Environment Effects Statement

Western Renewables Link

TECHNICAL REPORT

N Climate Change Assessment

N

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EES Technical Report N

Climate Change Assessment

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Glossary

AEP	Annual exceedance probability. The probability that an event of this size (e.g. rainfall amount in a given timeframe, wind speed) or greater will occur in a year.
AFDRS	Australian Fire Danger Rating System. This new system replaced the previous fire danger rating (FDR) system in 2022. Under the AFDRS, fire danger ratings are based on forecast fire behaviour indices, which reflect fire weather conditions and bushfire fuel availability. The scale has four classes, ranging from moderate to catastrophic.
AR5	Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), published 2013-14.
AR6	Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), published 2021-23.
AusNet	AusNet Transmission Group Pty Ltd
BoM	Bureau of Meteorology
CC Act	*Climate Change Act 2017*(Victoria)
CMIP5 / 6	Coupled Model Intercomparison Project 5 / 6 for climate modelling underpinning IPCC Fifth and Sixth Assessment Reports, respectively
Climate change scaling factors	The factors used to adjust (or scale) baseline climate records to account for projected climate change. These may be absolute numbers (for temperature) or percentages (other climate variables). The scaling factors relate to a specific greenhouse gas emissions scenario and future time period. They represent change from baseline conditions, which for AR6 are 1995-2014.
Distribution network	Electricity infrastructure that supplies lower voltage electricity (240V to 66kV) to individual residential customers, farmers and commercial businesses from terminal stations that are connected to the transmission network. Power is typically supplied via concrete or timber poles and single or multi-wire powerlines.
Downscale	'Downscaling' is the process by which coarse, global-scale climate models (or General Circulation Models, GCMs) are translated into finer resolutions, to better account for regional climate influences (e.g. topography).
Environment Effects Act	*Environment Effects Act 1978* (Victoria)
DCCEEW	Department of Climate Change, Energy, the Environment and Water (Commonwealth)
DEECA	Department of Energy, Environment and Climate Action
DELWP	The former Department of Environment, Land, Water and Planning (now DEECA)
DTP	Department of Transport and Planning
EPRs	Environmental Performance Requirements
EES	Environment Effects Statement
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
ESCI	Electricity Sector Climate Information Project
FDR	Fire Danger Rating. FDRs have historically been based on forecast values of FFDI and / or GFDI. This fire danger weather rating scale was replaced in 2022 by the new Australian Fire Danger Rating System (AFDRS) which is based on Fire Behaviour Indices. The former FDR system had a six-point scale, which in Victoria, ranged from Low–moderate to Code Red.

FFDI	Forest Fire Danger Index: an index of fire weather conditions that reflects longer term coarse bushfire fuel and soil drying and sub-daily temperature, wind and relative humidity. FFDI values scale for FDR.
GFDI	Grassland Fire Danger Index: an index of fire weather for grassland and agricultural areas. The index is based on the degree of grassy bushfire fuel curing and sub-daily temperature, wind and relative humidity. GFDI values also scale to FDR ratings.
IPCC	Intergovernmental Panel on Climate Change
kV	kilovolt
Principal Contractor	During the construction stage, there will be multiple principal contractors and sub-contractors involved in the delivery of the different project components. This EES refers to Principal Contractor as a catch all term for the contractor responsible for the works.
Project Area	The Project Area encompasses all areas that would be used to support the construction and operational components of the Project considered in the EES. The Project Area is contained within the Project Land and encompasses the following: ▪ Permanent infrastructure: - Transmission tower structures - Upgrade and connection to the Bulgana Terminal Station - Connection to the Sydenham Terminal Station - An upgrade of Elaine Terminal Station - The new 500kV terminal station near Bulgana - Access tracks required for operation ▪ Temporary construction areas and infrastructure: - Distribution line crossovers - Hurdles - Laydown areas - Stringing pads - Access tracks - Tower assembly areas - Workforce accommodation facilities.
Project Land	The Project Land encompasses all land parcels that could be used for the purpose of temporary Project construction and permanent operational components. The Project Land corresponds with the extent of the Specific Controls Overlay proposed in the draft Planning Scheme Amendment for the Project. This generally includes the entire land parcel intersected by a Project component.
Proposed Route	The Proposed Route is approximately 100 to 170m wide and encompasses the nominal future easement for the proposed new transmission line (including a buffer either side), and the terminal station areas. The Proposed Route is located within the Project Area.
RCP	Representative Concentration Pathway: a scenario of atmospheric warming in response to future greenhouse gas emissions. RCP scenarios are used in CMIP5 climate modelling for the IPCC's 5^{th} Assessment Report (AR5).
SSP	Shared Socioeconomic Pathway; a scenario of human social and economic development over the 21st century resulting in a particular trajectory in atmospheric greenhouse gas emissions. SSP scenarios are used in CMIP6 climate modelling for the IPCC's 6^{th} Assessment Report (AR6).

Study area	An approximately 25km area around the Project Land from which the meteorological observations used to characterise current and future climate to which the Project is exposed have been obtained.
Transmission network	Electricity infrastructure that conveys electricity from generators to distribution networks, which in turn, supply electricity to customers. An above ground transmission network typically comprises towers and the wires that run between them, underground cables, transformers, switching equipment, reactive power devices, and monitoring and telecommunications equipment. The transmission network in Victoria operates at voltages between 220kV and 500kV.
VCP2019	Victorian Climate Projections 2019, Clarke *et al*. (2019)
WHS	Work, Health and Safety
220kV	220kV transmission line
500kV	500kV transmission line

Executive summary

The Western Renewables Link (the Project) proposes a new transmission line starting at Bulgana, near Stawell in Victoria's west, and extending approximately 190km to Sydenham in Melbourne's north-west. The Project will enable the connection of new renewable energy generated in western Victoria into the National Electricity Market and increase the Victorian transmission capacity. The Project is being delivered by AusNet Transmission Group Pty Ltd (AusNet).

This climate change assessment forms part of the Environment Effects Statement (EES) prepared for the Project in accordance with the *Environment Effects Act 1978*. This report and the methodology applied in preparing this report, responds to requirements set out in the EES scoping requirements, with a view to assessing climate change as a potential influence on the Project.

The purpose of the climate change assessment is to characterise the current climate of the area in which the Project is proposed to be constructed, describe how this may change in response to projected increases in the quantity of greenhouse gases in the atmosphere and provide an overview of some key potential impacts of climate change on electricity transmission networks. Detailed consideration of potential Project impacts associated with climate change are considered by some of the individual specialist studies.

Overview

The Western Renewables Link is critical infrastructure required to unlock the renewable energy potential of Victoria as the state transitions to cleaner, more sustainable energy. The Project aims to deliver renewable energy from wind and solar farms in western Victoria, a key renewable energy zone, to homes across Victoria and into the electricity grid. The Intergovernmental Panel on Climate Change’s (IPCC’s) Sixth Assessment Report (AR6; IPCC, 2023) is unequivocal that climate change is a threat to human well-being and planetary health and there is an urgent need for global action on greenhouse gas mitigation and adaptation. The Project will help mitigate climate change impacts by increasing the accessibility of renewable energy into the electricity grid.

To support the connection of the new transmission line, a new terminal station comprising a 500kV switchyard and associated equipment is proposed near the existing Bulgana Terminal Station, together with the expansion of the existing Bulgana Terminal Station. Project works will be required to enable connection of the transmission line into the Sydenham Terminal Station. Upgrades are also required at the existing Elaine Terminal Station. Construction is expected to take approximately two years.

Current regional climate

Climate and weather conditions vary across the Project Land (i.e., the land parcels on and over which the Project will be constructed and used for its permanent operational components). Average annual rainfall increases from less than 600mm/y at its western and eastern extents to over 1000mm/y in elevated areas on the Great Dividing Range, east of Ballarat. Temperatures are also influenced by topography, with average maximum temperatures being higher at lower elevations in the west and east (~19°C) and lower (~16°C) in more elevated locations around the southern fringe of the Wombat State Forest. Average minimum temperatures are also lower in more elevated areas than in the far west and east. Days with very high temperature (≥40°C) occur at least once in most summers. Maximum recorded temperatures range between about 44°C and 47°C.

Dangerous fire weather conditions typically occur several times each year. These conditions are characterised by very high temperature, low humidity and strong winds. Meteorological records indicate that average and (particularly) high temperature extremes have been increasing in the landscapes in which the Project is proposed to be developed and annual rainfall has been declining.

Projected climate change

Detailed climate change projections (for rainfall and temperature) have been developed for three locations that are broadly representative of the study area for this climate change assessment; Ararat, Ballarat and Melbourne

Airport. The projections are based on modelling undertaken for the IPCC's Sixth Assessment Report. They consider two future greenhouse gas emissions (or Shared Socioeconomic Pathway; SSP) scenarios:

- SSP3-7.0: this scenario sees countries prioritise domestic issues over global cooperation. Economic development slopes and material-intensive consumption persists. Greenhouse gas emissions and global average temperatures continue to rise through the 21st century.
- SSP2-4.5: "middle of the road" scenario in which current social, economic and technological trends continue, with uneven progress towards equality and sustainability. Greenhouse gas emissions stabilise early in the second half of this century and decline rapidly thereafter. The scenario anticipates significantly reduced climate change relative to SSP3-7.0.

Projected trends in climate to which the Project Land may be exposed include:

- Warmer: daily maximum, minimum and average temperatures, as well as the temperature on extreme hot and cold days are all projected to increase. Maximum and extreme high temperatures are projected to increase at a greater rate than averages, minima or extreme low temperatures. The change in temperature is projected to be more rapid under the high emissions SSP3-7.0 scenario than the lower emissions SSP2-4.5 scenario.
- Drier: annual precipitation is projected to continue to decline, but with only small differences between emissions scenarios. Effects of reduced rainfall on surface water and groundwater resources may be exacerbated by the projected increase in potential evaporation and (small) reduction in relative humidity. Evaporation is projected to increase more rapidly under the higher emissions scenario. Stream flows and recharge to groundwater systems are projected to decline as a result.
- More solar radiation: solar radiation is projected to increase slightly, consistent with reduced cool season rainfall and cloudiness.
- Extreme precipitation: is projected to become heavier as the atmosphere warms, which may increase overland flows and exacerbate some flooding events.
- Wind speed: average wind speed is projected to decline slightly, with greater change under the higher emissions scenario. Extreme winds may increase or decrease, but only by a small amount (±2 m/s).
- Storms and lightning: conditions which are favourable to the formation of thunderstorms are likely to increase under climate change, although it is not clear how this will affect their frequency or severity.
- Fire weather: the frequency of days with highly elevated fire weather conditions is projected to increase. The frequency and severity of bushfires and grassfires may therefore be expected to increase, unless bushfire or grassfire fuel and ignition sources are managed to effectively prevent or control fire.

Implications of weather extremes and climate change for electricity transmission networks

The Electricity Sector Climate Information (ESCI) Project was initiated by the Australian electricity sector to provide tailored climate and extreme weather information for use in assessing the risk that climate change presents to system reliability and resilience. Electricity infrastructure performance is directly affected by weather conditions, with those effects likely exacerbated by projected climate change. Key climate change hazards for electricity transmission networks considered by the ESCI Project include:

- Rising temperature: electricity transmission may be impaired on days with extreme high temperature and during heatwave events, which are projected to increase in intensity and frequency with climate change.
- Increased frequency, severity and extent of bushfires: operation of transmission powerlines may be affected by heat and smoke associated with bushfires. Fire weather conditions may be exacerbated by climate change, which may affect the incidence, severity and / or extent of bushfires (subject to bushfire fuel availability).
- Extreme winds: very strong winds reduce transmission line capacity and threaten the integrity of transmission infrastructure. While conditions that are conducive to extreme winds in many regions of

Australia may be affected by climate change, increasing in some regions and decreasing in others, the amount of change projected is relatively small.

- Increased variability or reduction in rainfall, dam inflows and flooding: changes in rainfall and run-off regimes (influenced by the amount and seasonal distribution of rainfall and evaporation) may affect the amount of water available for hydropower generation and cooling in thermal power stations, as well as the demand for energy, flooding of electricity infrastructure and even potential damage from lightning.
- Compound extreme events: extremes in multiple climate variables occurring simultaneously (e.g., extreme wind and bushfire) or in close sequence can cause substantial disruption to electricity networks. The severity and / or impact of these events may be exacerbated by infrastructure failure and / or other human factor hazards. Climate change may increase the frequency and magnitude of such events.

Climate change and operation of the Project

The Project Land will likely be exposed to a variety of climate-related natural hazards, including extreme heat, elevated fire weather, extreme winds and changed rainfall conditions. Except for extreme winds, these hazards are projected to be significantly amplified by climate change over the Project's planned operating life. Design and construction of the Project are anticipated to mitigate most resulting potential impacts. Effects of extreme heat on the capacity of transmission lines to conduct electricity are difficult to avoid but will be partly mitigated by design features and inherent climate conditions that encourage heat dissipation (e.g., windy conditions), limiting the duration of the worst effects of extreme heat.

Environmental Performance Requirements

Two Environmental Performance Requirements (EPRs) have been proposed, one recommending that a thorough climate change risk assessment is undertaken for the Project during the detailed design stage. The second EPR recommends the initial climate change risk assessment is followed up at approximately five-year intervals. It would draw on the best available climate science relating to material changes in hazards for Project infrastructure at the time. Both assessments would consider risks climate change related hazards may pose to Project infrastructure and any effects on other potential Project impacts. They may also propose adaptation measures to address key risks.

1. Introduction

1.1 Background

The Western Renewables Link Project (the Project) proposes a new transmission line starting at Bulgana, near Stawell in Victoria's west, and extending approximately 190km to Sydenham in Melbourne's north-west. The Project will enable the connection of new renewable energy generated in western Victoria into the National Electricity Market and increase the Victorian transmission capacity. The Project is being delivered by AusNet Transmission Group Pty Ltd (AusNet).

The Project was originally referred to the former Minister for Planning under the *Environment Effects Act 1978* (Environment Effects Act) on 9 June 2020 by AusNet and it was determined that an Environment Effects Statement (EES) was required. On 22 August 2023, the Minister for Planning determined that the Project has the potential to cause significant environmental effects and that an EES was required to inform decision-makers in the granting of key approvals for the Project. In summary the key changes in the new proposed Project scope are:

- The urgent Sydenham Terminal Station Rebuild Project will be assessed and approved separately. A connection into the Sydenham Terminal Station forms part of Western Renewables Link scope
- The 220kV portion of the transmission line is proposed to be uprated to 500kV
- The new terminal station north of Ballarat will no longer be required
- A new 500kV terminal station near Bulgana will be required including a new 220kV connection to the existing Bulgana Terminal Station.

The Commonwealth Government's Department of Agriculture, Water and the Environment (DAWE) — now Department of Climate Change, Energy, the Environment and Water (DCCEEW) — has also confirmed that the Project is a 'controlled action' and will require assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Commonwealth has determined that it will use the bilateral assessment agreement and rely on the Victorian Government's assessment process (EES) to inform an approval decision under the EPBC Act.

1.2 Purpose of this report

The purpose of this climate change assessment report is to describe the current climate of the landscape which the Project is proposed to traverse and how climate models project this will change to 2090 under contrasting future greenhouse gas emissions scenarios. It satisfies applicable EES scoping requirements by assessing potential physical impacts of climate-related hazards on the Project and providing climate change projections that will assist other specialist studies in considering how climate change may amplify or mitigate any potential impacts of the Project.

This report also defines Environmental Performance Requirements (EPRs) that address the EES scoping requirement to consider the Project's on-going susceptibility to extreme weather, under climate change.

1.2.1 Climate change

In August 2021, Working Group I of the Intergovernmental Panel on Climate Change (IPCC) released its *Sixth Assessment Report* (AR6) on the physical science basis for climate change (IPCC, 2021). The report provides a contemporary understanding of the current state of the climate, how it is changing, how it may continue to change over shorter and longer timescales, and the influence of human activity in driving that change. It was the first main report of the AR6 cycle and was followed during 2022 by contributions from other IPCC Working Groups (on impacts, adaptation and vulnerability [IPCC, 2022a]; and on climate change mitigation [IPCC, 2022b]). The AR6 Synthesis Report was published in 2023 (IPCC, 2023).

The AR6 Working Group I report builds on its previous contribution to the IPCC's *Fifth Assessment Report* (AR5), published in 2013 (IPCC, 2013) and several IPCC Special Reports published during 2018 and 2019. Its findings are broadly consistent with AR5. Notably, it affirms that the increase of carbon dioxide, methane, and nitrous oxide in the atmosphere over the industrial era is the result of human activities. It concludes that human influence is the principal driver of a global mean surface temperature rise of almost 1.1°C since the start of the industrial era and many other observed changes across the atmosphere, ocean, ice and snow, and life on Earth.

Climate modelling in AR6 is based on a new set of 'Shared Socioeconomic Pathway' (SSP) scenarios that describe alternative trajectories for future greenhouse gas emissions. These are similar (but not identical) to some of the Representative Concentration Pathway (RCP) scenarios that underpinned climate change modelling in AR5. Even under the SSP scenarios with the most aggressive emissions reductions, the IPCC's best estimate is that global mean surface temperature rise will exceed 1.5°C, the target of the United Nations Framework Convention on Climate Change's 2015 Paris Agreement, during the next 20 years. Only under the two most aggressive decarbonisation scenarios is it likely that global warming will remain under the IPCC's 2°C threshold for dangerous human interference in the global climate system. Under high emissions growth scenarios, global temperatures could increase by over 4°C above pre-industrial levels by the end of this century.

The projected effects of this warming of the global climate system are far reaching (IPCC, 2021) and include:

- Frequency and intensity of hot extremes and marine heatwaves will increase
- Heavy precipitation events will intensify, with further increases in precipitation in most monsoonal regions and at high latitudes in the northern hemisphere
- Agricultural and ecological droughts will be more severe in regions that are subject to these phenomena
- Of the tropical cyclones that occur, the proportion in the higher categories will continue to increase
- Reductions in Arctic sea ice, snow cover and permafrost will accelerate.

While some changes in the climate system can be reversed if greenhouse gas emissions are reduced at scale across the globe, other changes to oceans, ice sheets, and sea level are effectively locked in and irreversible at centennial timescales (IPCC, 2021).

Projected climate change over the anticipated life of the Project could affect surface water and groundwater conditions, fire weather, land use and land management patterns and important ecological processes in native ecosystems.

