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Climate Adaptation Plan
77-83 Sutton Street, North Melbourne

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SUSTAINABLE DEVELOPMENT
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Proposed Mixed-use Development
77-83 Sutton Street, North Melbourne

Climate Adaptation Plan

July 2024

S5053 CAP.V1

PREPARED BY:

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Version	Date of Issue	Description	Author	Approved
V1	05-07-2024	For Council Endorsement	LB	SD

1. Executive Summary

SITE DESCRIPTION

Project: Mixed-use Development

Address: 77-83 Sutton Street, North Melbourne

Climate Zone: Temperate oceanic climate, Köppen *Cfb*

Assessment Conducted: July 2024

OBJECTIVE

The changes in the earth's climate are causing upheavals in the ecological cycles of the planet and increasing the number of risks threatening assets across the globe.

Sustainable Development Consultants have been commissioned to develop this Climate Adaptation Plan, to consider the impact climate change will have on the proposed multi use development at 77-83 Sutton Street, North Melbourne, and the surrounding area. This seeks to ensure that the project is resilient to whatever climate-related risks threaten it across the life of the development. It includes specific design responses of the risks identified, and the parties responsible to ensure that the risks are managed or altered to an appropriate level.

This plan has been developed to respond to the Green Star Design and As Built v1.3 Credit 3 Adaption and Resilience criteria, as detailed by the Green Building Council of Australia's Submission Guidelines.

OUR ASSESSMENT

Through our review of the *AS 5334:2013 – Climate change adaptation for settlements and infrastructure* standards, the key risks determined for the site from changes in climate are:

- **Temperature:** Increased overall average temperature and more extreme heat events will require HVAC systems with higher capacities, and the internal and external spaces are to be designed to provide comfortable areas for staff and visitors.
- **Rainfall:** An increase in extreme rainfall events means the building and site drainage systems need to be designed to accommodate large quantities of water and an overall decrease in rainfall on the site will cause reduced reliability of water tank supplies.
- **Extremes:** Greater fluctuations in weather conditions will see more extreme heat waves, storm events, floods and/or wind. The development must be capable of handling higher intensity weather events.

ADAPTATION AND IMPLEMENTATION

Amongst the many risks identified, specific design responses offer solutions focussed on 'high' and 'extreme' rated risks. These include actions such as reducing the urban heat island effect through cool roofs, having larger down-pipes, and increasing the HVAC systems' maximum loading to handle the warmer climates into the future. The details of each sustainable design feature, action and the persons responsible for executing them are included in Section 7 – Implementation Strategies.

2. Introduction

Sustainable Development Consultants (SDC) have been appointed by Blue Earth Group to consider the impact that climate change will have on the project area in an ongoing capacity, through the development of a Climate Adaptation Plan. This seeks to assess how the proposed mixed-use development will handle the changing climate with current projections based on the Intergovernmental Panel on Climate Change (IPCC) endorsed Global Circulation Models (GCMs), and data from the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

2.1 Site Description

The proposed development site at 77-83 Sutton Street, North Melbourne is located near the rail line and Moonee Ponds Creek. The site comprises of an old warehouse facility and is situated just north of the Arden Gardens Shopping Centre, close to a wide range of shops, restaurants, cafes and bars, as well as the North Melbourne Community Centre and public gardens. The site also has excellent access to a variety of public transport options, including Boundary Road/Racecourse Road being a six-minute walk away, and Macaulay Railway Station being a ten-minute walk away.

