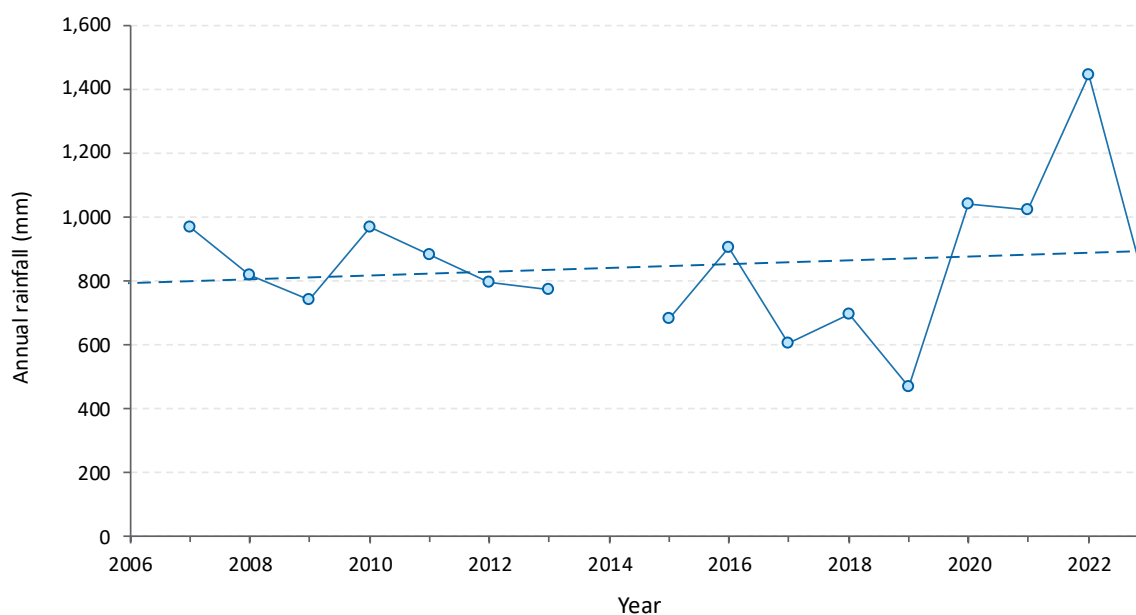
Parameter/statistic	Near future (2020-2039), rel. to baseline					Far future (2060-2079), rel. to baseline				
	Spring	Summer	Autumn	Winter	Annual	Spring	Summer	Autumn	Winter	Annual
<b>Change in temperature</b>										
Daily average (°C)	+0.69	+0.91	+0.70	+0.67	+0.74	+2.90	+2.75	+2.48	+2.32	+2.61
Daily maximum (°C)	+0.77	+1.03	+0.66	+0.78	+0.81	+3.24	+2.99	+2.58	+2.52	+2.83
Daily minimum (°C)	+0.67	+0.87	+0.76	+0.59	+0.72	+2.68	+2.74	+2.49	+2.19	+2.52
<b>Change in cold nights</b>										
Cold nights <2°C (days)	-3.18	-0.12	-2.26	-7.10	-12.67	-9.39	-0.17	-5.91	-26.60	-42.07
<b>Change in hot days</b>										
Hot days >35°C (days)	+0.02	+0.72	+0.06	0	+0.80	+0.73	+5.47	+0.23	0	+6.42

For the east coast of NSW, CSIRO & BoM (2015) note that there is very high confidence in continued substantial increases in projected mean, maximum and minimum temperatures in line with the understanding of the effect of further increases in greenhouse gas (GHG) concentrations. More hot days and warm spells are projected with very high confidence, and fewer frosts are projected with high confidence.

### 3.2.3 Rainfall, flood, and droughts

In the Central Tablelands region, rainfall is distributed fairly evenly throughout the year, with a slight summer increase, although there is a wide multi-annual variation driven largely by El Nino Southern Oscillation (ENSO) cycling. The region has a relatively high rainfall in comparison to neighbouring regions (NSW Government 2016).

Historical rainfall data were obtained for Lithgow, where it has been measured (in recent years<sup>7</sup>) since mid-2006. Figure 3.2 shows the timeseries of annual total rainfall. The record shows that, on average, Lithgow receives approximately 850 mm of rain per year, although the annual amount of rainfall is quite variable. There has been substantial variation in annual rainfall associated with the ENSO events and corresponding La Niña events.



**Figure 3.2** Historic rainfall data for Lithgow

As with temperature, the baseline period in the rainfall projections from AdaptNSW is 1995 to 2009. The Lithgow data again only covers the last three years of this period (2007 to 2009), and therefore the statistics for the more extensive period between 2007 and 2023 are given in Table 3.5. The average annual total rainfall at Lithgow for the period 2007 to 2023 was very similar to that for 2007 to 2009, but the maximum annual (and monthly) values were higher, and the minimum annual (and monthly) values were lower. Rainfall is generally highest in summer and early autumn, with May being the wettest month.

CSIRO & BoM (2015) note that, for the East Coast South sub cluster, the observed trends in rainfall are not as significant as those for temperature. While the sub-cluster experienced extended dry periods in the early 20<sup>th</sup> century, there is no clear long-term trend in annual rainfall during the available record.

<sup>7</sup> The full record goes back to 1878.

**Table 3.5 Rainfall statistics for Lithgow (2007-2023)**

Statistic	Monthly total												Annual total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Mean (mm)	95.4	94.7	100.8	50.4	38.0	65.8	50.0	54.9	50.5	54.9	89.4	95.6	846.9
Maximum (mm)	236.7	189.6	238.8	184.2	80.9	223.0	211.0	110.6	115.6	123.2	195.0	174.3	1,444.9
Minimum (mm)	13.6	20.6	28.0	3.6	6.2	20.6	6.2	21.2	5.2	9.9	21.1	1.1	466.2

Table 3.6 and Table 3.7 provides summaries of the rainfall projections under the low emissions and high emissions scenarios from the AdaptNSW interactive map, and for the 4 km grid cell containing the project. The region has considerable between-year variability in rainfall, and this variability is also reflected in the projections. On an annual basis, rainfall is projected to decrease moderately (around 5% to 8%) under both scenarios in the near future and decrease more substantially (around 11%) under both scenarios in the far future. In both the near and far future, for both emission scenarios, rainfall is projected to decrease across each season.