1.3 Structure of the report

The report is structured in the following way:

- **Introduction** (this section) which provides background details for the Project and outlines the purpose and structure of the climate change assessment.
- **EES scoping requirements** (Section 2) where the EES scoping requirements relevant to climate change are set out, and an indication of where each component of the EES scoping requirements has been considered and addressed in the climate change assessment.
- **Project description** (Section 3) where Project components and activities relevant to the assessment are explained including details pertinent to climate change vulnerability and resilience of the Project.
- **Legislation, policy and guidelines** (Section 4) which outlines the Commonwealth, State and other documents relevant to the assessment.
- **Method** (Section 5) where the approach applied to assess potential climate change impacts associated with the Project is explained.
- **Existing climate conditions** (Section 6) which identifies background conditions, a description of historical climate conditions for the Project's study area.
- **Climate change projections** (Section 7), a description of the projected changes in climate for the Project's study area that may result from historical and future greenhouse gas emissions.

- **Implications of weather extremes and climate change for electricity transmission networks** (Section 8), a description of how contemporary weather extremes may affect electricity transmission networks, how these may be amplified by climate change and what this may mean for the Project.
- **Implications of climate change for construction and operation of the Project** (Section 9), an assessment of the implications of climate and weather extremes for construction of the Project and of climate change for operation of the Project.
- **Environmental Performance Requirements** (Section 10), which either set out environmental outcomes to be achieved through the implementation of mitigation measures during construction, operation and decommissioning or prescribe actions to be undertaken during one or more of those stages to satisfy the EES evaluation objectives. EPR for climate change fall into the latter category. Compliance with the EPRs will be required as a condition of the Project's approval.
- **Conclusion** (Section 11) where the objectives, methods, outcomes and recommendations of the assessment are presented.

1.4 Related studies

This report should be read in conjunction with the following related technical reports from which this report draws specific information:

- **Technical Report A: Biodiversity Impact Assessment**: the assessment notes that climate change is a threatening process for some listed species, however climate change is not anticipated to amplify any Project-related impacts.
- **Technical Report K: Bushfire Impact Assessment**: which considers the potential influence of climate change on fire weather conditions experienced by the Project.
- **Technical Report Q: Geology and Soils Impact Assessment**: which considers the potential influence of extreme weather conditions on soil erosion and land stability through construction and operation of the Project.
- **Technical Report S: Groundwater Impact Assessment**: climate change forms part of the considerations of potential impacts of the Project in the surface water and groundwater impact assessments. Climate change is not expected to amplify any effects of the Project on groundwater.
- **Technical Report T: Surface Water Impact Assessment**: the assessment considers the potential for climate change to amplify flood conditions, their impacts on the Project and any potential impacts of the Project on those conditions.

2. EES scoping requirements

The EES scoping requirements – Western Renewables Link Environment Effects Statement (DTP, 2023) set out in detail the matters to be investigated, assessed and documented in the EES for the Project and are referred to in this report as the EES scoping requirements.

2.1 EES evaluation objectives

The EES scoping requirements specify evaluation objectives which provide a framework to guide an integrated assessment of environmental effects of the Project, in accordance with the *Ministerial guidelines for assessment of environmental effects under the Environment Effects Act 1978, Eighth edition, 2023*. The evaluation objectives identify desired outcomes in the context of key legislative and statutory policies, as well as the principles and objectives of ecologically sustainable development and environmental protection, including net community benefit.

The EES scoping requirements specify that the main EES report is to include descriptions of the existing environment and likely trends, including future climate change scenarios, where these are relevant to potential effects.

Two of the environmental impact themes set out in Section 4 of the EES scoping requirements refer to the potential physical impacts of climate change[1]:

- Section 4.5 Community amenity, safety, roads and transport: the evaluation objective for this theme is to *avoid, or minimise where avoidance is not possible, adverse effects for community amenity, health and safety, with regard to construction noise, vibration, dust, lighting, waste, greenhouse gas emissions, transport network, operational noise, fire risk management and electromagnetic radiation*. The scoping requirements associated with this theme and objective require consideration of the Project's ongoing sustainability, including susceptibility to extreme weather events in the context of modelled climate change scenarios.
- Section 4.6 Catchment values and hydrology: the evaluation objective for this theme is to *maintain the functions and values of aquatic environments, surface water and groundwater quality and stream flows and prevent adverse effects on protected beneficial uses*. The scoping requirements associated with this theme and objective require consideration of potential Project effects under appropriate climate change scenarios.

In order to meet the evaluation objectives, it is necessary to understand the potential effects of climate change on functions and values of the Project so that impacts can be appropriately avoided or mitigated. This climate change assessment report describes the current climate of the region in which the Project is located, how climate models indicate this may change to 2090 under contrasting future greenhouse gas emissions scenarios and what effects these may have for operation of the Project. It provides climate-related content for the main EES report, as well as climate change projections that inform other specialist studies, including those addressing community amenity, safety, roads and transport, catchment values and hydrology.

2.2 Assessment of specific environmental effects

The EES scoping requirements set out the key issues that the Project poses to the achievement of the evaluation objective, together with the features and values of the existing environment that are to be characterised – these are referred to as the 'existing conditions'. The EES scoping requirements also list potential effects of the Project and identify where mitigation measures may be required.

The EES scoping requirements pertaining to climate change are set out in Sections 4.5 and 4.6 of the EES scoping requirements. These are reproduced in Table 2.1, together with where these items have been addressed in this report (and other reports as applicable).

[1] Physical impacts of climate change is referenced here to distinguish from implications of the Project in relation to greenhouse gas emissions and climate change mitigation.

Table 2.1: Climate change scoping requirements

Aspect	Scoping requirement	Relevant sections
Key issues		
Community amenity, safety, roads and transport	Implications of the project for fire risk management on surrounding land, including fire ignition risks arising from the project. These implications may be influenced by projected change in fire weather conditions with climate change.	Current and projected changes in climate conditions are described in Sections 6 and 7 of this report. Current and projected changes in fire weather conditions are described in the Bushfire Impact Assessment. Current and projected changes in rainfall regime are described in Sections 6 and 7 of this report. Key issues and risks resulting from current and projected climate are described in applicable impact assessment reports: ▪ Bushfire Impact Assessment ▪ Surface Water Impact Assessment The Groundwater Impact Assessment does not identify any change in potential impacts of the Project that may result from climate change. The Geology and Soils Impact Assessment discusses potential for erosion during the Project's construction stage.
Catchment values and hydrology	Each of the key issues identified under catchment values and hydrology (below) are potentially also influenced by climate change: ▪ Potential for the project to have significant impact on waterways, floodplains and wetland systems. ▪ Potential for adverse effects on nearby and downstream water environments due to changed water quality or impacts on groundwater or waterway conditions during construction. ▪ Potential for adverse effects on the functions, values and beneficial uses of groundwater due to the project's activities, including water extraction, interception or diversion of flows, discharges or seepage from tower foundations or other earthworks and changes to salinity. ▪ Potential for disturbance of contaminated, saline, dispersive or acid sulphate soils. ▪ Potential for erosion resulting from construction and operation due to vegetation loss or other factors.	
Existing environment		
Community amenity, safety, roads and transport	Characterise the fire risks associated with the project area of interest and its environs.	Section 6 of this report describes the current climate of the project area. How this is projected to change with climate change is described in Section 7. The Bushfire Impact Assessment addresses existing fire weather conditions and projected changes with climate change. Aspects of the existing conditions for surface water, groundwater and soils are described in: ▪ Surface Water Impact Assessment ▪ Groundwater Impact Assessment ▪ Geology and Soils Impact Assessment.
Catchment values and hydrology	Characterise the groundwater (including depth, quality and availability to licence/use) and surface water environments and drainage features in the project area of interest and its environs. Characterise the interaction between surface water and groundwater within the project and broader area. Characterise the wetland systems in the project area of interest and its environs including the extent, types and condition of wetlands that could be impacted by the project, having regard to terrestrial and aquatic habitat, including as habitat corridors or linkages. Characterise soil types and structures in the study area and identify the potential location and disturbance of dispersive, acid sulphate, saline or potentially contaminated soils, or soils of other special characteristics that could affect or be affected by the project.	
Mitigation measures		
Community amenity, safety, roads and transport	Identify measures for avoiding, managing and minimising fire risks arising from or associated with the project, having regard to planning and other policy provisions.	This report only describes existing conditions and how they are projected to change with climate change. Potential mitigation measures are described in the respective impact assessments.
Catchment values and hydrology	Identify and evaluate aspects of project works and operations, and proposed design refinement options or	

Aspect	Scoping requirement	Relevant sections
	measures, that could avoid or minimise significant effects on water and catchment environments. Describe further potential and proposed design options and measures that could avoid or minimise significant effects on beneficial uses of surface water, groundwater and downstream water environments during the project's construction and operation, including response measures for environmental incidents. Describe further potential and proposed design options and measures that could avoid or minimise significant effects on soil stability. Describe available options for treatment or disposal of the various categories of solid and liquid wastes generated by the project.	▪ Bushfire Impact Assessment ▪ Surface Water Impact Assessment The Groundwater Impact Assessment does not identify any potential impacts associated with climate change and hence no mitigation measures were proposed. The Biodiversity Impact Assessment notes climate change as a threatening process, but it is not considered to be an amplifier of potential Project impacts on biodiversity and hence no mitigation measures have been proposed.
Likely effects		
Community amenity, safety, roads and transport	Identify and assess potential impacts on human health and safety that could result from the project. Assess the risks that the project could cause a fire affecting land and assets within or outside the project area of interest. Assess the implications of the project for fire risk management or bushfire suppression activities within the project area of interest or in its vicinity. Identify and assess risks to the project's ongoing sustainability including susceptibility to extreme weather events in the context of modelled climate change scenarios.	Likely effects of the Project on fire safety are described in the Bushfire Impact Assessment. Section 8 describes implications of extreme weather events and climate change for electricity transmission infrastructure. The Project's susceptibility to extreme fire weather events is described in the Bushfire Impact Assessment and EES Chapter 13: Bushfire.
Catchment values and hydrology	Assess the potential effects of the project on surface water and groundwater environments and beneficial uses, including on permanent and ephemeral waterways, floodplains and wetland systems in or near the project area of interest and its environs, considering appropriate climate change scenarios. Identify and assess potential effects of the project on soil stability, erosion and the exposure and disposal of contaminated or hazardous soils (e.g., acid sulphate soils). Identify potential environmental effects resulting from the generation, storage, treatment, transport and disposal of solid and liquid wastes, including soil, from project construction and operation.	Relevant effects of the Project on catchment values and hydrology are described in the Surface Water Impact Assessment. This report (Section 7) describes climate change features that may influence catchment values and water.

3. Project description

3.1 Project overview

The Project aims to address the current constraints of the western Victorian transmission network by providing the additional capacity, reliability and security needed to drive the development of further renewable electricity generation in western Victoria. By doing so, the Project supports the transition from coal-generated electricity to renewables and the efficient connection of renewable electricity into the National Electricity Market.

The Project comprises the construction and operation of a new approximately 190km overhead double circuit 500kV transmission line between Bulgana in Victoria's west and Sydenham in Melbourne's north-west. To support the connection of the new transmission line, the following works are proposed:

- The construction and operation of a new 500kV terminal station near Bulgana, and a 220kV transmission line connection to the existing Bulgana Terminal Station
- Expansion of the existing Bulgana Terminal Station
- Connection works at the Sydenham Terminal Station including the modification of a bay and a bay extension with associated infrastructure
- Upgrade of the existing Elaine Terminal Station, through the diversion of an existing line
- Protection system upgrades at connected terminal stations.

The Project's main features are summarised in Figure 3.1, The location is shown in Figure 3.2.

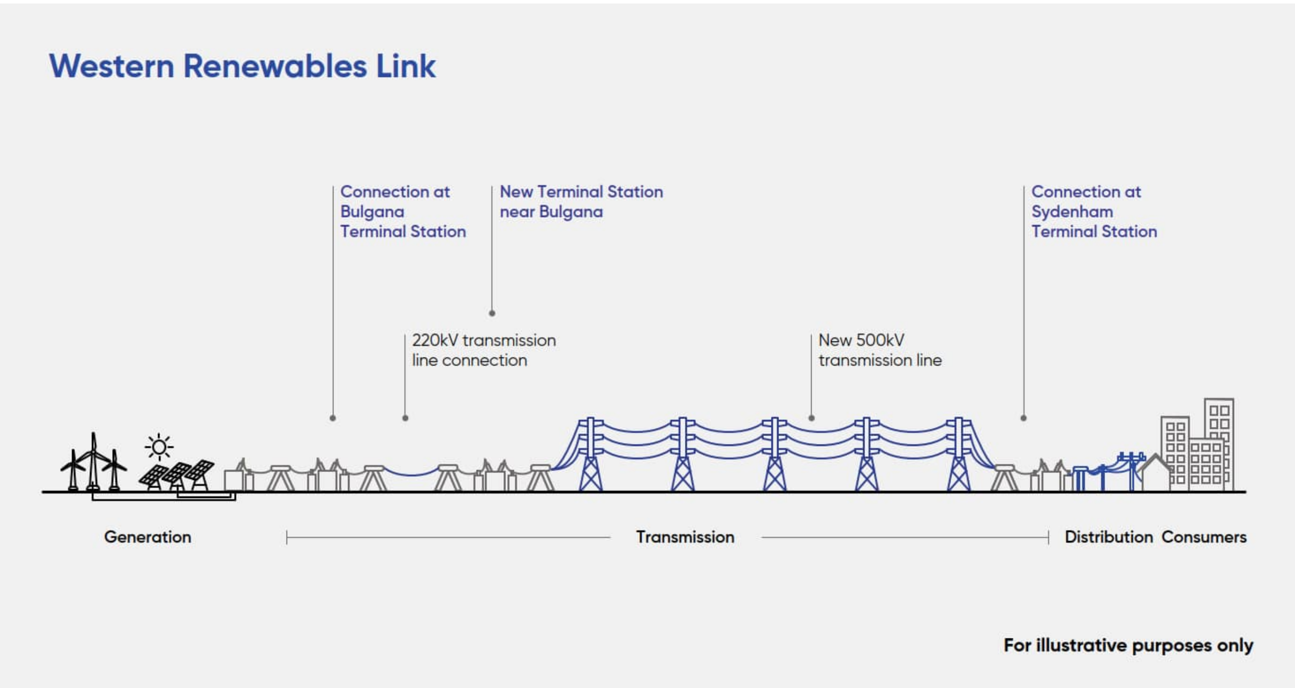


Figure 3.1: Western Renewables Link (Source: AusNet, 2024)

The Project can be described by the following key terms:

- **Project Land**: The Project Land encompasses all land parcels that could be used for the purpose of temporary Project construction and permanent operational components. The Project Land is shown in Figure 3.2.
- **Project Area**: The Project Area is contained within the Project Land and encompasses all areas that would be used to support the construction and operation of the Project. The Project Area is shown in Figure 3.2.

- **Proposed Route**: The Proposed Route is approximately 100 to 170m wide and encompasses the nominal future easement for the proposed new transmission line (including a buffer either side), and the terminal station areas. The Proposed Route is located within the Project Area.

The Proposed Route commences at the existing Bulgana Terminal Station with a 220kV transmission line connection to the new 500kV terminal station approximately 2.3km to the north-east. The Proposed Route then runs from the new 500kV terminal station to the north of the existing Ballarat to Horsham transmission line, where it runs parallel to the existing transmission line for approximately 60km. East of Lexton, the Proposed Route deviates from the Ballarat to Horsham transmission line, passing through the northern section of the Waubra Wind Farm between Mount Bolton and Mount Beckworth. Continuing east, the Proposed Route passes south of the Berry Deep Lead gold mining precinct and north of Allendale and Kingston. North of Kingston the Proposed Route turns south-east to Mount Prospect. From Mount Prospect to near Dean, the Proposed Route is adjacent to the existing Ballarat to Bendigo transmission line. Near Dean, the Proposed Route deviates from the existing transmission line to run south, then east through Bolwarrah, Bunding and Myrniong to Darley. The Proposed Route then continues eastward crossing Merrimu Reservoir north of Long Forest and along the northern boundary of MacPherson Park at Melton, connecting to the existing electricity network at the Sydenham Terminal Station.

The Project crosses six local government areas (LGAs):

- Shire of Northern Grampians
- Shire of Pyrenees
- City of Ballarat
- Shire of Hepburn
- Shire of Moorabool
- City of Melton.

For the purposes of this climate change assessment, the “study area” extends about 25km beyond the Project Land, as discussed in Section 5.2 and depicted in Figure 6.1.

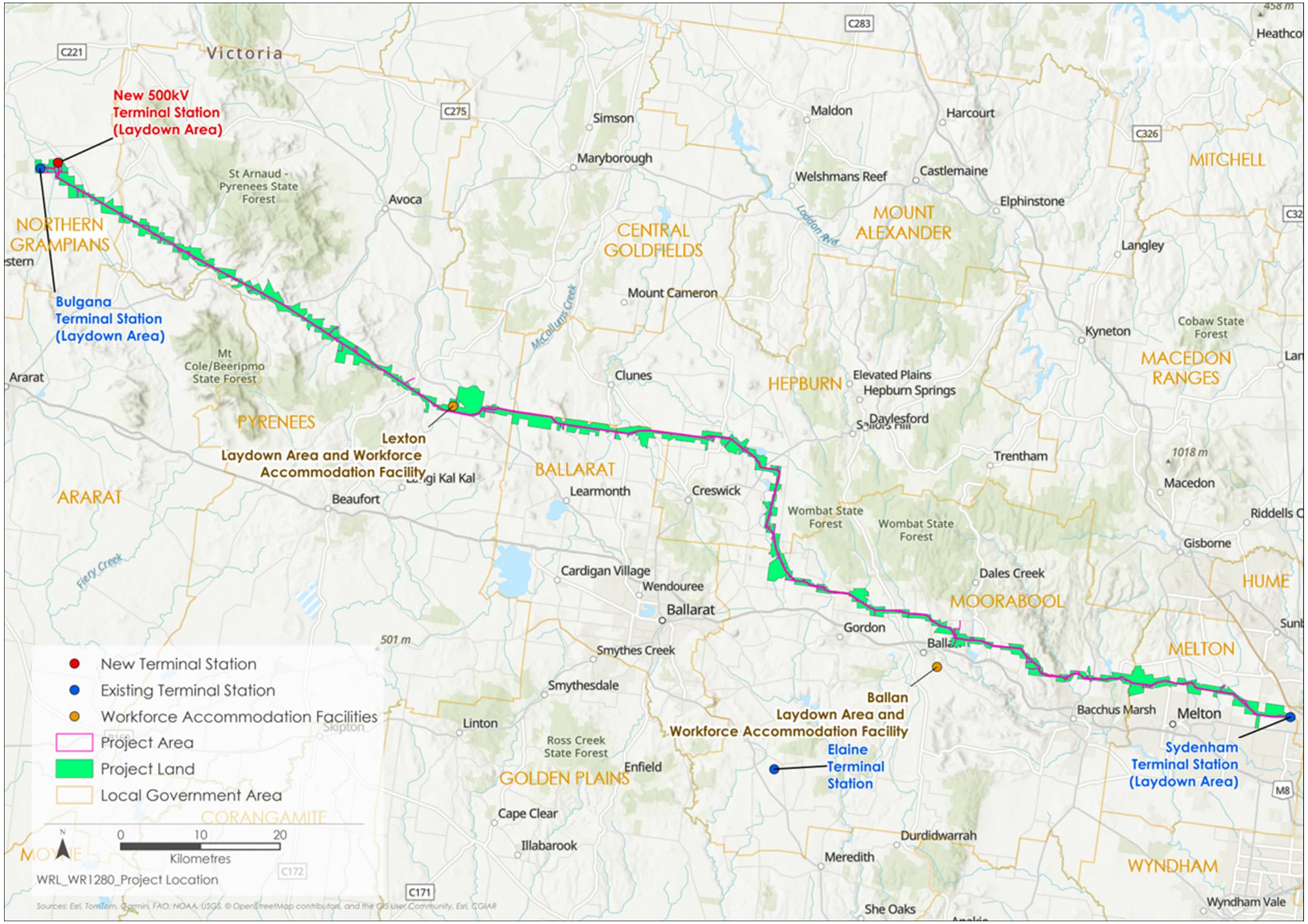


Figure 3.2: Project location (Source: Jacobs, 2025)

3.2 Project infrastructure

The proposed Project includes both permanent and temporary infrastructure, as described in Sections 3.2.1 and 3.2.2. The Project has been progressively refined from an initial broad area of interest as described **EES Chapter 5: Project development**.

3.2.1 Permanent infrastructure

The proposed Project includes the construction of infrastructure listed in Table 3.1. Further detail is provided in **EES Chapter 6: Project description**.

Table 3.1: Project infrastructure – key components*

Double circuit lattice towers	418 double circuit towers
Single circuit lattice towers	36 single circuit towers (18 sets of two side-by-side)
Approximate length of 500kV transmission line route	Approximately 190km, between Bulgana in Victoria's west to Sydenham in Melbourne's north-west.
Approximate length of 220kV transmission line route	Approximately 2.5km, between the existing Bulgana Terminal Station to the new terminal station
Terminal Stations	A new 500kV terminal station and associated infrastructure near Bulgana to be connected to the existing Bulgana Terminal Station via a 220kV connection.
	Expansion of the existing Bulgana Terminal Station to support connection of the new 500kV terminal station near Bulgana.
	A connection to the Sydenham Terminal Station, including the modification of a 500kV bay and a new 500kV bay extension with associated infrastructure
	Relocation and diversion of existing 220kV transmission lines at Elaine Terminal Station.

* Note: These figures are approximate and subject to final detailed design, which will consider further landholder consultation and geotechnical, site and other investigations.

For the safe and reliable operation of the transmission line, an easement is needed for the operation of the transmission line, and other related infrastructure to protect public safety and to provide access for maintenance and repair purposes. The transmission line easements will be typically between 70 and 100m wide for the Project.

The transmission line minimum clearances are specified by the Australian standard AS/NZS 7000:2016 Overhead Line Design and AusNet's Electricity Safety Management Scheme. Key assumptions and considerations of the towers that will form part of the Project and have been used as the basis of this report are described below.

- Transmission towers (towers) support the overhead conductors (wires or lines) at the required height above the ground to meet regulations and safety requirements. The preferred tower configuration will be a galvanised steel lattice structure similar to those found elsewhere across Victoria and within the national network. The typical tower height for the Project is between 60 and 80m.
- Each tower has four footings which will typically be 1.8m in diameter and 9m deep. The four footings base width will be between 10 and 17m. During construction, ground disturbance around each tower will typically be no greater than 50 by 70m.
- The spacing or span length between each tower is determined by the height from the ground that the conductors need to be to achieve the required ground clearance in the middle of the span. Typical span length is between 450 and 550m for the transmission line. Longer span lengths are possible over sensitive areas or to avoid impacts, however, longer spans require taller towers to provide safe ground clearances and wider easements to allow for greater sway of the conductors. Similarly, where it is difficult to achieve the

required ground clearance in the middle of the span, due to topography or obstacles, the tower span may be reduced.

- Each span comprises 26 conductors, made up of 12 conductors on each side of the tower cross arms and two ground wires across the top of the tower. Each conductor is approximately 32mm thick and made of aluminium wire strands with a steel core.

As part of the Project, the existing Bulgana Terminal Station will be upgraded to support connection of the new 500kV terminal station into the existing 220kV switchyard. The new 500kV terminal station will support the connection of the Project transmission line and future connections. The new terminal station will require additional land to the northeast of the existing Bulgana Terminal Station.

Upgrades required at Elaine Terminal Station will involve the relocation of existing 220kV transmission lines and diversion of an existing 220kV line into the terminal station. The footprint of the terminal station will not change, and all new equipment will be approximately the same height and scale as existing structures and equipment at the Elaine Terminal Station.

Connection works are proposed at Sydenham Terminal Station. The existing Sydenham Terminal Station will be re-built through the Sydenham Terminal Station Rebuild Project, prior to the Project works. The Project will connect into Sydenham through the modification of a 500kV bay and new 500kV bay extension.

3.2.2 Temporary infrastructure

During construction there will be additional work areas, including vehicle access tracks, temporary tower stringing pads, distribution line crossover points, potential hurdle locations, temporary laydown areas and workforce accommodation facilities.

Temporary laydown areas associated with the terminal stations and the transmission line will be used to sort materials, pre-assemble Project components and store equipment, vehicles and other supplies that support construction activities. Temporary fencing, gates, security systems and lighting will also be installed at the laydown areas. The Project will establish five laydown areas; two of which will be located at existing terminal station sites (Bulgana and Sydenham), one at the new 500kV terminal station near Bulgana, and an additional two sites at intermediate locations between the stations south-east of Lexton and south-east of Ballan. The two intermediate laydown areas are required for the construction of the transmission line and will be co-located with the workforce accommodation facilities. The size of each site (including workforce accommodation facilities) will vary depending on storage requirements. The site south-east of Lexton will be up to approximately 12ha and the site south-east of Ballan will be up to approximately 24ha.

AusNet proposes to utilise temporary workforce accommodation facilities to accommodate construction workforce personnel. Two facilities are proposed; one in each of the western and eastern portions of the Project, co-located with each of the intermediate laydown areas. Each facility will have capacity for up to 350 personnel and will provide individual accommodation units, a communal kitchen and meals area, laundry, gym facilities, mobile and Wi-Fi boosters and serviced cleaning. The layouts of the proposed accommodation facilities will be determined by the Principal Contractor.

3.3 Summary of key project activities

3.3.1 Construction

Construction of the Project will include preparatory activities (e.g., site investigations, establishment of laydown areas etc.), establishment of temporary infrastructure (such as water and wastewater infrastructure and power supplies), construction of towers and transmission line stringing works; construction works at terminal stations; site rehabilitation works; and pre-commissioning activities.

The overall construction duration of the Project is approximately two years. This schedule is dependent on adjustments required to deliver the Project and the granting of approvals within certain timeframes. For tower assembly and transmission line stringing, work will not be constant, with specialist crews following each other along the route doing specific jobs (clearing, site preparation, tower construction, conductor stringing, site rehabilitation, etc). As each work crew leaves a site (or property) there may be days, weeks, or possibly months of inactivity until the next crew arrives. The cumulative duration of construction work at each tower (i.e., time on each property) will be approximately 9 to 22 weeks (over a two-year period). Once construction is complete, site rehabilitation will occur and commissioning activities will include final inspections and other safety and pre-operational checks. Construction of the Project is anticipated to commence in late 2026 and be completed by late 2028.

Key activities associated with the construction of towers include:

- Site preparations, including necessary vegetation clearance
- Construction of vehicle access tracks and minor upgrades to existing roads and tracks
- Tower foundation construction
- Tower structure assembly and erection
- Transmission line stringing works
- Commissioning
- Site rehabilitation.

The works proposed at the new 500kV terminal station near Bulgana, the existing Bulgana Terminal Station and Sydenham Terminal Station will be constructed over a period of approximately 20 months, with key activities including:

- Site preparations, access and necessary vegetation clearance
- Earthworks
- Construction of footings, foundations and drainage systems
- Installation of structures and equipment
- Commissioning
- Landscaping and rehabilitation.

3.3.2 Operations

The operation and maintenance of transmission lines are subject to stringent regulatory controls to ensure public safety and the uninterrupted supply of electricity. All transmission line operators are required to comply with these controls and provide regular reports to the relevant authorities, including Energy Safe Victoria.

The key operation stage activities for the transmission line include:

- Scheduled inspections of the transmission line and easement (either by vehicle patrols or LiDAR/aerial surveys)
- Ongoing vegetation management to maintain safety clearances under the transmission line
- Tower maintenance inspections
- Repairs and maintenance to address issues found in above inspections.

While the terminal stations are operated remotely, staff are present at stations for inspections or maintenance. Routine inspections will occur bi-monthly, with personnel checking the overall condition of the terminal station's assets.

3.3.3 Decommissioning

The Project’s transmission line is designed for a service life of 80 years, while the terminal station works have been designed for a minimum life of 45 years. The terminal station works will be maintained and upgraded to enable the terminal stations to remain operational for the service life of the transmission line. At the end of the service life of the transmission line, the infrastructure will either be decommissioned or upgraded to extend its service life to maintain the security and reliability of the transmission network as determined by the network planner at that time. In the event of decommissioning, the key activities may involve:

- Lowering the overhead transmission line and ground wires to the ground and cutting them into manageable lengths to roll onto drums or reels for disposal as scrap metal
- Removing insulators and line hardware from structures at the site and disposal at an approved waste facility
- Dismantling towers in manageable sections, removing from the site and selling steel as scrap
- Excavation of footings below finish surface level
- Decommissioning and removal of terminal stations
- Easement restoration and rehabilitation, where required.

4. Legislation, policy and guidelines

This section provides an overview of key Commonwealth and state legislation relevant to climate change matters including identifying primary and likely secondary approval requirements for the Project.

4.1 Commonwealth legislation

Table 4.1: Key Commonwealth legislation relevant to climate change

Legislation	Relevance to this report
EPBC Act	
The EPBC Act provides the legal framework to protect and manage matters of national environmental significance (MNES), which include: world heritage properties; national heritage places; wetlands of international importance (Ramsar); listed threatened species and communities; listed migratory species; Commonwealth marine areas; the Great Barrier Reef Marine Park; nuclear actions; and water resources, in relation to coal seam gas and large coal mining development. Any project that is likely to have a significant impact on MNES, must be referred to the Commonwealth Minister for the Environment and Water via the Department of the Climate Change, Energy, the Environment and Water (DCCEEW) for a decision on whether the Project is a 'controlled action' requiring assessment and approval under the EPBC Act.	The Project was referred to the Commonwealth Minister for the Environment, who determined that the Project is a 'controlled action' requiring assessment and approval under the EPBC Act before it can proceed. The Minister's referral decision (EPBC 2020/8741) issued on 2 September 2020 determined that the Project is a 'controlled action' due to its potential to have a significant impact on listed threatened species and communities, and further stipulates that the Project will be assessed under the bilateral (assessment) agreement between the Commonwealth and Victorian Governments. The proposed action referred was varied on 20 November 2024 to reflect the Project description. Under the Victorian *Environment Effects Act 1978*, the EES process is an accredited assessment process under the bilateral (assessment) agreement.

4.2 State legislation

Table 4.2: Key state legislation relevant to climate change

Legislation	Relevance to this report
Environment Effects Act	
The *Environment Effects Act 1978* (Environment Effects Act) provides for the assessment of projects that may have a significant effect on the environment by enabling the Minister administering the Act to decide that an EES should be prepared. An EES may be required where: • There is a likelihood of regionally or State significant adverse environmental effects • There is a need for an integrated assessment of social and economic effects of a project or relevant alternatives • Normal statutory processes would not provide a sufficiently comprehensive, integrated, and transparent assessment. The process under the Environment Effects Act is not an approval process in itself; rather it is an assessment process that enables statutory decision-makers to make decisions about whether a project with potentially significant environmental effects should proceed.	On 22 August 2023, the Minister for Planning determined that the Project requires assessment through an EES under the Environment Effects Act, due to matters as set out in the Statement of Decision on Referral No. 2023R-04, and summarised below: ▪ The area of interest for the project supports significant environmental values, and other social values, potential aggregate impacts on which are of at least regional significance. ▪ Multiple alignment and design alternatives for the project within the area of interest require rigorous and transparent assessment and refinement ▪ An EES responds to community interest in project siting, alignment and design alternatives by providing appropriate opportunities for public input. The Minister for Planning issued the EES scoping requirements in November 2023 (Section 2), which have informed this assessment.

<table>
<tr><th>Legislation</th><th>Relevance to this report</th></tr>
<tr><td colspan="2">Climate Change Act 2017</td></tr>
<tr><td>The Climate Change Act 2017 (CC Act) provides for the setting of long-term and interim greenhouse gas emission reduction targets for Victoria, facilitation of consideration of climate change in specified areas of government decision-making and strategic responses to climate change. The Act includes a set of policy objectives for climate change and guiding principles. Key objectives relevant to the consideration of climate change in the Project are to:
▪ Build the resilience of the State's infrastructure, built environment and communities through effective adaptation and disaster preparedness action
▪ Manage the State's natural resources, ecosystems and biodiversity to promote their resilience.
One of the Act's guiding principles is that of risk management. It specifies, among other things, that decisions, policies, programs or processes should be based on a careful evaluation of the best practically available information about the potential impacts of climate change, to avoid where practicable serious or irreversible damage resulting from climate change.
The Act also provides for the preparation of a State climate change strategy and sectoral adaptation action plans.
The Minister responsible for the Act must also prepare a report on the science and data relevant to climate change in the State. That report must provide a synthesis of the best practicably available climate change science and its implications, data on observed changes in climate in the State, as well as other relevant information about the science and data relevant to climate change</td><td>This climate change assessment gathers data on historical climate and climate change projections that will enable decision-making on the Project EES to consider the projected impacts of climate change on both the Project and the lands and environments it is proposed to traverse.
The assessment draws climate change projection data sets developed for the Victorian government, as well as other climate change projection data that represent the best practically available climate change science.</td></tr>
<tr><td>Planning and Environment Act 1987</td><td></td></tr>
<tr><td>The Planning and Environment Act 1987 regulates the use and development of land in Victoria. The Act sets out the framework and procedures for preparing and amending planning schemes, obtaining planning permits, settling disputes, enforcing compliance with planning schemes, and other administrative procedures.</td><td>The Project must meet the objectives of planning in Victoria as set out in the Act and planning schemes.
The Planning Policy Framework provides a context for spatial planning and decision making. It seeks to ensure land use and development planning policies and practices integrate relevant environmental, social and economic factors in the interests of net community benefit and sustainable development.
New land uses and developments are subject to the Planning Policy Framework and local government Planning Schemes. Clause 13.01 Climate change impacts includes two clauses that are intended to address potential impacts from hazards associated with climate change. Clause 13.01-1S addresses natural hazards and climate change and Clause 13.01-2S addresses coastal inundation and erosion. The latter is not directly relevant to the Project.</td></tr>
</table>

4.3 Policy, guidelines and standards

Table 4.3: Policy, guidelines and standards relevant to climate change

Policy, Guidelines and Standards	Relevance to this report
Victoria's Climate Change Strategy, 2021	
The Strategy is primarily concerned with securing progress towards the State's 2050 net zero emission target. This includes harnessing Victoria's renewable energy resources and connecting new Renewable Energy Zones to the State's electricity grid through projects like the Project. The Strategy also includes a vision for Victoria to be climate resilient, prosperous and liveable. To that end, it supports: improved emergency management and disaster preparedness; resilient infrastructure, industries and communities that manage risks and opportunities that emerge with climate change; and functional and resilient natural ecosystems.	The Project proposes the development of new, long-lived infrastructure that is critical for the function of the State's and nation's energy grid and liveability of Victorians. To be resilient to climate over its proposed operating life, design, construction and operation of the Project needs to consider the potential effects of climate change.
Built Environment Climate Change Adaptation Action Plan 2022-2026	
The Plan (DELWP, 2022) is one of seven sectoral Adaptation Action Plans that have been prepared by the Victorian Government to "harness the opportunities and tackle the impacts of climate change". This Plan addresses climate risks and opportunities facing Victoria's built environment system, comprising its cities, towns and supporting infrastructure and services, including energy. The Plan's vision is for the state's cities, towns, homes, buildings and essential infrastructure to be located, designed and modified to support safe, vibrant, healthy and inclusive communities in a changing climate and contribute to emission reduction. Its objectives include for major infrastructure providers to be committed to climate change adaptation and emissions reduction and to integrate these into all relevant investment and decision-making across the built environment system. A key outcome sought by the Plan is for electricity, waste management and telecommunications infrastructure to be able to withstand, respond to and recover from extreme events. They are to be resilient to a changing climate, taking into account the interdependency that exists between telecommunications and energy systems. The Plan recognises the important role played by private sector energy utilities.	The Project proposes to build new, long-lived infrastructure that will be critical in supporting Victoria's built environment systems. Consistent with the Adaptation Action Plan, the Project is to be built to be resilient to extreme weather events (including bushfire, extreme heat and flooding) under climate change. Each of these hazards is considered in this report, with further information on bushfire and flooding provided in the Bushfire and Surface Water Impact Assessments, respectively.
Victoria's Climate Projections 2019, Technical Report (Clarke *et al*., 2019)	
The report describes a set of climate projections featuring (at the time) new high-resolution climate change simulations for Victoria. The projections were developed by CSIRO's Climate Science Centre and describe how the regional climate of Victoria is likely to respond to global warming with different scenarios of human greenhouse gas emissions. This work was commissioned by the then Victorian Department of Environment, Land, Water and Planning (DELWP; now Department of Energy, Environment and Climate Action, DEECA) to supplement previous projections of climate change for Victoria. It provides tailored climate projections and guidance for Victoria, in line with requirements of the *CC Act.*	The VCP2019 data set Is based on climate change modelling undertaken for the IPCC's Fifth Assessment Report (AR5). Earlier versions of this climate change assessment incorporated climate change projections based on the VCP2019 dataset. Climate change projections presented in this version of the climate change assessment have been updated to include downscaled AR6 climate change modelling outputs. Trends, findings and context from the VCP2019 report are still applicable and continue to inform climate resilience planning in Victoria.