**Table 3.6 Summary of rainfall projections – Low emissions scenario (SSP1-2.6) (4 km grid cell containing project)**

Parameter	Near future (2020-2039)					Far future (2060-2079)				
	Spring	Summer	Autumn	Winter	Annual	Spring	Summer	Autumn	Winter	Annual
Change in rainfall (%)	-11.6	-3.9	-6.3	-14.9	-8.6	-13.8	-7.9	-9.0	-16.9	-11.4

**Table 3.7 Summary of rainfall projections – High emissions scenario (SSP3-7.0) (4 km grid cell containing project)**

Parameter	Near future (2020-2039)					Far future (2060-2079)				
	Spring	Summer	Autumn	Winter	Annual	Spring	Summer	Autumn	Winter	Annual
Change in rainfall (%)	-2.9	-1.9	-0.3	-16.9	-5.0	-14.2	-2.2	-11.8	-20.8	-11.1

For the NSW coast in general, decreases in winter rainfall are projected with medium confidence. Other changes are unclear. An increased intensity of extreme rainfall events is projected with high confidence. Time spent in drought is projected, with medium confidence, to increase over the course of the century (CSIRO & BoM 2015).

Information on rainfall (for the East Coast) is also available from the Climate Change in Australia project. Table 3.8 summarises the maximum rainfall projections for the East Coast cluster in the RCP8.5 scenario (Dowdy et al 2015). According to CSIRO & BoM (2015), understanding of the physical processes that cause extreme rainfall, coupled with modelled projections, indicate with high confidence a future increase in the intensity of extreme rainfall events, although the magnitude of the increases cannot be confidently projected.

**Table 3.8 Summary of maximum rainfall projections (East Coast cluster)**

Parameter/ statistic	Near future (2030), rel. to baseline					Far future (2070), rel. to baseline				
	Spring	Summer	Autumn	Winter	Annual	Spring	Summer	Autumn	Winter	Annual
Change in maximum 1-day rainfall (median, %)	-5.6	+5.0	-1.5	-2.5	+1.5	-6.5	+10.8	-1.6	-8.9	+5.2

The combined changes in temperatures, rainfall and evaporation and climate systems are likely to make drought conditions in south-east Australia worse. The Standardised Precipitation Index (SPI) is used to assess the implications of climate change on droughts. Data for the East Coast cluster are summarised in Table 3.9 (Dowdy et al 2015). Time spent in drought is projected, with medium confidence, to increase over the course of the century in the RCP8.5 scenario. An increase in the frequency and duration of extreme drought is projected with low confidence (CSIRO & BoM 2015). With longer and more severe droughts, and water that flows into dams, will decrease<sup>8</sup>.

**Table 3.9 Summary of time in drought (East Coast cluster; RCP8.5)**

Parameter/statistic	Baseline (1995)	Near future (2030) <sup>(a)</sup>	Far future (2070) <sup>(a)</sup>
Time in drought (%) <sup>(b)</sup>	40	50	55
Duration of extreme drought <sup>(c)</sup> (months)	26	28	34
Freq. of extreme drought <sup>(c)</sup> (20 years)	1.3	1.8	2.0

Notes:

(a) Values are approximate, based on visual interpretation.

(b) Based on estimates of Standardised Precipitation Index (SPI), the proportion of time with SPI  $\leq -1$ .

(c) Based on SPI  $\leq -2$ .

### 3.2.4 Fire danger

The Forest Fire Danger Index (FFDI) is used in NSW to quantify fire weather. The FFDI combines observations of temperature, humidity, and wind speed with an estimate of the fuel state, with 17 stations in NSW and the ACT (DPIE 2019). FFDI values below 12 indicate low to moderate fire weather, 12-25 high, 25-49 very high, 50-74 severe, 75-99 extreme and above 100 catastrophic. Fire weather is classified as 'severe' when the FFDI is above 50, and most of the property loss from major fires in Australia has occurred when the FFDI reached this level.

The closest FFDI stations to the project are in Dubbo and Richmond, which will have a different climate to the project area. The annual and seasonal FFDI values at Dubbo and Richmond for the period 1990 to 2009 are summarised in Table 3.10. The highest mean FFDI occurs in spring and summer, and the lowest in autumn and winter. Severe fire weather conditions are estimated to occur, on average, around three days per year at Dubbo and two days per year at Richmond.

There is high confidence that climate change will result in a harsher fire-weather climate in the future. However, there is low confidence in the magnitude of that change because of the significant uncertainties in the rainfall projection (CSIRO & BoM 2015).

Table 3.11 and Table 3.12 summarises the fire danger projections under the low emissions and high emissions scenarios from the AdaptNSW interactive map for the 4 km grid cell containing the project. Relative to the baseline period, the average annual daily FFDI for both scenarios in this grid cell is projected to increase only slightly (around 0.1 days) in the near future, and by between 0.4 and 0.5 days under both scenarios in the far future.

<sup>8</sup> <https://www.climatechange.environment.nsw.gov.au/drought>

**Table 3.10 FFDI at locations in the region (DPIE 2019)**

Statistic and location	Spring	Summer	Autumn	Winter	Annual
<b>Mean FFDI</b>					
Dubbo	10.9	16.1	10.1	4.1	10.3
Richmond	9.8	8.3	5.2	5.4	7.1
<b>Number of severe fire weather days (FFDI &gt;50)</b>					
Dubbo	1.4	1.7	0.1	0	3.1
Richmond	0.7	1.0	0.1	0	1.8

**Table 3.11 Summary of fire danger projections – Low emissions scenario (SSP1-2.6) (4 km grid cell containing the project)**

Parameter	Near future (2020-2039), rel. to baseline					Far future (2060-2079), rel. to baseline				
	Spring	Summer	Autumn	Winter	Annual	Spring	Summer	Autumn	Winter	Annual
Change in high fire danger days (days)	+0.02	+0.14	0	0	+0.16	+0.15	+0.25	0	0	+0.40

**Table 3.12 Summary of fire danger projections – Low emissions scenario (SSP1-2.6) (4 km grid cell containing the project)**

Parameter	Near future (2020-2039), rel. to baseline					Far future (2060-2079), rel. to baseline				
	Spring	Summer	Autumn	Winter	Annual	Spring	Summer	Autumn	Winter	Annual
Change in high fire danger days (days)	+0.03	+0.09	+0.01	0	+0.13	+0.27	+0.31	+0.01	0	+0.59

### 3.2.5 Storms

Dowdy et al (2015) note that there is a strong annual cycle of thunderstorms throughout the East Coast cluster, with a maximum during the warmer months and a minimum during the cooler months. The cluster has thunderstorms on about 20 to 50 days per year. Tropical cyclones can occur during the warmer months of the year. The eastern Australian region typically has four tropical cyclones per year, although there is a downward trend in their frequency.

The main causes of extreme storms along the NSW coast are east coast lows (ECLs). A considerable proportion of the heavy rainfall events on the central eastern seaboard can be associated with ECLs, and they also provide important rainfall to fill catchments and reservoirs. Storms caused by ECLs vary from year to year, and decade to decade. This makes it difficult to predict when they will occur, how severe they will be, and how they might be affected by climate change. The literature suggests a decrease in the overall number of ECLs in the future, although the climate modelling predicts that there may be more extreme systems in the warmer months, and fewer small-to-moderate systems in the cooler months (CSIRO & BoM 2015).

For the 'East Coast south' sub-cluster, it is anticipated that the proportion of the most intense storms will increase over the century while the intensity of associated rainfall may increase further. Tropical cyclones are projected with medium confidence to become less frequent with projected increases in the proportion of the most intense storms (Dowdy et al 2015).

### 3.2.6 Summary and limitations

The past and future climate data for the area in which the project is located are consolidated in Table 3.13. The changes in the climate variables can be broadly summarised as follows:

- **Temperature:** Increases in average and maximum temperatures, as well as the number of hot days per year. The changes are more severe in the far future than in the near future. The confidence in the temperature predictions is very high.
- **Rainfall:** The rainfall projections from different data sources are variable. Based on the NARClIM 2.0 data for the project location:
  - a decrease in seasonal and annual rainfall in the near and far future for both emission scenarios
  - increased intensity of extreme rainfall events in the near and far future.

The confidence in the rainfall projections is generally low, although there is high confidence of an increased intensity.

- **Drought:** More frequent and prolonged droughts, with a low-to-medium level of confidence.
- **Fire danger:** Increase in high fire danger days. The confidence level is high for harsher fire-weather in general, but low for the actual magnitude of the change.
- **Storms:** Decrease in frequency of ECLs and tropical cyclones, but with increase in intensity in warmer months. The predictions for tropical cyclones have a medium confidence level.

**Table 3.13 Summary and interpretation of climate projections**

Parameter / statistic	Baseline (historical)	Near future (2020-2039)					Far future (2060-2079)				
		NARClIM 2.0	NARClIM 2.0	CCA (East Coast)	Interpretation for use in CCRA	Confidence (CCA)	NARClIM 2.0	NARClIM 2.0	CCA (East Coast)	Interpretation for use in CCRA	Confidence (CCA)
		(annual) (SSP1-2.6)	(annual) (SSP3-7.0)				(annual) (SSP1-2.6)	(annual) (SSP3-7.0)			
<b>Change in temperature</b>											
Daily average (°C)	-	+0.8	+0.7	+1.0	Moderate increase in average temp	Very high	+1.3	+2.6	+2.7	Large increase in average temp	Very high
Daily maximum (°C)	-	+0.8	+0.8	+1.1	Moderate increase in max. temp	Very high	+1.4	+2.8	+2.7	Large increase in max. temp	Very high
Cold nights <2°C (days)	-	-11.7	-12.7	-	Large reduction in freq. of cold nights	High	-19.6	-42.1	-	Large reduction in freq. of cold nights	High
Hot days >35°C (days)	-	+1.0	+0.8	-	Increased freq., severity & duration of extreme high temp	Very high	+2.1	+6.4	-	Increased freq., severity & duration of extreme temp	Very high
<b>Change in rainfall</b>											
Change in rainfall (%)	-	-8.6	-5.0	-4.5	Based on NARClIM 2.0, rainfall projected to reduce moderately, this is more significant under a low emissions scenario	Low for both the size and sign of change	-11.4	-11.1	-8.2	Based on NARClIM 2.0, rainfall projected to decrease by a fairly large amount	Low for both the size and sign of change
Change in max. 1day rain (%)	-	-	-	+1.5	Increased intensity of extreme rainfall events	High for increase in intensity; low for size of increase	-	-	+5.2	Increased intensity of extreme rainfall events	High for increase in intensity; low for size of increase

Parameter / statistic	Baseline (historical)	Near future (2020-2039)					Far future (2060-2079)				
		NARCIIM 2.0	NARCIIM 2.0	CCA (East Coast)	Interpretation for use in CCRA	Confidence (CCA)	NARCIIM 2.0	NARCIIM 2.0	CCA (East Coast)	Interpretation for use in CCRA	Confidence (CCA)
		(annual) (SSP1-2.6)	(annual) (SSP3-7.0)				(annual) (SSP1-2.6)	(annual) (SSP3-7.0)			
<b>Droughts</b>											
Time spent in drought (%)	40	-	-	50	Longer periods of drought	Medium	-	-	55	Longer periods of drought	Medium
Duration of extreme drought (months)	26	-	-	28	Increase of 8% in duration	Low	-	-	34	Increase of 30% in duration	Low
Freq. of extreme drought (/20y)	1.3	-	-	1.8	Increase in frequency	Low	-	-	2.0	Increase in frequency	Low
<b>Fire danger</b>											
Change in high fire danger (days)	-	+0.2	+0.1	-	Very small increase in frequency and severity of bushfires	High for harsher fire-weather in general, low for the magnitude of the change	+0.4	+0.6	-	Small increase in frequency and severity of bushfires	High for harsher fire-weather in general, low for the magnitude of the change
<b>Storms</b>											
Thunderstorms	-	-	-	-	Decline in the number of ECLs, but with more extreme systems in warmer months	N/A	-	-	-	Decline in the number of ECLs, but with more extreme systems in warmer months	N/A
Tropical cyclones (TCs)	-	-	-	-	TCs are projected to become less frequent, but with an increase in the proportion of intense storms	Medium	-	-	-	TCs are projected to become less frequent, but with an increase in the proportion of intense storms	Medium

### 3.3 Initial risk rating with no measures

#### 3.3.1 Climate risk and adaptation workshop

The effects of the future changes in climate were considered in relation to potential impacts on project assets or functions, including areas such as physical structures, transport, and worker safety. In total, 10 potential construction impacts and 28 potential operational impacts were identified.