Policy, Guidelines and Standards	Relevance to this report
Victoria's Climate Science Report 2024 (DEECA, 2024)	
The report updates the 2019 Victoria's Climate Projections report and is based on outputs from CMIP6 modelling for the IPCC's *Sixth Assessment Report*. It describes climate projections for Victoria based on the AR6 SSP scenarios and what these projections may mean for the key climate change hazards experienced in Victoria. The report provides updated and tailored climate projections and guidance for Victoria, in line with requirements of the *CC Act.*	The data behind the report is based on high resolution, downscaled climate change modelling. The report provides generalised regional examples of climate change projections for hot days, frost, snow, as well as seasonal and extreme rainfall. Further details on climate change projections will be provided in a web site being developed by the Victorian Government. The report also describes how climate change may affect key climate-related natural hazards: flooding, heatwaves, drought, bushfire and sea level rise.
Victorian Planning Provisions	
Clause 13 *Environmental risks and amenity* of the Victorian Planning Provisions (VPP) specify that planning should prepare for and respond to the impacts of climate change. As described in Clause 13.01 *Climate change impacts* and Clause 13.01-1S *Natural hazards and climate change*, the impacts of natural hazards arising from climate change are to be mitigated through: ▪ Risk-based planning that considers climate change in planning and management decision making processes ▪ Identifying at risk areas using the best available data and climate change science ▪ Integrating strategic land use planning with emergency management decision making. ▪ Directing population growth and development to low-risk locations. ▪ Developing adaptation response strategies for existing settlements in risk areas to accommodate change over time. ▪ Ensuring planning controls allow for risk mitigation or risk adaptation strategies to be implemented. ▪ Siting and designing development to minimise risk to life, property, the natural environment and community infrastructure from natural hazards. Clause 13.01 also requires the consideration of the potential impacts of climate change on coastal inundation and erosion, but these are not relevant to the Project.	This report provides data and analysis that supports the consideration of climate change in planning, risk assessment and decision-making in relation to the Project.

4.4 Local government climate change responses

A summary of climate change responses by local governments intersected by the Project Land is given in Table 4.4. While all local governments acknowledge climate change, some have no formal response.

Table 4.4: Local government climate change responses

Plan or strategy	Relevance to this report
Pyrenees Shire Council Climate change response and mitigation action plan (Pyrenees Shire Council, 2021)	
The public-facing version of Pyrenees Shire Council's Climate change response and mitigation action plan describes the projected physical impacts of climate change and notes that these are driven by greenhouse gas emissions. The plan describes impacts of both aspects and Council's planned responses.	The plan describes key physical impacts of climate change as being hotter and drier weather and more extreme weather events. Key actions relevant to this report include: ▪ Developing a heatwave plan (may have relevance to Project workforce and/or operations) ▪ Investing in fire protection planning and works, flood mitigation and resilient infrastructure.
Ballarat net zero emissions plan (City of Ballarat, 2022)	
City of Ballarat's net zero emissions plan describes Council's proposed transition towards being a carbon neutral municipality. It proposes actions to address five themes: business, homes, new developments, transport and waste, but does not explicitly address potential physical impacts of climate change.	The net zero emissions plan is not directly relevant to this report, which considers potential physical impacts of climate change.
Sustainable Hepburn 2022 / 2026 (Hepburn Shire Council, 2022)	
Environmental sustainability is identified by the Hepburn Shire community as their top priority. Sustainable Hepburn outlines Council's strategy to address environmental sustainability. Its themes include beyond zero emissions, natural environment and biodiversity, low waste and climate resilience.	Sustainable Hepburn's climate resilience theme seeks to lessen the consequences of climate change impacts for the municipality and assist in preparedness for the types of future climate-related natural hazard events (e.g., bushfire, flood) that are considered in this report.
Sustainable Environment Strategy 2016-26 (Moorabool Shire Council, 2016)	
Climate change is embedded in Moorabool Shire's Sustainable Environment Strategy. The Strategy addresses Council's greenhouse gas emissions and resource use, as well as the need to adapt to the projected physical impacts of climate change. Council's vision for climate adaptation is to "support and deliver activities to reduce the impact of and vulnerability to future climate change."	Theme 3.1 of the Strategy outlines Council's proposed approach to climate adaptation. It identifies higher temperatures, reduced annual and season rainfall, heavy rainfall events and extreme weather as key climate change hazards for the municipality. The key responses to these include understanding and responding to risks from climate change on Council operations and the community.
Environment Plan 2017-2027 (Melton City Council, 2017)	
Climate change is embedded in Melton City Council's overarching Environmental Plan. It is recognised as a key issue for the municipality and the plan. The plan includes both mitigation and adaptation actions as part of Council's climate response.	Theme 3.4 of the action plan outlines a series of objectives and actions for Council's climate response. These address both greenhouse gas emissions and climate change risks and potential impacts, seeking to lessen the severity of climate change and the effect on the community from the hazards considered in this assessment.

5. Method

5.1 Overview

This section describes the method that was used to characterise the current climate of the study area, how this may change in response to emissions of greenhouse gases from human activities over the course of this century and some potential implications of this for electricity transmission infrastructure. Key steps included:

1. Identify Bureau of Meteorology (BoM) observation locations close to the Project Land with reasonably continuous, long-term weather records that provide a suitable basis for characterising the current and projected future climate to which the Project will be exposed.
2. Define a study area for the climate change assessment, based on the locations with suitable meteorological observations.
3. Collate historical meteorological observations for the representative locations within the study area and characterise current climate, including fire weather conditions.
4. Select the future greenhouse gas emissions scenarios for which climate change scaling factors[2] will be derived for the study area.
5. Collate climate change scaling factors, use these to adjust baseline meteorological records and characterise future climate.
6. Review and assess the potential implications of weather extremes and projected climate change on electricity transmission infrastructure and the Project.
7. Propose monitoring and EPRs for the Project's operation that are relevant to climate change.

5.2 Study area

A review of BoM meteorological observations from locations in proximity to the Project Land identified that only those for Ararat (Ararat Prison), Ballarat (Ballarat Aerodrome) and Melbourne Airport had largely continuous, long-term (>30year) records of rainfall, temperature, wind conditions and relative humidity that were suitable for characterising the current and future climate to which the Project will be exposed. These locations, all within about 25km of the Proposed Route (Figure 3.2), were used to define the study area for this assessment (see Figure 6.1) and are broadly representative of the Project Area.

5.3 Existing conditions

Baseline climate for the Project Land is described using daily meteorological observations from Ararat, Ballarat and Melbourne Airport, as discussed in Section 5.2. Maps showing (modelled) spatial variability in rainfall and temperature have also been prepared, using data from the SimCLIM climate data tool (CLIMsystems, 2019; Figure 6.1, Figure 6.2).

Historical climate data were also used to calculate baseline fire weather conditions, based on the Forest Fire Danger Index (FFDI; McArthur, 1967) and Grassland Fire Danger Index (GFDI; McArthur, 1966). Fire weather calculations require sub-daily values of temperature, relative humidity and windspeed, in addition (for FFDI) to daily maximum temperature and rainfall. As sub-daily relative humidity and windspeed data are not available for Ararat, fire weather conditions were only calculated for Ballarat and Melbourne Airport. The analysis of fire weather conditions is provided in the Bushfire Impact Assessment. Information on fire weather conditions and how they may change with climate change are provided in the Bushfire Impact Assessment.

[2] Climate change scaling factors are the amount or percentage change in a climate variable that is projected to occur by a given timeframe under a specific greenhouse gas emissions scenario.

5.4 Greenhouse gas emissions scenarios and climate change projections

Detailed climate change projections for rainfall and temperature have been developed for the study area, based on historical climate records for Ararat, Ballarat and Melbourne Airport. The projections are based on climate modelling undertaken for AR6 and consider two emissions or Shared Socioeconomic Pathway (SSP) scenarios (Figure 5.1):

- SSP3-7.0: this scenario sees countries prioritise domestic issues over global cooperation. Economic development slopes and material-intensive consumption persists. Greenhouse gas emissions and global average temperatures continue to rise through the 21st century. This scenario provides a more plausible upper range for greenhouse gas emissions and climate change than the most extreme future emissions scenario, SSP5-8.5.
- SSP2-4.5: a "middle of the road" scenario that anticipates extension of current social, economic and technical trends, resulting in uneven progress towards equality and sustainability worldwide. Under this scenario, greenhouse gas emissions stabilise early in the second half of this century and decline rapidly thereafter. It anticipates significantly reduced climate change relative to SSP3-7.0 but is unlikely to achieve the target of the 2014 Paris Agreement on climate change[3], to limit global warming to 1.5°C above pre-industrial conditions.

The SSP2-4.5 scenario aligns with the RCP4.5 scenario used in climate change modelling for AR5, but is not identical. SSP3-7.0 is a high emissions scenario but anticipates less growth in emissions than the AR5 RCP8.5 scenario. The RCP4.5 and RCP8.5 scenarios have been extensively used in climate change assessments (in Victoria and elsewhere) to enable consideration of a wide and plausible range of future climate change conditions for risk and impact assessment.

Rapid and highly effective global action to reduce greenhouse gas emissions may result in slightly less warming and reduced impacts from climate change than anticipated by SSP2-4.5. While SSP3-7.0 represents a plausible upper limit to future emissions, climate models used to project this scenario's effect on the climate system diverge significantly and it is possible that changes in climate may be significantly more severe than anticipated by the mean values used in this analysis.

Climate change scaling factors (the projected change in climate relative to baseline or 'reference period' conditions) were sourced from the Climate Insights tool[4] for each of the three BoM monitoring station locations used to characterise the study area. Baseline conditions for the AR6 modelling consider the 20-year period 1995 to 2014 (i.e. a 20-year period centred on 2005).

Climate change projections were derived for 2030, 2050, 2070 and 2090 by adjusting daily meteorological records for the same 20-year baseline period with climate change scaling factors for the respective future time horizons. Projections for 2030 only considered one scenario (SSP3-7.0) as there is little material difference in projected climate (at that time) between emissions scenarios. Projections for 2050, 2070 and 2090 were developed for both SSP2-4.5 and SSP3-7.0. Climate change scaling factors for time horizons beyond 2100 are not readily available.

Projected changes in fire weather conditions were also prepared for the two emissions scenarios. These were calculated after daily and sub-daily meteorological records used in calculation of fire weather conditions were adjusted with the respective climate change scaling factors.

[3] The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at the UN Climate Change Conference (COP21) in Paris, France, on 12 December 2015. It entered into force on 4 November 2016. Its overarching goal is to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels" and pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels." To limit global warming to 1.5°C, greenhouse gas emissions must peak before 2025 at the latest and decline 43% by 2030. https://unfccc.int/process-and-meetings/the-paris-agreement

[4] CLIMsystems (2023) *Climate Insights*, https://www.climateinsights.global/.

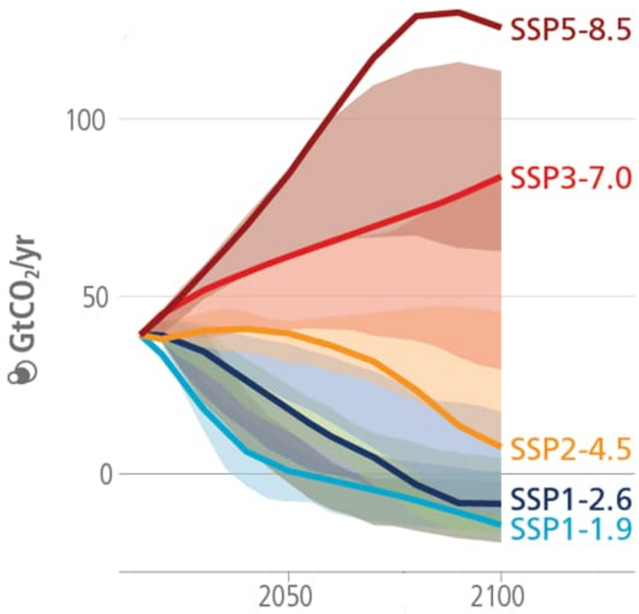


Figure 5.1: Annual equivalent gigatonnes of carbon dioxide ($GtCO_2$) emissions associated with IPCC Shared Socioeconomic Pathway (SSP) scenarios to 2100 *Source:* IPCC (2023)

Narratives about other projected changes in climate were sourced from the VCP 2019 Technical Report (Clarke *et al.*, 2019), Victoria's Climate Science Report 2024 (DEECA, 2024) and other credible sources. Projections for extreme rainfall under climate change were also sourced from Australian Rainfall and Run-off, including the 2024 update to rainfall intensity calculations (ARR; Ball *et al.*, 2019; https://data.arr-software.org/).

This climate change assessment is based on data and information from various public sources (including those listed in Table 5.1).

Table 5.1: Data sources

Data	Source
Climate change projection factors applicable to the Project Area	Victorian Climate Projections, 2019 for Central Highlands and Greater Melbourne regions. Source: https://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/victorian-climate-projections-2019/ Climate Insights, a proprietary climate data access tool developed by CLIMsystems Pty Ltd. It draws on outputs of Coupled Model Intercomparison Project 6 (CMIP6) climate modelling in support of AR6. Source: https://www.climateinsights.global/
Historical climate records applicable to the study area	Bureau of Meteorology (BoM) climate records for selected locations considered to be representative of the study area and with consistent rainfall and temperature records: a) Ararat Prison (station 089085) b) Ballarat Aerodrome (station 089002) c) Melbourne Airport (station 086282) Source: http://www.bom.gov.au/climate/data/
Australian Rainfall and Run-off	Australian Rainfall and Runoff Data Hub, Version 4.2 Source: https://data.arr-software.org/
Baseline climate change spatial data	SimCLIM, a proprietary climate data access tool developed by CLIMsystems. It draws on outputs of IPCC climate modelling. Source: https://www.climsystems.com/simclim/

5.5 Stakeholder engagement and community feedback

Stakeholders and the community were consulted to support the preparation of this report and to inform the development of the Project and understanding of its potential impacts. In addition to consultation undertaken with specific stakeholders, consultation has been ongoing with the community throughout the design development and the EES process.

Feedback relevant to the climate change assessment is summarised in Table 5.2, along with where and how those topics are addressed in this report.

Table 5.2: Community consultation feedback for climate change

Matter raised	Where matter has been addressed in this report
Climate change may strengthen extreme winds, leading to greater frequency of transmission tower collapse Some community members have noted the collapse of transmission towers under extreme winds (e.g., Anakie 2024, Cressy, 2020; South Australia, 2016) and damage to distribution power supply infrastructure during severe winds (June 2021) as evidence of the possibility of that transmission infrastructure might fail, leading to fire ignition and / or the loss of access or / egress to / from potential fire grounds due to infrastructure blocking roads. Concerns have been raised that these events may be exacerbated by climate change.	Projected effects of climate change on extreme wind conditions are discussed in Section 7. Implications of weather extremes and climate change for transmission networks are discussed in Section 8.
Climate change may exacerbate fire weather conditions, leading to increased frequency, severity and impact of bushfires Concern has been expressed that the warmer and drier conditions projected to be associated with climate change in southern Australia may exacerbate fire weather conditions and the behaviour of fires following any ignitions.	Projected effects of climate change on fire weather and bushfire-related potential impacts of the Project are discussed in the Bushfire Impact Assessment. Implications of weather extremes and climate change for transmission networks are discussed in Section 8.

5.6 Assumptions, limitations and uncertainties

The following assumptions, limitations and uncertainties apply to this impact assessment:

- This report refers to future conditions under climate change. Projections provided are based on a set of models describing the implications of potential future greenhouse gas emissions. Model results, as well as the methods used to combine them, may change as climate science develops. Actual future conditions may differ from the projections provided.
- Current and projected future climate for the study area has been characterised using data for the three locations closest to the Project with suitable meteorological records (Ararat Prison, Ballarat Aerodrome, Melbourne Airport; as discussed in Section 5.2), as well as downscaled (high-resolution) climate change projections for these locations. It is clear from Figure 6.1 and Figure 6.2 that the three locations do not sample all of the variability in rainfall and temperature regimes and, by inference, fire weather conditions that may be experienced by the Project Land. However, the data and detailed analyses presented here provide good insights into current and potential future conditions and provide a useful basis for relevant specialist studies to consider the implications of climate change for the Project. It is not considered that this climate change assessment is materially limited by the availability of meteorological data.

6. Existing climate conditions

6.1 Regional climate overview

Rainfall and temperature conditions vary across the study area (Figure 6.1, Figure 6.2). Average annual rainfall across the study area varies from less than 500mm/y at Bacchus Marsh to over 1000mm/y in elevated areas of the Wombat Forest, north of Ballan. Along the Proposed Route, average annual rainfall increases from about 550mm/y at the Project's western extent at Bulgana, to over 800mm/y along elevated sections of land between about Newlyn and north of Myrniong. Average annual rainfall drops to about 500mm/y as the Proposed Route descends to Darley and remains at about this level to the Project's eastern extent at Sydenham.

Average daily maximum temperature (Figure 6.2) across the study area, like rainfall, is influenced by topography. Average maximum temperatures are higher at lower elevations in the west and east of the Project Land (~19°C) and are lower (~16°C) in more elevated locations around the fringe of the Wombat State Forest.

Average daily minimum temperatures (not shown) follow similar patterns, with the far west of the Project Land and areas eastwards from Bacchus Marsh having higher average daily minimum temperatures and more elevated areas across the Great Dividing Range having lower temperatures.

6.2 Climate profile

As noted in Section 5.2, the climate profile for the study area is based on observations from BoM meteorological stations located at:

- Ararat: station 089085 (Ararat Prison)
- Ballarat: station 089002 (Ballarat Aerodrome)
- Melbourne Airport section: station 086282 (Melbourne Airport).