A climate risk and adaptation workshop was held with EnergyAustralia in August 2024. In the workshop, climate hazards were presented, and the corresponding risks to the project and the environment were discussed with the project team. This led to the definition of the risk ratings, and a discussion of potential mitigation and adaptation measures. Residual risks were also defined. A spreadsheet-based tool (a risk register) was used to facilitate the risk assessment, and to log the outcomes of the workshop.

It is noted that at the time of the climate risk and adaptation workshop, climate projections were only available from NARClIM 1.0 and NARClIM 1.5. Following the realisation of NARClIM 2.0 in 2025, the climate hazards and risk ratings were reviewed and revised where necessary.

#### 3.3.2 Risk rating method

The risk rating approach involved determining the following for each identified impact in the absence of mitigation measures:

- the likelihood of the impacts occurring
- the consequences of the impacts occurring
- the combination of the likelihood and consequences to define a risk rating.

The likelihood and consequence were considered in accordance with *AS 5334 Climate change adaptation for settlements and infrastructure – A risk-based approach* (see Appendix A) and were informed by the climate and projection data.

The relative levels of risk associated with the various impacts were used to prioritise their management.

#### 3.3.3 Results

The risk ratings with no measures are provided in Appendix B. Following the workshop, EMM finalised the register and distributed it to the project team for further review and comment. The risk register was updated based on additional feedback received.

The initial risk profile for the project is summarised in Table 3.14.

Construction risks were only assessed for the near-future scenario. A mixture of low, medium and high risk ratings were identified. High initial risks were associated with delays to construction as a result of bushfires and flooding, and these are summarised in Table 3.15.

Operational risks were assessed for the near-future and far-future scenarios. All of the initial risk ratings were either 'low' or 'medium'.

**Table 3.14 Initial risk profile for the project**

Risk rating	Near future (2030)	Far future (2070)
<b>Construction</b>		
Low	2	Not applicable
Medium	5	Not applicable
High	3	Not applicable
Extreme	0	Not applicable
<b>Total</b>	<b>10</b>	Not applicable
<b>Operation</b>		
Low	17	16
Medium	11	12
High	0	0
Extreme	0	0
<b>Total</b>	<b>28</b>	<b>28</b>

**Table 3.15 Climate change impacts with high risk (construction)**

Risk ID	Climate hazard	Potential impact (2030)
CON-F-01	Harsher fire weather, with more frequent and severe bushfires	Delays to construction. Fire and smoke events - prevent access to site.
CON-R-01	Increased intensity of extreme rainfall events	Delays to construction. Heavy downpours damage unsurfaced roads, cause slope instability that blocks roads, or cause flooding.
CON-R-02		Delays to construction. Physical damage to works due to inundation. Safety. Environmental consequences – reduced water quality.

### 3.4 Identification of current/proposed and additional measures

The next step involved the identification of current/proposed measures to mitigate, adapt or build resilience to the identified risks from an operational perspective. This included an evaluation of the likely effectiveness of these measures, using the following categories:

- substantially effective
- partially effective
- largely ineffective.

Where the currently proposed measures were identified as being partially effective or largely ineffective, additional measures were considered to eliminate or reduce the likelihood or consequence of the identified risks and associated impacts (see Appendix B).

By considering risks in the near future and far future, this process took into account whether the measures would remain effective over time as climate change risks increase.

### 3.5 Residual risk

The final step was the assessment of residual risks once all measures had been applied. The residual risk ratings are provided in Appendix B.

For most potential climate change impacts during construction, the residual risk was determined to be 'low'. The three impacts with a residual risk above 'low' are identified in Table 3.16.

**Table 3.16 Climate change impacts with residual risk above 'low' (construction)**

Risk ID	Climate hazard	Potential impact	Residual risk (2030)
CON-R-01	Increased intensity of extreme rainfall events	Delays to construction. Heavy downpours damage unsurfaced roads, cause slope instability that blocks roads, or cause flooding.	Medium
CON-R-02		Delays to construction. Physical damage to works due to inundation. Safety. Environmental consequences – reduced water quality.	Medium
CON-S-02	Increased severity of storms	Delays to construction. Increased severity (and possibly frequency) of lightning strikes prevent work on site due to safety risk.	Medium

For project operation, and for all potential climate change impacts, the residual risk was determined to be 'low'. For these, it is therefore considered that additional measures would not need to be considered.

### 3.6 Review

As identified, the residual risk of climate change-related impacts is generally low for the project. The effectiveness of site management strategies and design will be reviewed on an ongoing basis throughout the life of the project, in line with annual environmental reporting requirements for the site.

## 4 Summary and conclusions

This CCRA report has been prepared for the Lake Lyell Pumped Hydro Energy Storage (PHES) Project.

The climate in the area of the project in the near future (2030) and far future (2070) was characterised using a range of data sources, including the projection data from the NARClIM 2.0 project. Climate was characterised using information on temperature, rainfall, drought, fire danger and storms.

A climate risk and adaptation workshop was held with EnergyAustralia. The effects of the future changes in climate were considered in relation to potential impacts on the construction and operation of the project, including areas such as physical structures, transport and worker safety. In total, 10 potential construction impacts and 28 potential operational impacts were identified. In the workshop, the potential risks were discussed with the project team.

Construction risks were only assessed for the near-future scenario. Initially, a mixture of low, medium and high risk ratings were identified. High initial risks were associated with delays to construction as a result of bushfires and flooding. Operational risks were assessed for the near-future and far-future scenarios. All of the initial risk ratings were either 'low' or 'medium'.