These sites are the closest locations to the Project Land with relatively continuous, long-term meteorological records for rainfall and temperature that cover most of the climate change projection baseline or reference period (1995 to 2014). Ararat and Ballarat are taken as being broadly representative of the west of the Project Land (Bulgana to east of Ballan) and Melbourne Airport is taken to be broadly representative of the east of the Project Land (Bacchus Marsh to Sydenham).

Average annual rainfall at Ararat is 587mm, with recorded annual totals ranging between 302 and 909mm. Rainfall is greatest during winter and spring, with the months between June and September having the highest average monthly rainfall total (Figure 6.3). Seasonal patterns in temperature are as expected for western Victoria, with warmer temperatures recorded during summer and early autumn and cooler temperatures recorded during the three winter months. The highest maximum temperature recorded at Ararat is 44.7°C, in February 2009. Average maximum temperatures range between 11.8°C in July and 27.1°C in February, with average minimum temperatures ranging between 3.4°C in July and 11.3°C in February. The lowest recorded temperature is -7.3°C (July 1976).

Average annual rainfall at Ballarat is 689mm, with recorded annual totals ranging between 302 and 996mm. There is slightly more rainfall at Ballarat than at Ararat, particularly during spring (Figure 6.3).

Seasonal patterns in temperature at Ballarat are similar to those observed at Ararat. Warmer temperatures are recorded during summer and early autumn and cooler temperatures are recorded during winter. The highest temperature recorded at Ballarat is 44.1°C, in February 2009. Average maximum temperatures range between 10.1°C in July and 25.3°C in January, with average minimum temperatures ranging between 3.2°C in July and 11.5°C in February. The lowest recorded temperature is -6°C (July 1982).

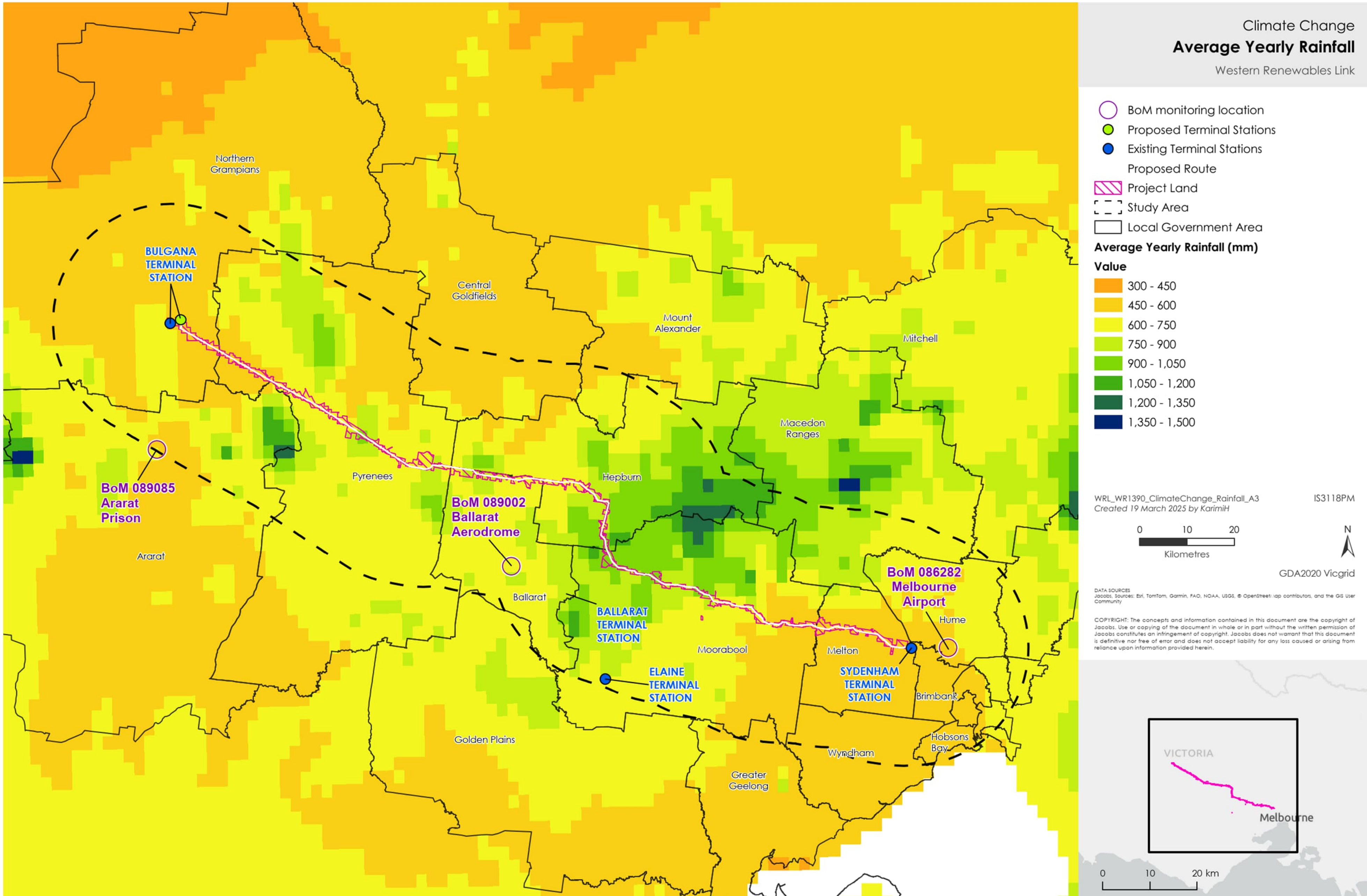


Figure 6.1: Baseline annual rainfall conditions for the Project Land and climate change assessment study area. Map shows the locations of Bureau of Meteorology weather stations whose records were used in this assessment.

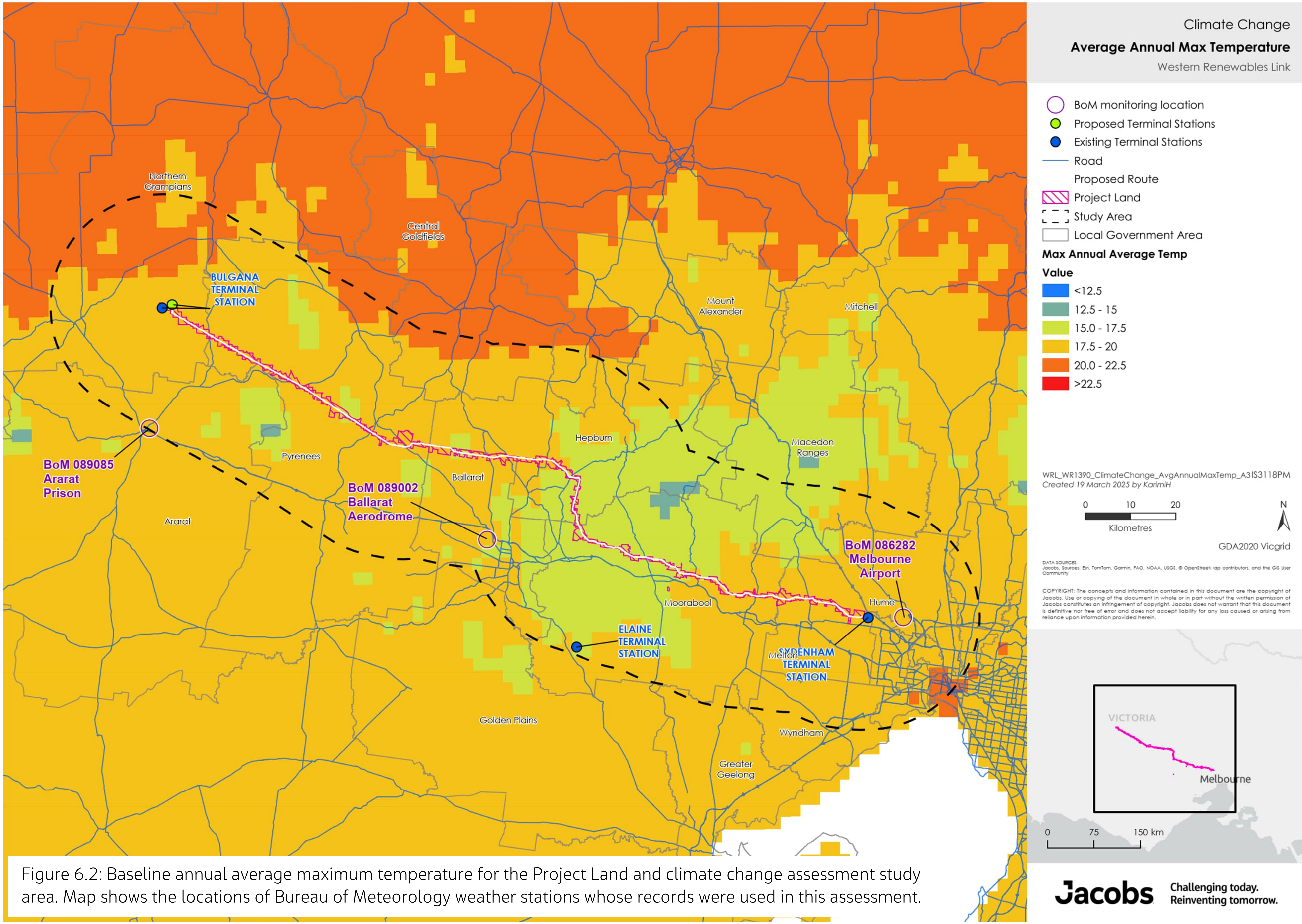


Figure 6.2: Baseline annual average maximum temperature for the Project Land and climate change assessment study area. Map shows the locations of Bureau of Meteorology weather stations whose records were used in this assessment.

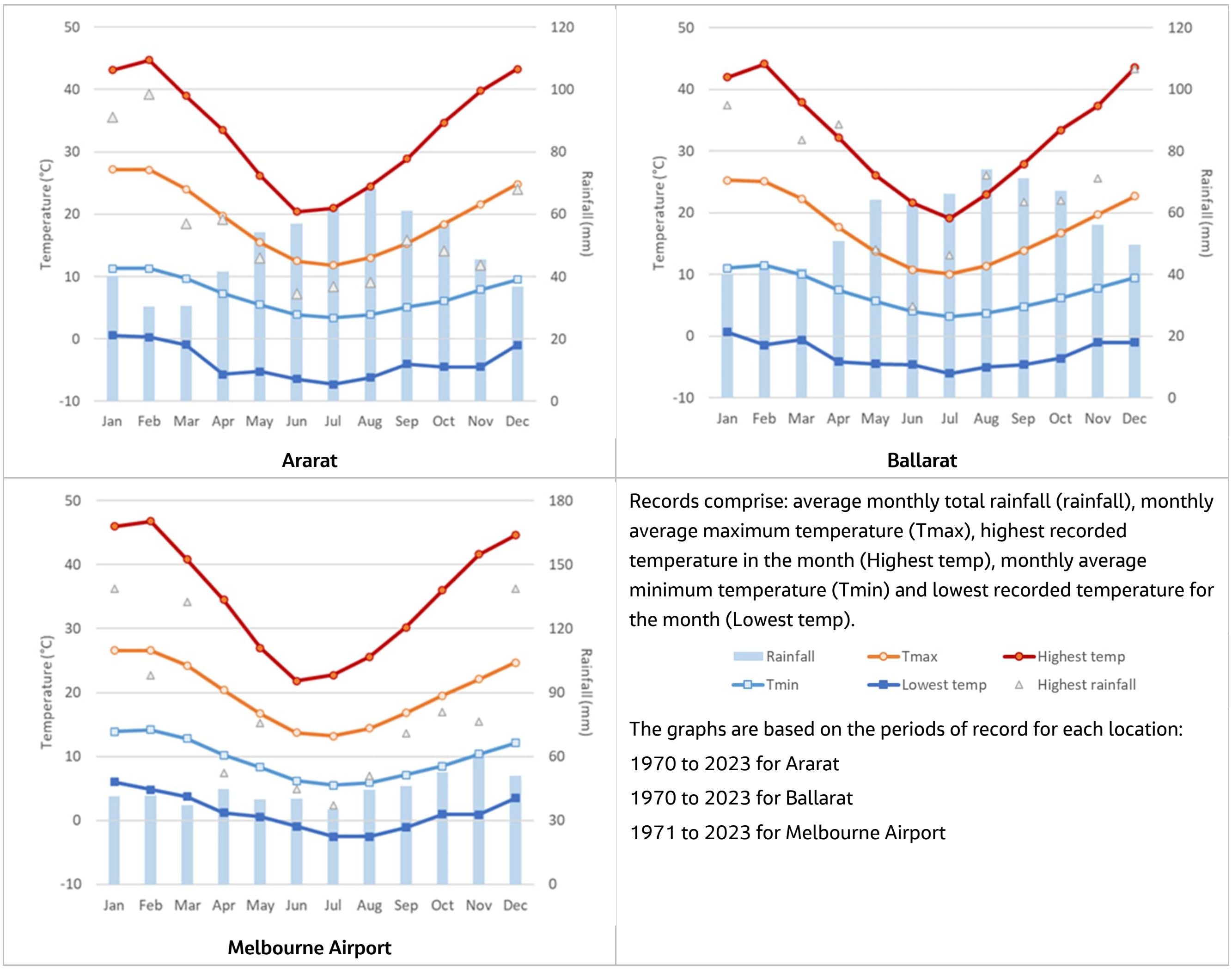


Figure 6.3: Monthly average and extreme rainfall and monthly average and extreme temperature for three locations in the vicinity of the Project, Ararat, Ballarat and Melbourne Airport. (Sources: BoM meteorological data, Jacobs, 2024)

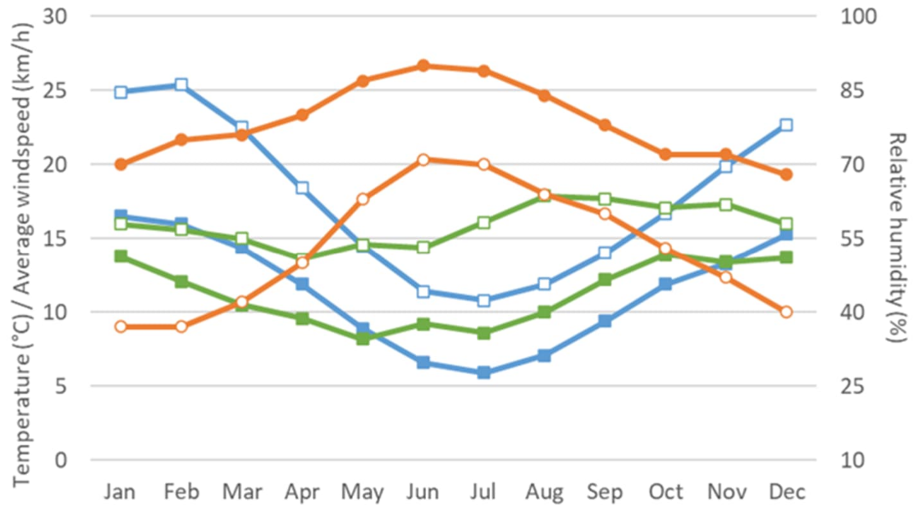
Average annual rainfall at Melbourne Airport is 541mm, with recorded annual totals ranging between 310 and 821mm. Unlike Ararat and Ballarat, where rainfall is winter dominant, rainfall in this part of the study area is bimodal, with a small peak in autumn and a more pronounced peak in spring (Figure 6.3). Seasonal patterns in temperature are consistent with those at Ararat and Ballarat, with warmer temperatures recorded during summer and early autumn and cooler temperatures recorded throughout winter. Temperatures above 46°C have been recorded in January and February (in 2019 and 2009, respectively). Average maximum temperatures are slightly higher than at Ararat and Ballarat and range between 13.2°C in July and 26.6°C in January and February. Average minimum temperatures range between 5.4°C in July and 14.1°C in February. The lowest recorded temperature is -2.5°C.

Days with temperatures over 40°C have been recorded at all three stations during summer and, for Melbourne Airport, in November and March as well. Freezing temperatures (0°C or below) have been recorded in autumn, winter and spring at both Ararat and Ballarat. While freezing temperatures have been recorded at Melbourne Airport between June and September, they are much less common than in the more elevated and inland parts of the study area.

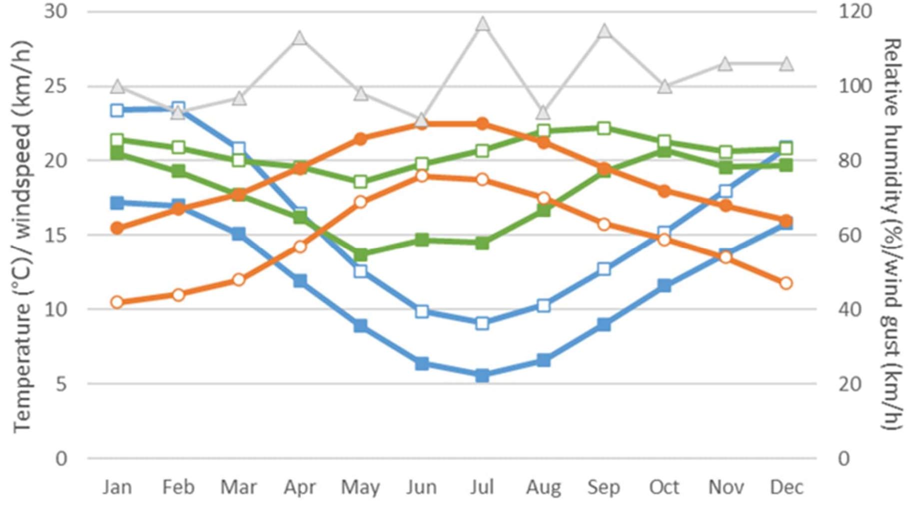
The highest recorded daily rainfall totals are 99mm at Ararat, 122mm in Ballarat and 139mm at Melbourne Airport. Extreme daily rainfall totals are typically greater in late summer-early autumn than at other times of year. The highest daily rainfall total was recorded in February at each of the three locations.

Daily and seasonal of patterns of variation in temperature, wind speed and relative humidity are similar for each of the three locations (Figure 6.4). Temperatures at 9 am are typically lower than they are at 3 pm, by about 3 to 5°C in the cooler months and 7 to 8°C in the warmer months. Wind speed is also lower at 9 am than at 3 pm, with windspeed at Melbourne Airport consistently greater than at Ararat or Ballarat. Relative humidity is higher in the morning than in the afternoon, with the difference greater in summer than at other times of year.

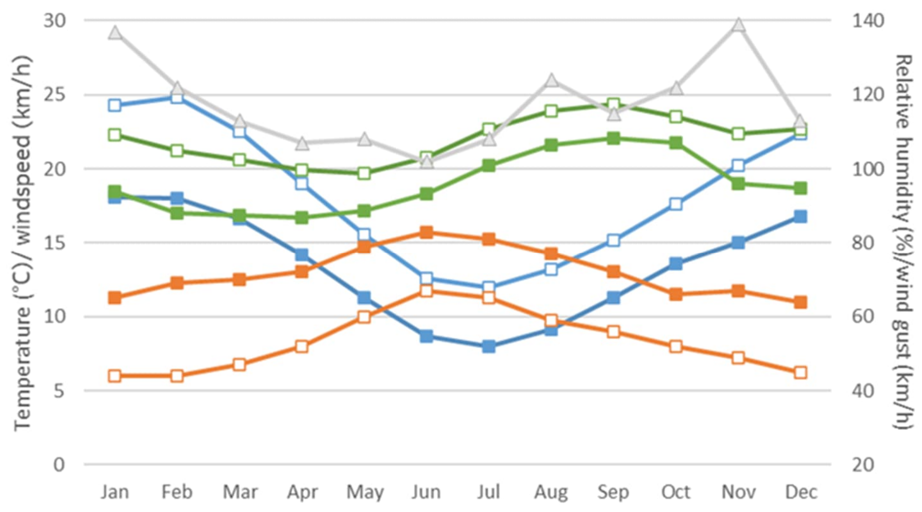
The maximum wind gust recorded at Ballarat is 117km/h, with gusts of 100km/h or more recorded in January, April, July, September, November and December. The strongest wind gust recorded at Melbourne Airport is 139km/h. Wind speeds over 100km/h have been recorded during each month of the year (Figure 6.4). While wind speed is measured at Ararat, wind gusts are not recorded.



Ararat



Ballarat



Melbourne Airport

Records comprise: maximum recordeed wind gust (Ballarat and Melbourne Airport only) and average monthly 9 am and 3 pm temperature, relative humidity and windspeed.

- 9 am temperature
- 3 pm temperature
- 9 am wind speed
- 3 pm wind speed
- 9 am relative humidity
- 3 pm relative humidity
- Max wind gust

The graphs are based on the periods of record for each location:

1969 to 2010 for Ararat

1908 to 2010 for Ballarat

1970 to 2020 for Melbourne Airport

Figure 6.4: Average monthly 9 am and 3 pm temperature, relative humidity and wind speed for three locations in the study area, Ararat, Ballarat and Melbourne Airport. Monthly maximum recorded wind gust for Ballarat and Melbourne Airport (data not available at Ararat).

6.3 Climate trends

Total annual rainfall as well as maximum, average, and minimum temperature for each year of record (from 1970-2023) are plotted for Ararat, Ballarat and Melbourne Airport in Figure 6.5. These show upwards trends in yearly maximum and average temperatures and downwards trends in rainfall across the study area.

Figure 6.5: Historical trends in rainfall and maximum, average and minimum temperature for Ararat, Ballarat and Melbourne Airport (1970 to 2023)

Yearly maximum, average and minimum temperatures have been trending upwards at Ararat from 1970 (by 0.9, 0.3 and 0.2°C/decade, respectively). Over that same period, annual rainfall has been trending downwards (by 29mm/decade). Climate trends are similar at Ballarat, with yearly maximum and average temperatures trending upwards (by 0.9 and 0.1°C/decade, respectively). Annual rainfall and yearly minimum temperatures have been trending downwards (by 35mm/decade and 0.3°C/decade, respectively). Yearly maximum, average and minimum temperatures have also trended upwards at Melbourne Airport (1971 onwards), by 0.7, 0.2 and 0.2°C/decade, respectively. Annual rainfall has trended downwards over the same period (by 38mm/decade).

The downwards trend in the lowest temperature recorded each year at Ballarat is consistent with the declining trend in rainfall, with drier conditions in winter and spring associated with clear skies and low overnight temperatures.

7. Climate change projections

Climate Insights is a proprietary tool by CLIMsystems Pty Ltd and provides downscaled climate change projection information globally. The information is based on global climate model outputs from CMIP6 modelling that supported the IPCC's *Sixth Assessment Report* (as noted in Section 1.2.1). It also takes account of regional influences on climate and weather (e.g., proximity to coast, elevation, rain shadows). Climate change scaling factors, which are used to adjust historical climate data sets to derive new climate change projections, are available for each month, for two future emissions scenarios (SSP2-4.5 and SSP3-7.0) and for every five years from 2005 to 2100. The results are for an ensemble (or suite) of climate models and hence for each emissions scenario and time horizon, there is an indication of the variability in climate change projections (i.e. 5th, 50th and 95th percentile results).

A summary of the climate change scaling factors derived from Climate Insights and applicable to the Project is given in Table 7.1[5]. The key trends highlighted include:

- Warmer: daily maximum, minimum and average temperatures, as well as temperatures on extreme hot and cold days are all projected to increase. Maximum or extreme high temperatures are projected to increase at a greater rate than averages, minima or extreme low temperatures. The change in temperature is projected to be more rapid under the high emissions SSP3-7.0 scenario than the lower emissions SSP2-4.5 scenario.
- Drier: annual precipitation is projected to decline, but with only small differences between emissions scenarios. While annual average rainfall is projected to decline by a relatively small amount, increased temperature and evaporation and reduced relative humidity are projected to reduce the availability of surface water and groundwater resources (DELWP, 2020).
- More solar radiation: solar radiation is project to increase slightly, consistent with reduced rainfall and cloudiness.
- Heavier extreme precipitation: extreme rainfall events are projected to become heavier as the atmosphere warms.
- Fire days: increased frequency of days of elevated fire weather conditions, during which the FFDI exceeds the 95th percentile for the baseline period.
- Average wind speed declines: average wind speeds are projected to decline slightly, with greater change under the higher emissions scenario.

Table 7.1: Climate change scaling factors for locations from which baseline meteorological observations were obtained. Scaling factors are given for the median of regional climate model results and are relative to 2005 baseline.

Climate change scaling factor for climate variable	2030	2050		2070		2090	
	SSP3-7.0[1]	SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Ararat							
Daily maximum temperature (°C)	0.6	1.1	1.2	1.5	1.9	1.7	2.6
Daily minimum temperature (°C)	0.5	0.9	1.0	1.3	1.6	1.4	2.2
Daily mean temperature (°C)	0.6	1.0	1.1	1.4	1.8	1.6	2.5
Precipitation (%)	-1.1	-2.1	-2.6	-2.9	-3.6	-3.2	-5.0
Relative humidity (%)	-0.5	-0.9	-0.9	-1.2	-1.5	-1.4	-2.1
Evapotranspiration (%)	2.1	4.0	4.3	5.4	6.8	6.1	9.5
Solar radiation (%)	0.7	1.2	1.3	1.7	2.1	1.9	2.9
Average wind speed (%)	0.9	1.7	1.9	2.4	3.0	2.7	4.2

[5] Data presented in Table 7.1 represent the median result for the ensemble of climate change models considered by Climate Insights. To show the range in projections within a given scenario, Appendix A provides the median and 5 and 95% values for the various climate aspects presented in Table 7.1.

Climate change scaling factor for climate variable	2030	2050		2070		2090	
	SSP3-7.0[1]	SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Extreme wind speed[2] (%)	2.5	2.7	2.4	-0.8	3.1	3.3	-1.0
Days/year >40°C (days)	0.2	0.5	0.6	0.7	1.0	08	1.4
Days/year <2°C (days)	-6.6	-11.3	-12.1	-14.7	-16.9	-16.1	-20.8
1% AEP 24h rainfall event (%)	6.5	12.1	13.0	16.5	20.5	18.6	28.8
Extreme rainfall (ARR)[3] (%)	10	14	15	17	21	20	29
Ballarat							
Daily maximum temperature (°C)	0.6	1.1	1.2	1.5	1.9	1.7	2.6
Daily minimum temperature (°C)	0.5	0.9	1.0	1.3	1.6	1.5	2.3
Daily mean temperature (°C)	0.6	1.0	1.1	1.3	1.8	1.6	2.5
Precipitation (%)	-1.2	-2.2	-2.3	-3.0	-3.7	-3.3	-5.1
Relative humidity (%)	-0.4	-0.8	-0.9	-1.1	-1.4	-1.2	-1.9
Evapotranspiration (%)	2.3	4.2	4.6	5.8	7.2	6.5	10.2
Solar radiation (%)	0.7	1.3	1.4	1.8	2.2	2.0	3.1
Average wind speed (%)	1.0	1.8	1.9	2.4	3.0	2.7	4.3
Extreme wind speed[2] (%)	0.8	1.5	-0.3	-0.6	-1.0	2.8	-1.5
Days/year >40°C (days)	0.3	0.5	0.6	0.8	1.2	0.9	2.0
Days/year <2°C (days)	-8.4	-14.9	-16.2	-20.0	-23.8	-22.0	-28.9
# Fire days/y (days)[4]	-	4	4	5	6	5	10
1% AEP 24h rainfall event (%)	6.1	11.4	12.3	15.6	19.3	17.5	27.1
Extreme rainfall (ARR)[3] (%)	10	14	15	17	21	20	29
Melbourne Airport							
Daily maximum temperature (°C)	0.6	1.2	1.2	1.6	2.0	1.8	2.8
Daily minimum temperature (°C)	0.5	1.0	1.0	1.3	1.6	1.5	2.3
Daily mean temperature (°C)	0.6	1.1	1.1	1.5	1.8	1.6	2.5
Precipitation (%)	-1.1	-2.1	-2.3	-2.9	-3.6	-3.3	-5.0
Relative humidity (%)	-0.4	-0.8	-0.9	-1.1	-1.4	-1.3	-2.0
Evapotranspiration (%)	2.3	4.3	4.6	5.9	7.3	6.6	10.3
Solar radiation (%)	0.8	1.5	1.6	2.0	2.5	2.3	3.6
Average wind speed (%)	1.0	1.9	2.0	2.6	3.2	2.9	4.5
Extreme wind speed[2] (%)	0.4	1.3	0.1	1.4	0.2	3.6	-0.5
Days/year >40°C (days)	0.6	1.0	1.1	1.5	2.0	1.7	3.0
Days/year <2°C (days)	-2.6	-4.6	-4.8	-5.5	-6.2	-5.9	-7.3
# Fire days/y (days)[4]	-	6	6	8	10	9	15
1% AEP 24h rainfall event (%)	7.6	14.0	15.1	19.2	23.8	21.6	33.4
Extreme rainfall (ARR)[3] (%)	10	14	15	17	21	20	29

Note:

1. Climate change factors for 2030 do not vary materially between SSP2-4.5 and SSP3-7.0 and hence only projections for the latter are presented here. Climate projections for the various SSP scenarios diverge more markedly beyond 2050.
2. Extreme wind: 1% annual exceedance probability (AEP) extreme wind event.
3. ARR – data from Australian Rainfall and Runoff data hub (https://data.arr-software.org/) for interim climate change factors for extreme rainfall. 1% AEP extreme rainfall event.
4. #Fire days/y: number of days/y where FFDI exceeds the 95th percentile for the baseline period (following the definition of Clarke *et al.*, 2019). Data only available for Ballarat and Melbourne Airport. No calculation provided for 2030.

The Victorian Climate Projections 2019 (VCP2019) technical report (Clarke *et al*., 2019), Victoria's Climate Science Report 2024 (DEECA, 2024) and other sources (as cited below) provide additional information on climate change projections to that summarised in Table 7.1. Key points that are relevant to the Project include:

- Heat: average and extreme temperatures are projected to increase, regardless of emissions scenario. However, effective emissions reduction is expected to avoid the extreme temperatures that may become frequent under a high-emissions pathway. Temperature projections for Victoria are close to global average projections for heat; with hotter and more frequent hot days, more time spent in heatwaves, greater heatwave intensity, and fewer nights of extreme cold temperatures. VCP19 modelling suggests that central and southeast Victoria may warm more than other regions, which may affect the Project's operating environment.
- Extreme rainfall: a warmer atmosphere can hold more water, so with all else being equal, heavy rainfall at the scale of minutes to a day is expected to increase in most places and seasons as a general response to climate change. This process can be offset or enhanced by changes to the intensity, frequency or other characteristics of the weather systems that bring heavy rainfall. In places where average rainfall is projected to decrease slightly, the rainfall from wet days, heavy rainfalls and extreme daily rainfall is still projected to increase under a high emissions scenario. General drying of the climate with projected climate change may mean that small floods in rural areas become smaller. Increased intensity of infrequent heavy rainfall events may mean that large floods become larger (DEECA, 2024).
- Fire weather: the occurrence of fire depends on the amount of bushfire fuel present, its availability to burn (i.e., its dryness), a source of ignition and suitable weather conditions. Fire weather may be expressed in terms of the Forest or Grassland Fire Danger Indices (FFDI / GFDI), which account for fire weather and fuel dryness, but not fuel load. Fire days are defined for the VCP2019 as days when the FFDI exceeds the 95th percentile of the FFDI for 1986 to 2005 and do not directly correspond with fire danger ratings (FDR) used in public fire weather communications[6]. Five of the six downscaled climate simulations used in VCP2019 project an increase in the number of fire days of at least 10 per year by 2090 (high emissions scenario) for most of Victoria[7]. Projections based on AR6 climate change modelling suggests the number of fire days under the higher emissions SSP3-7.0 scenario will increase by 10 and 15days/y at Ballarat and Melbourne Airport, respectively, by 2090 (Table 7.1).
- River flows and groundwater recharge: the projected reduction in rainfall and increased evaporation are anticipated to lead to reduced soil water content across southern Australia and consequent reductions in annual average runoff and groundwater recharge (Grose *et al.,* 2015). The reduction in average annual runoff is projected to vary regionally across Victoria and could be between 7% and over 40% (by 2065) in catchments traversed by the Project (DELWP, 2020). Droughts in Victoria are likely to increase in duration and intensity (i.e., they will be warmer and drier) with climate change (DEECA, 2024).
- Extreme wind conditions: projections of extreme wind conditions under climate change are less certain than for rainfall and temperature (Grose *et al.,* 2015), due to fewer climate models providing wind speed estimates and the influence of local topography and vegetation. Clarke *et al*. (2019) provided projections of change in 20-year return period wind speeds. Regional climate models suggest either small increases or decreases in extreme wind speeds (~ ±1m/s), with some seasonal differences[8]. In more recent research for the ESCI project, Brown and Dowdy (2021) found that the frequency of conditions potentially giving rise to severe convective winds in south-eastern Australia (which drive most wind-related damage to transmission infrastructure) are projected to remain unaffected by climate change or reduce slightly in frequency.

Results from the application of the climate change scaling factors (to 2070) to historical meteorological data for the study area are given in Figure 7.1 to Figure 7.3, for Ararat, Ballarat and Melbourne Airport, respectively.

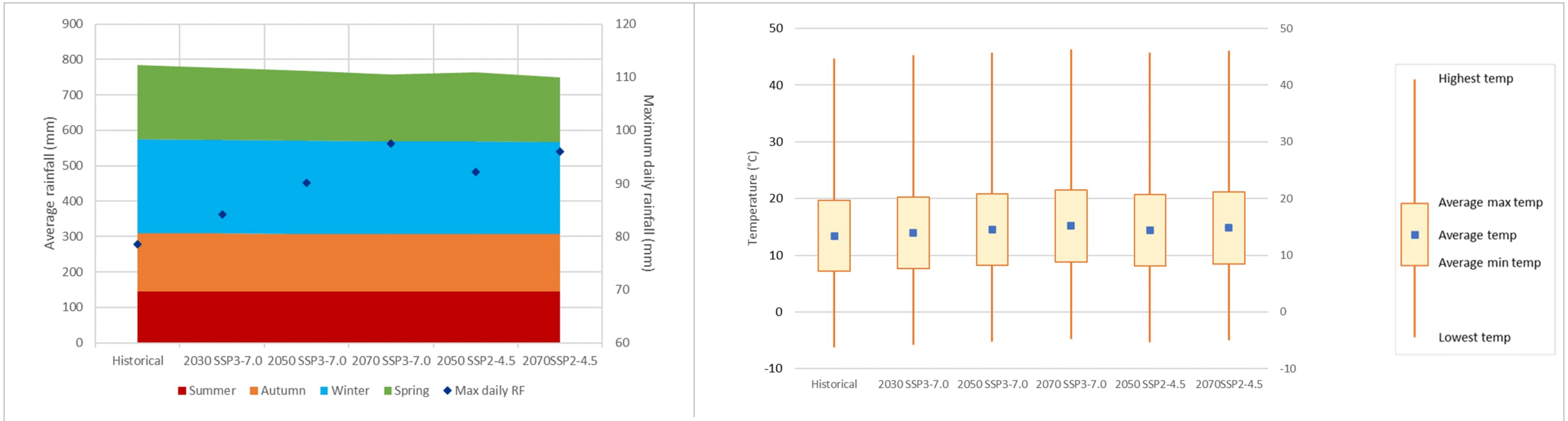
[6] Note that in September 2022 the old system of fire danger rating (FDR) was superseded by the new Australian Fire Danger Rating System (AFDRS), which has a new four-point scale for fire danger and is based on new Fire Behaviour Indices (FBI; which incorporate fire weather conditions and fuel loads). Fire weather calculations carried out for the Project are based on the earlier FFDI and GFDI indices, these scale directly to the former FDR system rather than to the new AFDRS.

[7] To avoid duplication, projected fire weather conditions for the study area under climate change are presented in the EES Bushfire Impact Assessment rather than in this report.

[8] AS/NZS1170.2:2021, the Australian Standard for considering effects of wind on structures (Standards Australia, 2021) considers the potential effect of climate change on extreme wind speeds, but for Victoria (unlike areas exposed to tropical cyclones) provides no adjustment factor.

The graphs show that the most pronounced seasonal changes in rainfall will occur in spring and that differences in 2070 between the higher and lower emissions scenarios are relatively small. Average and extreme temperatures are projected to increase, with the extreme highest temperature approaching 50°C at Melbourne Airport by about 2070 (SSP3-7.0).