Planned and additional measures were then considered. These included:

- Design
  - designing dam components in accordance with Australian Standards, which account for temperature variability and extreme rainfall events
  - incorporation of an ability to move water within the broader system (e.g. Upper Cox's River Water Supply Scheme, including Thomsons Reservoir)
  - establishment of Asset Protection Zones for buildings, with fire-resistant materials used for structures
  - debris and trash screens on water intakes
  - geotechnical stability embedded into the dam design
  - lightning protection systems.
- Operation
  - regular maintenance and monitoring, including clearing of vegetation.
- Plans and schedules
  - compliance with water extraction licences, dam safety requirements and Water Sharing Plan
  - incorporation of an emergency response procedure and flood forecasting into operating procedures, to mitigate the risk of flooding during extreme rainfall events
  - implementation of a bushfire emergency management and operations plan
  - Work Health & Safety policies
  - contractor policies (to include strategies to mitigate identified risks).

For most potential climate change impacts during construction, the residual risk (once all measures had been applied) was determined to be 'low'. Three impacts (relating to delays caused by bushfires and storms) had a medium residual risk. For project operation, and for all potential climate change impacts, the residual risk was determined to be 'low'. For these residual risks, it is therefore considered that additional measures would not need to be considered.

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## Abbreviations

AHD	Australian Height Datum
BoM	Bureau of Meteorology
CCRA	climate change risk assessment
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ECL	East Coast Low
EIS	environmental impact statement
FFDI	Forest Fire Danger Index
FSL	full-supply level
GCM	global climate model
GHG	greenhouse gas
ha	hectare
IPCC	Intergovernmental Panel on Climate Change
km	kilometre
ML	megalitres
NARClIM	NSW and Australian Regional Climate Modelling
NEM	National Electricity Market
NSW	New South Wales
RCM	regional climate model
RCP	representative concentration pathway
RL	Reduced Level – the height or elevation above the point adopted as the site datum for the purpose of establishing levels
SEARs	(NSW Planning) Secretary’s Environmental Assessment Requirements
TC	tropical cyclone

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# Appendix A

Risk rating method

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**Table A.1 Likelihood criteria**

Rating	Recurrent risks	Single events
Almost certain	Could occur several times per year	More likely than not – probability greater than 50%
Likely	May arise about once per year	As likely as not – 50/50 chance
Possible	May arise once in 10 years	Less likely than not but still appreciable – probability less than 50% but still quite high
Unlikely	May arise once in 10 to 25 years	Unlikely but not negligible – probability low but noticeably greater than zero
Rare	Unlikely during the next 25 years	Negligible – probability very small, close to zero

**Table A.2 Consequence criteria**

Consequence	Impact area				
	Safety	Production	Environment	Compliance	Workforce
Catastrophic	Large numbers of serious injuries or loss of lives	Loss of a key source of supply or ceasing of activity, threatening production	Major widespread loss of environmental amenity and progressive irrecoverable environmental damage	Obvious and proven breaches of legal and regulatory requirements with the prospect of corporate or individual penalties	Severe shortages of personnel or workplace disruption would make it difficult to sustain operations
Major	Isolated instances of serious injuries or loss of lives	Disruption to a key source of supply or to an activity, having a serious effect on production	Severe loss of environmental amenity and a danger of continuing environmental damage	Significant amounts of management and advisers’ effort would be required to answer charges of compliance failures	Operations would be severely affected by shortages of personnel
Moderate	Small numbers of injuries	Components of the supply chain or the activity would require additional management attention to maintain production levels	Isolated but significant instances of environmental damage that might be reversed with intensive efforts	Formal action would be required to answer perceived breaches or charges of compliance failure	Parts of the workforce and staff team would require more than normal levels of management attention
Minor	Serious near misses or minor injuries	Isolated supply or activity issues would arise but would be resolved	Minor instances of environmental damage that could be reversed	Minor perceived or actual breaches of compliance would be resolved	Isolated personnel shortages would be resolved
Insignificant	Appearance of a threat but no actual harm	Minor supply or activity issues would arise but would pass without special attention	No environmental damage	Concerns about compliance would be resolved without special action	Minor workforce issues would pass without any special attention

**Table A.3 Risk matrix**

Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Medium risk	Medium risk	High risk	Extreme risk	Extreme risk
Likely	Low risk	Medium risk	High risk	High risk	Extreme risk
Possible	Low risk	Medium risk	Medium risk	High risk	High risk
Unlikely	Low risk	Low risk	Medium risk	Medium risk	Medium risk
Rare	Low risk	Low risk	Low risk	Low risk	Medium risk

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# Appendix B

Climate change risk register

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The climate change risk register is provided for project construction in Table B.1, and for project operation in Table B.2.

**Table B.1 Climate change risk register – construction**

Risk ID	Climate hazard	Potential impact on project asset or function	Risk assessment (no measures)						Planned measures Description	Effectiveness	Additional measures	Residual risk	
			2030			2070						2030	2070
			Likelihood	Consequence	Rating	Likelihood	Consequence	Rating				Rating	Rating
CON-T-01	<b>Temperature</b> Increase in average and maximum temperature. Increased frequency, severity & duration of extreme temperature periods.	<b>Delays to construction</b> <i>Water extraction for initial filling</i> Increased temperatures lead to delays to the initial fill of the upper reservoir.	Unlikely	Moderate	Medium	.	.	.	Ability to move water within the broader system: Upper Cox's River Water Supply Scheme (inc. Thomsons Reservoir).	Substantially effective	N/A	Low	.
CON-T-02		<b>Delays to construction</b> <i>Health and safety - heat stress</i> Extreme temperatures lead to heat stress on workers, or restricted working conditions / hours due to WHS policies.	Unlikely	Minor	Low	.	.	.	WHS policies / contractor policies, air conditioning in accommodation camp and office, construction plant, etc. Significant underground works.	Substantially effective	N/A	Low	.
CON-F-01	<b>Fires</b> Harsher fire weather in general. Very small to small increase in the frequency and severity of bushfires.	<b>Delays to construction</b> <i>Access</i> Fire and smoke events - prevent access to site.	Possible	Major	High	.	.	.	WHS policies, bush fire management and emergency management - e.g. firefighting controls, evacuation plans etc. Consider need for fire sprinkler system.	Partially effective	Bushfire fuel management (such as hazard reduction burns) on EA or NPWS land (subject to ecological assessment), bush fire refuge buildings to be incorporated into design.	Low	.
CON-F-02		<b>Delays to construction</b> <i>Health</i> Fire and smoke events - risk to health results in evacuation of workers.	Possible	Moderate	Medium	.	.	.	WHS policies, bush fire management and emergency management, e.g. firefighting controls, evacuation plans etc. Consider need for fire sprinkler system.	Substantially effective	N/A	Low	.