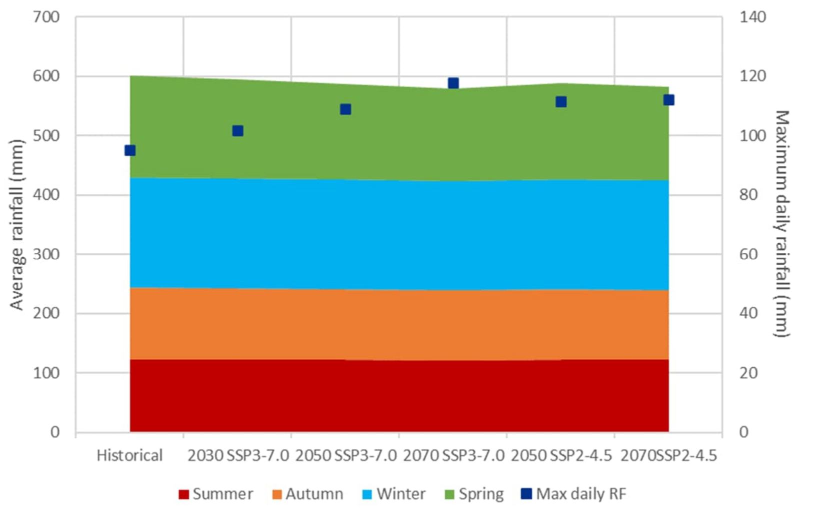
Extreme daily rainfall is projected to increase by about 20mm/day at each location under the 2070 high emissions scenario (based on 2024 AR&R projections).



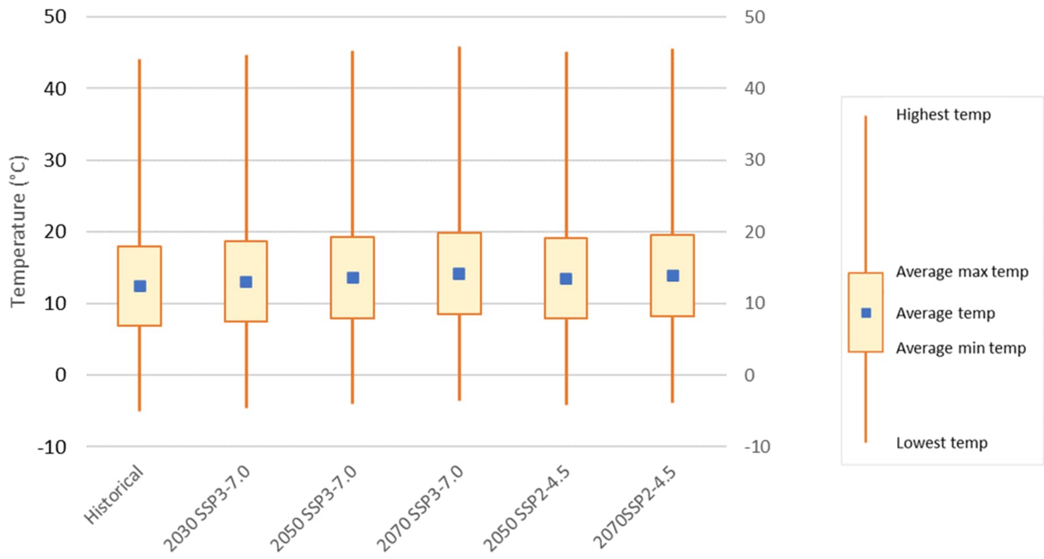
a) Seasonal and annual rainfall, maximum daily rainfall total

b) Extreme and average temperatures

Figure 7.1: Historical and projected change in seasonal and annual rainfall and extreme and average temperatures for Ararat: 2030 SSP3-7.0, 2050 SSP2-4.5 and SSP3-7.0 and 2070 SSP2-4.5 and SSP3-7.0

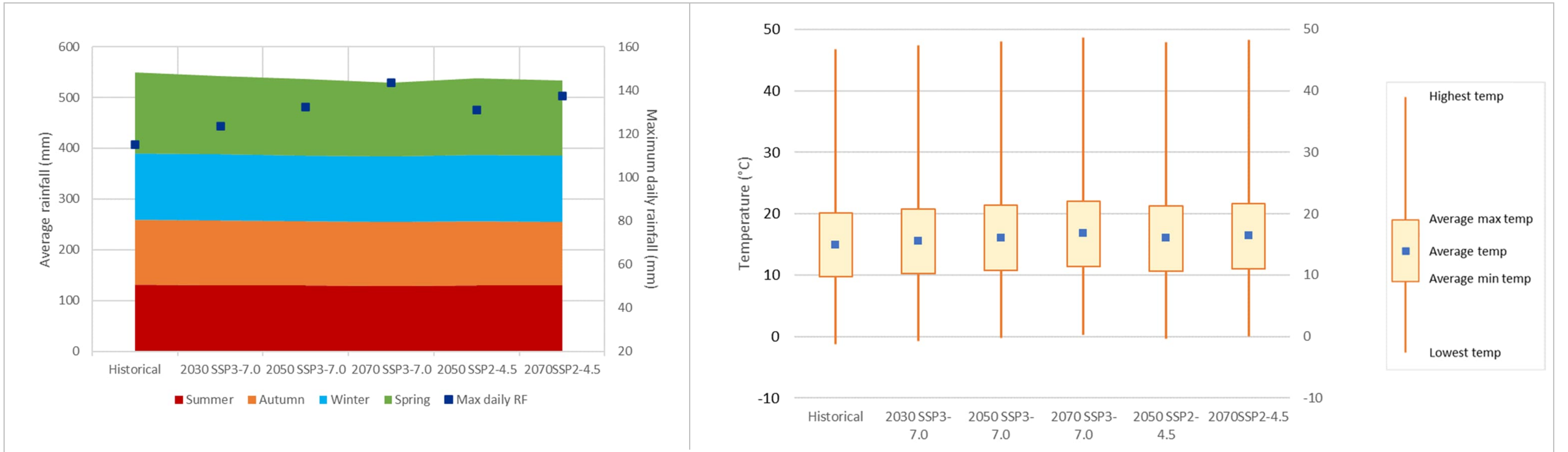


a) Seasonal and annual rainfall, maximum daily rainfall total



b) Extreme and average temperatures

Figure 7.2: Historical and projected change in seasonal and annual rainfall and extreme and average temperatures for Ballarat: 2030 SSP3-7.0, 2050 SSP2-4.5 and SSP3-7.0 and 2070 SSP2-4.5 and SSP3-7.0



a) Seasonal and annual rainfall, maximum daily rainfall total

b) Extreme and average temperatures

Figure 7.3: Historical and projected change in seasonal and annual rainfall and extreme and average temperatures for Melbourne Airport: 2030 SSP3-7.0, 2050 SSP2-4.5 and SSP3-7.0 and 2070 SSP2-4.5 and SSP3-7.0

8. Implications of weather extremes and climate change for electricity transmission networks

The ESCI Project[9] was initiated in response to the Finkel[10] Independent review into the future security of the National Electricity Market and its recommendation that the Coalition of Australian Governments (COAG) Energy Council develop a strategy to improve the integrity of energy infrastructure and the accuracy of supply and demand forecasting. Effects of extreme weather on a future energy system under climate change are anticipated to become increasingly significant. The ESCI Project delivered tailored climate and extreme weather information for use by the electricity sector in assessing the risks that climate change presents to sector investments, system reliability and system resilience.

Electricity supply and demand are closely connected to weather. Electricity infrastructure performance is directly affected by weather conditions, with those effects potentially exacerbated by projected climate change. Electricity transmission and distribution networks are vulnerable to extreme weather events, some of which may be exacerbated by climate change. Climate change hazards that may affect the electricity system include (ESCI Project, 2021):

- *Rising temperature:* electricity generation, transmission and distribution are sensitive to temperature and may be adversely affected on days with extreme high temperature and during heatwave events. Average and extreme temperatures and the duration and intensity of heatwave events are projected to increase with climate change (see Section 7).

  The energy transfer capacity of transmission and distribution powerlines decreases (i.e., the line derates) when operating above its design temperature. Operating temperature is influenced by line design, electrical loading, ambient temperature, solar radiation and wind speed. Maximum summer day rating of transmission lines is projected to decrease in response to increased temperature due to climate change. The level of derating is reduced (relative to conventional electricity distribution lines) for higher voltage transmission lines and powerlines with higher temperature ratings (ESCI Project, 2021).

- *Increased frequency, severity and extent of bushfires:* operation of distribution and transmission powerlines may be affected by heat and smoke associated with bushfires. Fire weather conditions may be exacerbated by climate change, with the frequency of highly elevated fire weather conditions projected to increase in many regions (see Section 9). These changes may affect the incidence, severity and/or extent of bushfires, as well as the incidence of bushfire-related disruptions to electricity transmission and / or damage to transmission infrastructure.

- *Extreme winds:* wind generation of electricity is sensitive to changes in average and extreme wind speeds and very strong winds reduce transmission line capacity and threaten the integrity of transmission infrastructure. All 11 incidents of transmission structure collapse recorded in Victoria between 1959 and 2020 have been due to extreme wind conditions (AusNet, 2020)[11].

  Conditions that are conducive to severe convective winds (the form of extreme wind posing the greatest risk to transmission infrastructure in many regions of Australia) are projected to be affected by climate change. In some regions of Australia, these conditions are anticipated to become more frequent. In other regions (including southern Australia), their frequency is projected to be unchanged or decrease slightly (Brown and Dowdy, 2021).

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[9] https://www.climatechangeinaustralia.gov.au/en/projects/esci/

[10] Report of the Independent Review into the Future Security of the National Electricity Market by Dr Alan Finkel, Karen Moses, Chloe Munro, Terry Effeney and Prof Mary O'Kane: https://www.energy.gov.au/government-priorities/energy-markets/independent-review-future-security-national-electricity-market

[11] All historical transmission structure collapse incidents have been experienced by towers that were designed to different and less robust standards than will be used in designing transmission towers for the Project. Since the publication of this information (AusNet, 2020), severe winds (In February 2024) resulted in the collapse of six transmission towers near Anakie, north of Geelong (https://www.energysafe.vic.gov.au/media-centre/news/energy-safe-investigates-transmission-towers-collapse).

- *Increased variability or reduction in rainfall, dam inflows and flooding:* changes in rainfall and run-off regimes (influenced by the amount and seasonal distribution of rainfall and evaporation) may affect the amount of water available for hydropower generation and cooling in thermal power stations, as well as the demand for energy (e.g., due to a requirement of operate sea water desalination plants), potentially changing demand and supply requirements for energy transmission. Reduced soil water content may increase damage to transmission infrastructure from lightning due to reduced soil conductance. It may also reduce thermal conductance from underground powerlines, leading to increased operating temperatures and reduced electricity transmission capacity.
- Compound extreme events: extremes in multiple climate variables occurring simultaneously (e.g., extreme wind and bushfire) or in close sequence can cause substantial disruption to electricity networks. The severity of these events may be exacerbated by infrastructure failure and/or other human factor hazards. Climate change may increase the frequency and magnitude of such events, although there is low confidence in projections about such changes.

9. Implications of climate change for construction and operation of the Project

9.1 Climate and weather extremes and construction of the Project

Activities associated with construction of the Project are described in Section 3.3.1. It is possible that during the planned two-year construction period, construction activities will be disrupted by natural hazards associated with extreme weather or climate conditions, potentially including:

- *Extreme heat:* individual days of extreme heat and more prolonged heat wave conditions could disrupt construction due to potential impacts on the health and well-being of the construction workforce. Work schedules and / or practices may need to be temporarily modified to provide for a safe work environment.
- *Extreme rainfall:* shorter and longer duration heavy rainfall events and associated overland flows and riverine flooding have potential to temporarily disrupt construction and / or damage construction sites and access tracks. In some cases (e.g., where flooding cuts or washes away roads), there is potential for the safety of the construction workforce to be affected. As with extreme heat, work schedules and / or practices may need to be temporarily modified to provide for a safe work environment. Rehabilitation works may also be required to repair affected construction sites or access tracks and / or rectify any damage to surrounding areas that resulted from this.
- *Prolonged wet weather:* prolonged wet weather may also disrupt construction activities or schedules, particularly due to restrictions on access in wet or waterlogged areas.
- *Storms and extreme wind:* lightning and extreme winds could disrupt construction activities, present a safety hazard to the construction workforce and damage partly constructed electricity transmission infrastructure. Work practices would need to be adjusted to ensure the safety of the workforce during storm events and any damage caused to Project infrastructure may need to be assessed and rectified.
- *Bushfire:* landscape fire may threaten construction crews, damage construction equipment and affect some components of the electricity transmission infrastructure being constructed. Some construction activities also have potential to ignite fires that could escape and affect surrounding property and communities. Potential bushfire impacts during construction and their mitigation are discussed in detail in the Bushfire Impact Assessment.

While it is clear from the IPCC's *Sixth Assessment Report* (e.g., IPCC, 2023) that at least some of these conditions may be influenced by climate change and human-induced greenhouse gas emissions, they will mainly reflect natural climate variability during the construction stage of the Project. Effects of these climate-related natural hazards will need to be considered in scheduling construction works, developing and implementing work practices (such as work health and safety protocols around heat, storms and other severe weather; siting laydown areas and hazardous goods storage with appropriate flood protection and setbacks from fire-prone vegetation, erosion protection and mitigation at temporary construction sites and laydown areas). While climate and weather extremes, such as extreme heat, dangerous fire weather and extreme rainfall, may materially affect construction, the anticipated mitigations are well-embedded in current good practice for workplace health and safety and environmental management.

9.2 Potential implications of climate change for the operational life of the Project

It is clear from the discussion in Sections 6 and 7, that the climate experienced by the Project Land may change significantly, particularly if global efforts to reduce greenhouse gas emissions are ineffective. Drawing on the discussion in Section 8 of the potential implications of climate change for electricity transmission networks generally, this section provides a brief assessment of what the key climate change-related natural hazards may mean for operation of the Project:

- *Rising temperature:* rising temperatures over the Project's operating life may diminish the capacity of the transmission line to transfer electricity, although this is only likely to occur on the relatively infrequent days with significantly elevated temperature, and particularly, the even less frequent days in the Project Land with high temperatures and little wind to dissipate heat gain.
- *Fire weather conditions:* since the Proposed Route passes through cleared agricultural land or, in areas of native vegetation or forestry plantation (that requires a cleared easement), the infrastructure is unlikely to be exposed to fires of such high intensity that it would be damaged, even if fire weather is exacerbated by climate change. As critical electricity supply infrastructure that mainly passes through agricultural land, transmission of electricity through Project infrastructure would only likely be suspended because of landscape fire under exceptional conditions.[12]
- *Extreme winds:* the most recent science indicates that there is no clear evidence that extreme wind conditions experienced by the Project Land will be materially exacerbated by climate change. This is reinforced by the recently updated Australian Standard for design of elevated structures to account for wind loadings (AS1170.2-2021; Standards Australia, 2021), which has not included a climate change scaling factor for design wind speeds for southern Australia.

  Wind loadings for high security requirement regional transmission lines, such as the Project, are to account for both downdraft winds and tornadoes, following AS/NZS 1170.2-2021 Structural design actions. Part 2: Wind actions (Standards Australia, 2021). Under this standard, design for the Project's transmission towers will account for at least a 400-year return period wind gust (i.e. wind gust speed that would be expected to occur or be exceeded once in a 400-year period, on average), with additional allowances for local terrain effects and the height of the towers (~55m/s or 200km/h for 70m 500kV transmission towers). As noted above, the design wind speed for the Project Land does not require scaling for climate change.
- *Changed rainfall conditions:* annual rainfall is projected to decline across the study area, with some changes in seasonality. When combined with increased evaporation, soils are anticipated to be drier and catchment run-off reduced (DELWP, 2020; Section 7). This may increase demand on the electricity grid (e.g., reflecting increased reliance on sea water desalination to meet shortfalls in water supply due to rainfall deficits), electrical loading on the transmission line and the criticality of Project infrastructure.

  Heavy rainfall, which may cause flooding and erosion of exposed and susceptible soils, is projected to become more extreme with climate change. This could increase exposure to flood and/or erosion-related impacts for parts of the Project (e.g., some access tracks), but is unlikely to materially exacerbate any potential impacts of the Project[13].
- *Compound extreme events:* these are low probability, but potentially high consequence climate-linked events that may affect the Project or amplify its impacts on the Project Land or surrounding regions (e.g., extreme wind event concurrent with landscape bushfire leads to structural failure of Project infrastructure that affects egress from or fire serve access to firegrounds, as discussed in the Bushfire Impact Assessment). While there is evidence that some types of extreme events may be exacerbated by climate change (i.e., extreme rainfall, temperature, fire weather) it is not possible to confidently attribute compound effects to any amplification of impacts on or of the Project.

The Project Land will likely experience a range of extreme weather events (e.g., extreme heat, storms and extreme winds and rainfall) and climate-related natural hazards (e.g., bushfires, floods) during operation of the Project. The severity of some of these events and hazards (particularly extreme heat, heavy rainfall, floods, severe fire weather) are anticipated to be amplified by climate change, while others (i.e., extreme wind) may not. Based on current knowledge, most potential impacts in operation of the Project are addressed through design standards (e.g., for extreme wind) or construction techniques (e.g., construction and maintenance of regulated vegetation clearances in the transmission line easement) and are expected to be effectively mitigated.

[12] Further details on the potential impacts associated with bushfires and their mitigation are provided in the Bushfire Impact Assessment.
[13] Further details on the potential impacts associated with heavy rainfall and other surface water conditions, and their mitigation, are provided in the Surface Water Impact Assessment.

The main unavoidable implication of climate change for operation of the Project is the effect of increased incidence and severity of extreme heat on transmission capacity. Extreme heat conditions are often associated with very high demand for electricity (for cooling), but these conditions affect both electricity generation (especially from solar panels) and transmission capacity. The impact of extreme heat on the capacity of transmission lines is partly mitigated by the size of the transmission lines and the materials used. In addition, extremely hot weather in Victoria is typically accompanied by sufficient wind to dissipate the heat that would otherwise accumulate within the lines and reduce electricity transmission.

10. Environmental Performance Requirements

To meet the EES objective to consider the Project’s on-going susceptibility to extreme weather, under climate change, two EPRs have been recommended (Table 10.1).

10.1 Mitigation measures

Climate change is projected to exacerbate fire weather conditions and flooding. Mitigation of any potential impacts associated with these effects during the Project’s construction and operation are considered in the Bushfire Impact Assessment and Surface Water Impact Assessment, respectively. No additional requirements to accommodate potential climate change effects were identified in the Bushfire Impact Assessment. The Surface Water Impact Assessment includes one EPR (SW4) that would result in climate change effects being considered in a design stage flood assessment for the Project. The Groundwater and Biodiversity Impact Assessments did not identify any adverse potential effects associated with climate change in relation to the Project and hence no specific mitigations were required.

10.2 Environmental Performance Requirements

The science underpinning climate models continues to evolve. New climate change modelling is typically undertaken for each successive IPCC Assessment Report cycle (typically 5 to 7 years). Once the results of global climate models are made available as part of the reporting cycle, further regional climate modelling may be undertaken to downscale the global model outputs. This work is undertaken by climate change modelling agencies to better reflect smaller-scale influences on climate and weather (e.g., topography) and smaller scale climate processes (e.g., storm formation).

Climate change projections reported here are based on outputs of the Coupled Model Intercomparison Projects 5 and 6 (CMIP5 / 6), which were undertaken for the IPCC’s AR5 and AR6, respectively. Plans are underway for further global climate modelling initiatives. As outputs from post-CMIP6 climate modelling become available, these should be reviewed by AusNet to determine whether the design standards used for Project infrastructure provide it with sufficient climate resilience given projected changes in extremes of weather and climate. If necessary and practicable, asset management practices may need to be adjusted to ensure the infrastructure can satisfy performance expectations.

Two climate change EPRs are proposed, as per Table 10.1. These reflect the need to explicitly and in detail consider climate change risks and responses in the Project’s detailed design, as well as the need to provide on-going assurance that Project infrastructure and its management provide the necessary climate resilience to satisfy service objectives over its operating life.

Table 10.1: Climate change Environmental Performance Requirements

EPR code	Environmental Performance Requirements	Project component	Stage
CC1	**Undertake a climate change risk assessment** 1. Undertake a climate change risk assessment for the Project during its detailed design stage to consider risks climate change related hazards may pose to Project infrastructure. This assessment must: a) Consider risks to Project infrastructure that arise from climate change b) Consider how existing risks to surrounding communities, land uses, properties and environments that arise from climate change may change as a result of the Project c) Develop practicable adaptation measures, if necessary, to address priority risks and provide assurance that the Project will satisfy performance expectations as critical electricity supply infrastructure over its planned operating life under projected climate change.	All Project components	Design
CC2	**Review climate change risk** 1. Five-yearly reviews of the best available climate change science relating to key climate-related hazards for Project infrastructure will be used to update the climate change risk assessment for the Project (EPR CC1). Where new information suggests the climate-related hazard context for the Project has materially changed or is projected to change materially from that considered in the initial climate change risk assessment, additional measures (or climate adaptations) may be identified to provide assurance that Project infrastructure will satisfy performance expectations as critical electricity supply infrastructure under climate change. Those measures would be implemented through on-going asset management.	All Project components	Operation

The risk-based approach to on-going climate risk consideration that is incorporated into the EPRs is consistent with the “risk management” guiding principle of Victoria’s CC Act, which specifies (Section 25) that decisions, policies, programs or processes should be based on *a careful evaluation of the best practically available information about the potential impacts of climate change, to avoid where practicable serious or irreversible damage resulting from climate change*. On-going consideration of climate risk for the Project in the context of evolving best available information on climate change is needed to avoid damages resulting from climate change.

11. Conclusion

Climate and weather conditions vary across the Project Land. Average annual rainfall increases from less than 600mm/y at its western and eastern extents to over 1000mm/y in elevated areas of the Wombat State Forest, north of Ballan. Temperatures across the Project Land are also influenced by topography, with average maximum temperatures being higher at lower elevations in the west and east of the Project Land (~19°C) and lower (~16°C) in more elevated locations around the fringe of the Wombat State Forest. Average minimum temperatures are also lower in more elevated areas than in the far west and east. Days with very high temperature (>40°C) occur at least once in most summers. Maximum recorded temperatures in the Project Land range between about 44°C and 47°C.

Average and (particularly) high temperature extremes have been increasing within the Project Land over the past 50 years and annual rainfall has been declining. These trends are projected to continue. Maximum and average temperatures across the Project Land are projected to increase by 1.5°C to 2.5°C or more over the Project's planned operating life. Annual average rainfall is projected to decline slightly over that timeframe. Relatively short-duration, heavy rainfall events are projected to become more intense, with the change in intensity following changes in air temperature. The change is projected to be greater for short duration heavy rainfall events (one to a few hours) than longer duration events (one to several days).

Climate change is also projected to lead to drier soils, reduced groundwater recharge and reduced surface water flows. Average windspeeds are projected to decline slightly. Projected changes in extreme wind conditions are uncertain. They may increase or decrease from historical levels, but are only projected to change by less than about 2m/s.

The Project Land will likely be exposed to a variety of climate change-related natural hazards, including extreme heat, elevated fire weather, extreme winds and changed rainfall conditions. With the exception of extreme winds, these hazards are projected to be amplified by climate change over the Project's operating life. Potential impacts are anticipated to be effectively mitigated through design and construction of the Project.

Effects of extreme heat on the capacity of transmission lines to conduct electricity are difficult to avoid but will be partly mitigated by their size, the materials used and inherent climate conditions. Environmental heat loading of powerlines is greatest when very high temperatures coincide with high solar radiation exposure and low wind speeds. In Victoria, very high temperatures (say ≥40°C) rarely coincide with still conditions; such conditions occur infrequently and last for relatively short periods (rarely more than 2 hours)[14]. Hence, the impact of increased incidence of extreme heat impacts on electricity transmission will likely be limited in frequency and duration.

Climate change projections have been considered in the assessment of potential impacts of the Project in the Bushfire, Surface Water and Groundwater Impact Assessments.

Two EPRs have been proposed, one that recommends a detailed climate change risk assessment is undertaken for the Project during the detailed design stage and the second which recommends this be followed up at approximately five-year intervals. These should draw on the best available climate science on Project-applicable climate hazards. Both assessments would consider risks climate change may pose to Project infrastructure and any effects on other potential Project impacts. It may also propose adaptation measures to address key risks.

[14] Atmospheric heat loading of powerlines is maximised when high temperatures coincide with low wind speed and high levels of solar radiation. Such conditions are unusual within the study area. For example, of the 194 individual hourly records of temperature of 40°C or more at Melbourne Airport, only 30 were associated with windspeeds less than 20km/h and only two (on different days) were less than 10km/h.

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Appendix A. Additional climate change projection data

The climate change scaling factors provided in Section 7 are the median model results for each climate variable. The table below provides the median results with the 5th and 95th percentile ranges to give an indication of model spread.

Table A.1: Climate Insights climate change scaling factors for the Project Land (median, with 5th and 95th percentile range in brackets)

Year	2030	2050		2070		2090	
Climate aspect	**SSP3-7.0**	**SSP2-4.5**	**SSP3-7.0**	**SSP2-4.5**	**SSP3-7.0**	**SSP2-4.5**	**SSP3-7.0**
Ararat							
Daily maximum temperature (°C)	0.6 (0.4 - 0.9)	1.1 (0.7 - 1.7)	1.2 (0.7 - 1.9)	1.5 (0.9 - 2.4)	1.9 (1.1 - 2.9)	1.7 (1 - 2.6)	2.6 (1.6 - 4.1)
Daily minimum temperature (°C)	0.5 (0.3 - 0.8)	0.9 (0.6 - 1.5)	1 (0.6 - 1.6)	1.3 (0.8 - 2)	1.6 (1 - 2.5)	1.4 (0.9 - 2.3)	2.2 (1.4 - 3.5)
Daily mean temperature (°C)	0.6 (0.3 - 0.8)	1 (0.6 - 1.5)	1.1 (0.7 - 1.7)	1.4 (0.9 - 2.1)	1.8 (1.1 - 2.6)	1.6 (1 - 2.4)	2.5 (1.5 - 3.7)
Precipitation (%)	-1.1 (-8.5 - 10.3)	-2.1 (-15.8 - 19.1)	-2.3 (-17.1 - 20.5)	-2.9 (-21.7 - 26.1)	-3.6 (-26.9 - 32.4)	-3.2 (-24.4 - 29.3)	-5 (-37.8 - 45.5)
Relative humidity (%)	-0.5 (-1.7 - 0.9)	-0.9 (-3.2 - 1.7)	-0.9 (-3.4 - 1.8)	-1.2 (-4.3 - 2.3)	-1.5 (-5.4 - 2.9)	-1.4 (-4.9 - 2.6)	-2.1 (-7.6 - 4)
Evapotranspiration (%)	2.1 (1.4 - 3.4)	4 (2.6 - 6.3)	4.3 (2.8 - 6.8)	5.4 (3.6 - 8.7)	6.8 (4.5 - 10.8)	6.1 (4.1 - 9.8)	9.5 (6.3 - 15.3)
Solar radiation (%)	0.7 (-0.7 - 2.2)	1.2 (-1.4 - 4)	1.3 (-1.5 - 4.3)	1.7 (-1.9 - 5.5)	2.1 (-2.3 - 6.8)	1.9 (-2.1 - 6.2)	2.9 (-3.2 - 9.6)
Average wind speed (%)	0.9 (-4.4 - 6.3)	1.7 (-8.3 - 11.8)	1.9 (-8.9 - 12.7)	2.4 (-11.3 - 16.1)	3 (-14 - 20)	2.7 (-12.7 - 18.1)	4.2 (-19.7 - 28.1)
Extreme wind speed (1% AEP event, %)	2.5 (-7.9 - 6.2)	2.7 (-6.4 - 9)	2.4 (-5 - 9.5)	-0.8 (-5.8 - 13.3)	3.1 (-9.5 - 7.6)	3.3 (-5.5 - 13)	-1 (-5.9 - 8.7)
Days per year >40°C (Days)	0.2 (0.1 - 0.5)	0.5 (0.2 - 1.1)	0.6 (0.2 - 1.1)	0.7 (0.3 - 1.5)	1 (0.4 - 2.1)	0.8 (0.4 - 1.8)	1.4 (0.7 - 4.2)
Days per year < 2°C (days)	-6.6 (-4.6 - -9.5)	-11.3 (-7.7 - -15.7)	-12.1 (-8.3 - -16.4)	-14.7 (-10.1 - -18.6)	-16.9 (-12.2 - -21.1)	-16.1 (-11.2 - -20)	-20.8 (-15.9 - -24)
1% AEP rainfall event (24 h) (%)	6.5 (-3.4 - 16.8)	12.1 (-6.4 - 31.2)	13 (-6.9 - 33.6)	16.5 (-8.7 - 42.7)	20.5 (-10.9 - 53)	18.6 (-9.8 - 48)	28.8 (-15.2 - 74.4)
Extreme rainfall (ARR)[2] (%)	10	14	15	17	21	20	29
Ballarat							
Daily maximum temperature (°C)	0.6 (0.4 - 0.9)	1.1 (0.7 - 1.7)	1.2 (0.7 - 1.8)	1.5 (0.9 - 2.3)	1.9 (1.2 - 2.8)	1.7 (1.1 - 2.6)	2.6 (1.6 - 4)
Daily minimum temperature (°C)	0.5 (0.3 - 0.8)	0.9 (0.6 - 1.4)	1 (0.6 - 1.6)	1.3 (0.8 - 2)	1.6 (1 - 2.5)	1.5 (0.9 - 2.2)	2.3 (1.4 - 3.4)
Daily mean temperature (°C)	0.6 (0.3 - 0.8)	1 (0.6 - 1.5)	1.1 (0.7 - 1.6)	1.4 (0.8 - 2.1)	1.8 (1 - 2.6)	1.6 (0.9 - 2.3)	2.5 (1.5 - 3.6)
Precipitation (%)	-1.2 (-8.1 - 9.1)	-2.2 (-15.1 - 17)	-2.3 (-16.2 - 18.3)	-2.9 (-20.7 - 23.2)	-3.7 (-25.6 - 28.8)	-3.3 (-23.2 - 26.1)	-5.1 (-36 - 40.5)
Relative humidity (%)	-0.4 (-1.6 - 0.9)	-0.8 (-3 - 1.7)	-0.9 (-3.2 - 1.9)	-1.1 (-4.1 - 2.4)	-1.4 (-5 - 3)	-1.2 (-4.6 - 2.7)	-1.9 (-7.1 - 4.2)
Pan evaporation (%)	2.3 (1.5 - 3.5)	4.2 (2.7 - 6.5)	4.6 (3 - 7)	5.8 (3.8 - 8.9)	7.2 (4.7 - 11.1)	6.5 (4.2 - 10)	10.2 (6.6 - 15.6)

Year	2030	2050		2070		2090	
Climate aspect	**SSP3-7.0**	**SSP2-4.5**	**SSP3-7.0**	**SSP2-4.5**	**SSP3-7.0**	**SSP2-4.5**	**SSP3-7.0**
Solar radiation (%)	0.7 (-0.8 - 2.2)	1.3 (-1.4 - 4)	1.4 (-1.5 - 4.3)	1.8 (-2 - 5.5)	2.2 (-2.4 - 6.8)	2 (-2.2 - 6.2)	3.1 (-3.4 - 9.6)
Average wind speed (%)	1 (-4.7 - 6.5)	1.8 (-8.8 - 12.1)	1.9 (-9.4 - 13)	2.4 (-12 - 16.6)	3 (-14.9 - 20.6)	2.7 (-13.5 - 18.6)	4.3 (-20.9 - 28.8)
Extreme wind speed (1% AEP event, %)	0.8 (-6.7 - 4.4)	1.5 (-6 - 9.5)	-0.3 (-5.4 - 9.4)	-0.6 (-5.3 - 12.7)	-1 (-6.3 - 9.1)	2.8 (-5.6 - 11.3)	-1.5 (-6.7 - 7.3)
Days per year >40°C (Days)	0.3 (0.2 - 0.4)	0.5 (0.3 - 1)	0.6 (0.3 - 1.2)	0.8 (0.4 - 1.8)	1.2 (0.6 - 2.3)	0.9 (0.5 - 1.9)	2 (0.9 - 3.8)
Days per year < 2°C (days)	-8.4 (-5.5 - -12.2)	-14.9 (-9.8 - -20.7)	-16.2 (-10.5 - -21.5)	-20 (-12.8 - -26.1)	-23.8 (-16.6 - -29)	-22 (-14.8 - -27.8)	-28.9 (-21.6 - -34.2)
1% AEP rainfall event (24 h) (%)	6.1 (-0.7 - 20)	11.4 (-1.3 - 37.1)	12.3 (-1.4 - 39.9)	15.6 (-1.8 - 50.7)	19.3 (-2.3 - 63)	17.5 (-2.1 - 57)	27.1 (-3.2 - 88.4)
Extreme rainfall (ARR)[2] (%)	10	14	15	17	21	20	29
Melbourne Airport							
Daily maximum temperature (°C)	0.6 (0.4 - 0.9)	1.2 (0.7 - 1.7)	1.2 (0.8 - 1.8)	1.6 (1 - 2.3)	2 (1.2 - 2.9)	1.8 (1.1 - 2.6)	2.8 (1.7 - 4.1)
Daily minimum temperature (°C)	0.5 (0.3 - 0.8)	1 (0.6 - 1.5)	1 (0.6 - 1.6)	1.3 (0.8 - 2)	1.6 (1 - 2.5)	1.5 (0.9 - 2.3)	2.3 (1.4 - 3.5)
Daily mean temperature (°C)	0.6 (0.3 - 0.8)	1.1 (0.6 - 1.5)	1.1 (0.7 - 1.7)	1.5 (0.9 - 2.1)	1.8 (1.1 - 2.6)	1.6 (1 - 2.4)	2.5 (1.5 - 3.7)
Precipitation (%)	-1.1 (-7.8 - 9)	-2.1 (-14.5 - 16.7)	-2.3 (-15.6 - 17.9)	-2.9 (-19.9 - 22.8)	-3.6 (-24.7 - 28.3)	-3.3 (-22.4 - 25.6)	-5 (-34.6 - 39.7)
Relative humidity (%)	-0.4 (-1.8 - 1)	-0.8 (-3.3 - 1.9)	-0.9 (-3.5 - 2.1)	-1.1 (-4.5 - 2.7)	-1.4 (-5.5 - 3.3)	-1.3 (-5 - 3)	-2 (-7.8 - 4.6)
Pan evaporation (%)	2.3	4.3	4.6	5.9	7.3	6.6	10.3
	(1.4 - 3.4)	(2.7 - 6.3)	(2.9 - 6.8)	(3.7 - 8.6)	(4.6 - 10.8)	(4.2 - 9.7)	(6.5 - 15.2)
Solar radiation (%)	0.8 (-0.8 - 2.3)	1.5 (-1.5 - 4.2)	1.6 (-1.6 - 4.5)	2 (-2 - 5.8)	2.5 (-2.5 - 7.2)	2.3 (-2.3 - 6.5)	3.6 (-3.5 - 10.1)
Average wind speed (%)	1 (-4.8 - 6.6)	1.9 (-8.9 - 12.3)	2 (-9.6 - 13.3)	2.6 (-12.1 - 16.9)	3.2 (-15.1 - 21)	2.9 (-13.6 - 19)	4.5 (-21.2 - 29.4)
Extreme wind speed (1% AEP event, %)	0.4 (-6.6 - 4.5)	1.3 (-4.3 - 8.7)	0.1 (-8.4 - 8.3)	1.4 (-4 - 9.6)	0.2 (-6.6 - 10.4)	3.6 (-4.5 - 9.5)	-0.5 (-5.7 - 6.6)
Days per year >40°C (Days)	0.6 (0.3 - 0.9)	1 (0.7 - 1.7)	1.1 (0.8 - 1.8)	1.5 (0.9 - 2.4)	2 (1 - 3.4)	1.7 (0.9 - 3.2)	3 (1.4 - 5.7)
Days per year < 2°C (Days)	-2.6 (-1.5 - -3.8)	-4.6 (-2.9 - -5.6)	-4.8 (-3 - -5.7)	-5.5 (-3.7 - -6.7)	-6.2 (-4.5 - -7.3)	-5.9 (-4.2 - -7)	-7.3 (-5.6 - -8)
1% AEP rainfall event (24 h) (%)	7.6 (-3.1 - 22.6)	14 (-5.8 - 42)	15.1 (-6.3 - 45.2)	19.2 (-8 - 57.5)	23.8 (-9.9 - 71.4)	21.6 (-9 - 64.6)	33.4 (-13.9 - 100.2)
Extreme rainfall (ARR)[2] (%)	10	14	15	17	21	20	29

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