Risk ID	Climate hazard	Potential impact on project asset or function	Risk assessment (no measures)			Planned measures Description	Effectiveness	Additional measures	Residual risk			
			2030		2070				2030	2070		
			Likelihood	Consequence	Rating				Likelihood	Consequence	Rating	Rating
CON-F-03		<b>Delays to construction</b> <i>Safety</i> Fire and smoke events - risk of injury or death.	Rare	Catastrophic	Medium			WHS policies, bush fire management and emergency management, e.g. firefighting controls, evacuation plans etc. Consider need for fire sprinkler system.	Substantially effective	N/A	Low	
CON-R-01	<b>Rainfall</b> (NARClim 2.0) Decrease in annual rainfall in the near future and fairly large decrease in the far future. Increased intensity of extreme rainfall events.	<b>Delays to construction</b> <i>Access</i> Heavy downpours damage unsurfaced roads, cause slope instability that blocks roads, or cause flooding.	Possible	Major	High			Design of construction management. Erosion and sediment controls. Construction risk management plan.	Partially effective	Further consideration during detailed design.	Medium	
CON-R-02		<b>Delays to construction</b> <i>Flooding</i> Physical damage to works due to inundation. Safety. Environmental consequences – reduced water quality	Possible	Major	High			Construction risk management plan.	Partially effective	Further consideration during detailed design. Contingency measures (e.g. back up pumps).	Medium	
CON-D-01	Longer periods of drought. Increase in drought duration. Increase in drought frequency.	<b>Delays to construction</b> <i>Water extraction for initial filling</i> Droughts lead to longer delays to the initial fill of the upper reservoir.	Rare	Major	Low			Ability to move water within the broader system: Upper Cox's River Water Supply Scheme (inc. Thomsons Reservoir, etc).	Substantially effective	N/A	Low	

Risk ID	Climate hazard	Potential impact on project asset or function	Risk assessment (no measures)						Planned measures		Additional measures		Residual risk	
			2030			2070			Description	Effectiveness			2030	2070
			Likelihood	Consequence	Rating	Likelihood	Consequence	Rating					Rating	Rating
CON-S-01	<b>Storms</b> Decrease in the number of East Coast Lows, but with more extreme systems in warmer months.	<b>Delays to construction</b> <i>Access</i> Storms damage or block access routes.	Likely	Minor	Medium	.	.	.	Contractors equipped to clear roads.	Substantially effective	N/A		Low	.
CON-S-02	Tropical cyclones becoming less frequent, but with an increase in the proportion of intense storms.	<b>Delays to construction</b> <i>Safety</i> Increased severity (and possibly frequency) of lightning strikes prevent work on site due to safety risk.	Possible	Moderate	Medium	.	.	.	App for safety. Risk & opportunities register considers weather.	Partially effective	N/A		Medium	.

**Table B.2 Climate change risk register – operation**

Risk ID	Climate hazard	Potential impact on project asset or function	Risk assessment (no measures)						Planned measures	Additional measures	Residual risk			
			2030			2070					Description	Effectiveness	2030	2070
			Likelihood	Consequence	Rating	Likelihood	Consequence	Rating					Rating	Rating
OP-T-01	<b>Temperature</b> Increase in average and maximum temperature. Increased frequency, severity & duration of extreme temperature periods.	<b>Physical asset</b> <i>Dams and ancillaries</i> Higher temperatures, more frequent hot days and heatwaves lead to damage, deterioration or performance of dam and ancillaries (turbines, pumps, condensers, communications, heating, air conditioning, etc.), requiring repair and increased maintenance, with disruption to operation. Specifically, heat could degrade the reservoir liner.	Rare	Moderate	Low	Rare	Moderate	Low	Regular maintenance of asset, OEM selection.	Substantially effective	N/A	Low	Low	
OP-T-02		<b>Operation</b> <i>Water extraction and electricity generation</i> Higher temperatures, more frequent hot days and heatwaves lead to increased evaporation from reservoirs, potentially reducing hydropower generation.	Unlikely	Moderate	Medium	Possible	Moderate	Medium	Ability to move water within the broader system: Upper Cox's River Water Supply Scheme (inc. Thomsons Reservoir).	Substantially effective	Include and/or expand drought reserve in upper reservoir. Covering/shading of reservoir to reduce evaporation.	Low	Low	

Risk ID	Climate hazard	Potential impact on project asset or function	Risk assessment (no measures)			Planned measures Description	Effectiveness	Additional measures	Residual risk				
			2030		2070				2030	2070			
			Likelihood	Consequence	Rating				Likelihood	Consequence	Rating	Rating	Rating
OP-T-03		<b>Health and safety</b> <i>Heat stress</i> Extreme temperatures lead to heat stress on workers (or restricted working conditions/hours due to WHS policies), affecting the functioning of the asset.	Rare	Minor	Low	Rare	Minor	Low	WHS policies, scheduling of regular maintenance.	Substantially effective	N/A	Low	Low
OP-F-01	<b>Fires</b> Harsher fire weather in general. Very small to small increase in the frequency and severity of bushfires.	<b>Physical asset</b> <i>Dams and ancillaries</i> Bushfire damage to the dam and ancillaries. Extreme fire events damaging structures, buildings and utilities, which disrupts operation. Upper reservoir liner would be most at risk.	Rare	Major	Low	Rare	Major	Low	APZs for buildings (site office). Materials used for structures are resistant to fire. Firefighting water and equipment stored on site.	Partially effective	Bushfire fuel management (such as hazard reduction burns) on EA land (subject to ecological assessment).	Low	Low
OP-F-02		<b>Physical asset</b> <i>Dams and ancillaries</i> Burned vegetation/debris falling in to the reservoirs, including runoff, potentially impacting/blocking reservoir intakes.	Likely	Minor	Medium	Likely	Minor	Medium	Debris and trash screens on intakes. Regular maintenance. Vegetation setbacks from infrastructure. Clearing vegetation/buffer surrounding the reservoir.	Substantially effective	N/A	Low	Low

Risk ID	Climate hazard	Potential impact on project asset or function	Risk assessment (no measures)			Planned measures		Additional measures		Residual risk			
			2030			2070			Description	Effectiveness	2030	2070	
			Likelihood	Consequence	Rating	Likelihood	Consequence	Rating			Rating	Rating	
OP-F-03		<b>Physical asset</b> <i>Dams and ancillaries</i> Bushfire damage and loss of power to the asset affecting operation.	Rare	Moderate	Low	Rare	Moderate	Low	Bushfire management plan. Maintain/clearing of easement. Transgrid maintenance of 330 kV easement outside scope of project, but is a requirement of their standards.	Substantially effective	N/A	Low	Low
OP-F-04		<b>Physical asset</b> <i>Dams and ancillaries</i> Smoke affects filters, requiring replacement.	Possible	Minor	Medium	Possible	Minor	Medium	Bushfire management procedures for vent system.	Substantially effective	N/A	Low	Low
OP-F-05		<b>Operation</b> <i>Electricity generation</i> Increased bushfires may mean more water taken from reservoirs for firefighting, reducing availability for electricity generation.	Rare	Minor	Low	Possible	Minor	Medium	Ability to move water within the broader system: Upper Cox's River Water Supply Scheme (inc. Thomsons Reservoir).	Substantially effective	N/A	Low	Low
OP-F-06		<b>Operation</b> <i>Access</i> Impacts on transport network (internal/external roads). Access routes to the asset affected by physical damage to roads from fire (short-term, or long-term if damage is extensive).	Rare	Insignificant	Low	Unlikely	Insignificant	Low	Road design for main access route and permanent roads, road maintenance, emergency bushfire egress route via Mt Walker fire trail.	Partially effective	Bushfire fuel management (such as hazard reduction burns) on EA land (subject to ecological assessment).	Low	Low

Risk ID	Climate hazard	Potential impact on project asset or function	Risk assessment (no measures)						Planned measures		Additional measures		Residual risk	
			2030			2070			Description	Effectiveness			2030	2070
			Likelihood	Consequence	Rating	Likelihood	Consequence	Rating					Rating	Rating
OP-F-07		<b>Operation</b> <i>Access</i> Fire and smoke events prevent access to site, or result in evacuation of workers, disrupting operation and maintenance.	Possible	Minor	Medium	Possible	Minor	Medium	WHS policies, bush fire management and emergency management, e.g. firefighting controls, evacuation plans, etc.	Partially effective	Bushfire fuel management (such as hazard reduction burns) on EA or NPWS land (subject to ecological assessment), bush fire refuge buildings to be incorporated into design.	Low	Low	
OP-F-08		<b>Health and safety</b> <i>Visibility</i> Smoke affects visibility along access roads, causing traffic accidents, resulting in injury and vehicle damage.	Rare	Major	Low	Rare	Major	Low	WHS policies, bush fire management and emergency management, e.g. firefighting controls, evacuation plans, etc.	Substantially effective	N/A	Low	Low	
OP-F-09		<b>Health and safety</b> <i>Injury from fire/smoke</i> Fire and smoke events resulting in death, or serious illness or minor injuries requiring medical treatment.	Rare	Catastrophic	Medium	Rare	Catastrophic	Medium	WHS policies, bush fire management and emergency management, e.g. firefighting controls, evacuation plans, etc.	Substantially effective	N/A	Low	Low	

Risk ID	Climate hazard	Potential impact on project asset or function	Risk assessment (no measures)			Planned measures	Additional measures	Residual risk					
			2030		2070			Description	Effectiveness	2030	2070		
			Likelihood	Consequence	Rating					Likelihood	Consequence	Rating	Rating
OP-R-01	<b>Rainfall</b> (NARCLiM 2.0) Decrease in annual rainfall in the near future, and fairly large decrease in the far future. Increased intensity of extreme rainfall events.	<b>Physical asset</b> <i>Dams and ancillaries</i> Extreme rainfall exceeds the operational criteria of dam or other components, resulting in damage, shutdown or extended disruption.  (Noting that there is no catchment area for the upper reservoir).	Rare	Major	Low	Rare	Major	Low	Existing spillway/system of fuse gates that can handle 1 in 2.4 million year events.	Partially effective	N/A	Low	Low
OP-R-02		<b>Physical asset</b> <i>Dams and ancillaries</i> Slope instability. Surface water triggers failures.	Rare	Catastrophic	Medium	Rare	Catastrophic	Medium	Location and dam design and sizing, maintenance and monitoring. Design and construction will be mitigation. Geotechnical stability embedded into dam design, commissioning and testing, regular maintenance and monitoring.	Substantially effective	N/A	Low	Low
OP-R-03		<b>Physical asset</b> <i>Dams and ancillaries</i> Flooding of powerhouse.	Rare	Catastrophic	Medium	Rare	Catastrophic	Medium	Infill to be designed so it can't happen. MAT/EVCT ventilation tunnel and main access tunnel design. Designed to be above flood level.	Substantially effective	N/A	Low	Low
OP-R-04		<b>Physical asset</b> <i>Reservoir</i> Slope instability. Heavy rain triggers slope movement, rockfall, mudslides into reservoirs.	Possible	Moderate	Medium	Possible	Moderate	Medium	Detailed design plan is to assess risk and propose options for mitigation.	Partially effective	Ongoing review and monitoring and intervention.	Low	Low

Risk ID	Climate hazard	Potential impact on project asset or function	Risk assessment (no measures)						Planned measures	Additional measures	Residual risk			
			2030			2070					Description	Effectiveness	2030	2070
			Likelihood	Consequence	Rating	Likelihood	Consequence	Rating					Rating	Rating
OP-R-05		<b>Physical asset</b> Increased sediment load resulting in loss of reservoir storage capacity & connectivity of Farmers Creek to reservoir (and turbine erosion).	Rare	Minor	Low	Rare	Minor	Low	Detailed design plan is to assess risk and propose options for mitigation.	Partially effective	Ongoing review and monitoring and intervention.	Low	Low	
OP-R-06		<b>Physical asset</b> <i>Switchyard and connections</i> Slope instability. Heavy rain triggers slope movement, rockfall, mudslides.	Rare	Moderate	Low	Rare	Moderate	Low	Site selection. Drainage, diversions, culverts incorporated into current civil design.	Substantially effective	N/A	Low	Low	
OP-R-07		<b>Operation</b> <i>Electricity generation</i> Increased variability in water levels leads to more unpredictable electricity generation (peak, time day, seasonal).	Rare	Moderate	Low	Rare	Moderate	Low	Ability to move water within the broader system: Upper Cox's River Water Supply Scheme (inc. Thomsons Reservoir etc)	Substantially effective	N/A	Low	Low	

Risk ID	Climate hazard	Potential impact on project asset or function	Risk assessment (no measures)						Planned measures	Additional measures	Residual risk			
			2030			2070					Description	Effectiveness	2030	2070
			Likelihood	Consequence	Rating	Likelihood	Consequence	Rating					Rating	Rating
OP-R-08		<p><b>Other</b> <i>Environment</i></p> <p>Increased rainfall and flooding could increase the risk of more frequent dam spilling. Potential impacts include scouring, impacts on downstream (of Lake Lyell) habitat, water quality impacts, potential flooding downstream, damage to property.</p>	Rare	Minor	Low	Rare	Minor	Low	Monitoring program of downstream environment.	Substantially effective	N/A	Low	Low	
OP-D-01	Longer periods of drought. Increase in drought duration. Increase in drought frequency.	<p><b>Physical asset</b> <i>Dams, ancillaries and other components</i></p> <p>If drought is followed by intense rainfall, there could be damage to roads and ERSED, and slope instability.</p>	Unlikely	Moderate	Medium	Unlikely	Moderate	Medium	Maintenance, monitoring (including TARP, e.g. in Water Management Plan).	Substantially effective	N/A	Low	Low	

Risk ID	Climate hazard	Potential impact on project asset or function	Risk assessment (no measures)			Planned measures		Additional measures		Residual risk			
			2030			2070			Description	Effectiveness	2030	2070	
			Likelihood	Consequence	Rating	Likelihood	Consequence	Rating			Rating	Rating	
OP-D-02		<p><b>Operation</b> <i>Water extraction and electricity generation</i></p> <p>Drought leads to greatest restrictions on water availability, which can result in less water being available for hydropower generation. Prolonged drought periods cause water levels to drop, potentially preventing operation.</p>	Rare	Major	Low	Rare	Major	Low	Ability to move water within the broader system: Upper Cox's River Water Supply Scheme (inc. Thomsons Reservoir, etc)	Substantially effective	N/A	Low	Low
OP-S-01	<p><b>Storms</b></p> <p>Decrease in the number of East Coast Lows, but with more extreme systems in warmer months.</p> <p>Tropical cyclones becoming less frequent, but with an increase in the proportion of intense storms.</p>	<p><b>Physical asset</b> <i>Dams and ancillaries</i></p> <p>High winds and/or lightning cause damage to structures and systems, including electricity poles/cables, power systems, motors etc. Interruptions to power supply and loss of amenity (e.g. lighting) or communication systems, equipment failure, impacting the asset operations.</p>	Rare	Minor	Low	Rare	Minor	Low	Design includes lightning protection system, comms is underground.	Substantially effective	N/A	Low	Low
OP-S-02		<p><b>Physical asset</b> <i>Transmission lines</i></p> <p>Storms could result in damage to transmission lines.</p>	Rare	Major	Low	Rare	Major	Low	Site selection of towers, easement is cleared. Exposure is limited due to short length of project transmission lines.	Substantially effective	N/A	Low	Low

Risk ID	Climate hazard	Potential impact on project asset or function	Risk assessment (no measures)			Planned measures		Additional measures		Residual risk			
			2030			2070			Description	Effectiveness	2030	2070	
			Likelihood	Consequence	Rating	Likelihood	Consequence	Rating			Rating	Rating	
OP-S-03		<p><b>Operation</b> <i>Electricity generation</i></p> <p>Debris in water from storms. Storms result in large, suspended material in the water (e.g. tress, branches), leading to blockages and damage, thereby increasing maintenance and affecting operation. Could damage liner/membrane of upper reservoir, such as when water level is low. Would need extreme storm (tornado).</p>	Rare	Major	Low	Rare	Major	Low	Tree screens on intakes, regular maintenance.	Partially effective	N/A	Low	Low
OP-S-04		<p><b>Operation</b> <i>Access</i></p> <p>Impacts on transport network. More severe storms causing damages to trees, resulting in blocked local roads, preventing access by operators and essential services (usually short-term).</p>	Likely	Insignificant	Low	Likely	Insignificant	Low	WHS policies, emergency management policies /evacuation plans, etc.	Partially effective	Alternative site access could be provided through national park. Could only be used in case of emergency.	Low	Low

Risk ID	Climate hazard	Potential impact on project asset or function	Risk assessment (no measures)			Planned measures		Additional measures		Residual risk			
			2030			2070		Description	Effectiveness	2030	2070		
			Likelihood	Consequence	Rating	Likelihood	Consequence			Rating	Rating	Rating	
OP-S-05		<p><b>Health and safety</b> <i>Injury from storms</i></p> <p>Danger to staff that are onsite during an event. On-site staff could be vulnerable to storm-related injury and death (e.g. wind-blown objects, electric shock).</p>	Rare	Catastrophic	Medium	Rare	Catastrophic	Medium	WHS policies and training, emergency management policies /evacuation plans etc.	Substantially effective	N/A	Low	Low
OP-S-06		<p><b>Health and safety</b> <i>Traffic accidents</i></p> <p>Storms and heavy rainfall increase risk of traffic accidents, exposure, need for evacuation if there is flooding.</p>	Rare	Catastrophic	Medium	Rare	Catastrophic	Medium	WHS policies. Road design for main access route and permanent roads, road maintenance, emergency egress route via Mt Walker fire trail, permanent bridge designed for flood levels.	Substantially effective	N/A	Low	Low