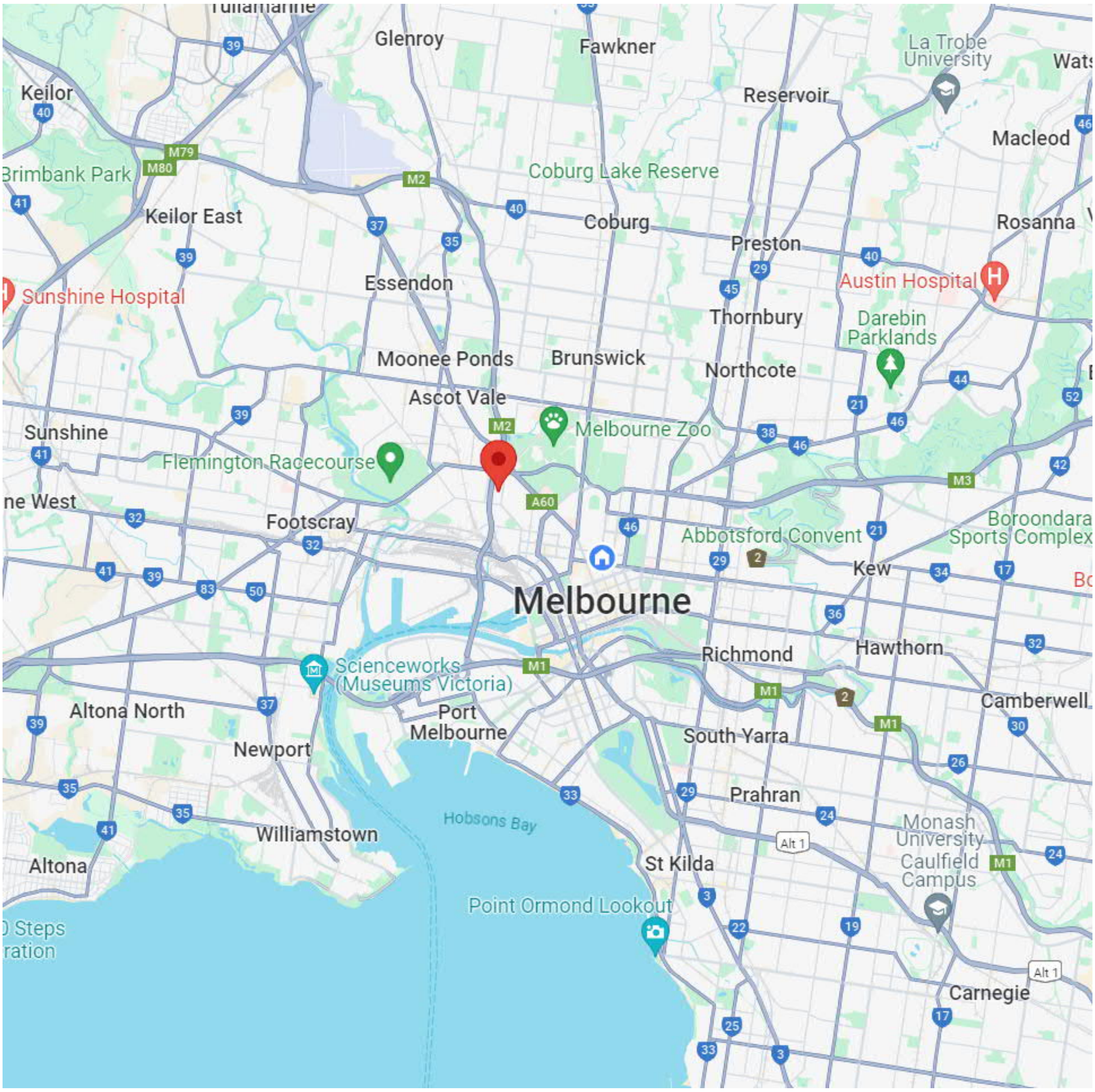

Figure 1: Location of 77-83 Sutton Street, North Melbourne relative to Melbourne CBD (Source: Landchecker)

Figure 2: Aerial view of 77-83 Sutton Street, North Melbourne (Source: Landchecker, Markup by SDC)

3. Background and Methodology

3.1 Sustainable Development Objectives

The Green Star Compliance Requirements set out to encourage and recognise the quality of design, construction and operation of sustainable buildings and communities across Australia. This report supports compliance with the 'Adaption and Resilience' credit and aims to encourage and recognise projects that are resilient to the impacts of a changing climate and natural disasters.

It is important to note that this document refers primarily to preparing the development to *adapt* to climate change, as opposed to *mitigating* climate change. While mitigation is very important in the united effort to reduce the extent of climate change to a target of 2°C levels by 2100, adaptation is necessary to respond to the changes already occurring on our planet, and the projections showing how they will continue.

The Melbourne City Council have developed a Climate Change Adaptation Strategy, "Climate Change Adaptation Strategy Refresh 2017",[1] which aims to ensure services and assets are taking into consideration the latest science to build a vibrant and resilient city.

3.2 Green Star Requirements

One point is awarded where the following Climate Adaptation Plan Compliance Requirements are met:

CLIMATE ADAPTATION PLAN

The Climate Adaptation Plan must contain, as a minimum, the following information:

- Summary of project's characteristics (site, location, climatic characteristics);
- Assessment of climate change scenarios and impacts on the project using at least two timescales, relevant to the project's anticipated lifespan. This must include a summary of potential direct and indirect (environmental, social and economic) climate change impacts on the project;
- Identification of the potential risks (likelihood and consequence) for the project and the potential risks to people. This risk assessment is to be based on a recognised standard;

[1] https://www.melbourne.vic.gov.au/sitecollectiondocuments/climate-change-adaptation-strategy-refresh-2017.pdf

- A list of actions and responsibilities for all high and extreme risks identified; and
- Stakeholder consultation undertaken during plan preparation and how these issues have been incorporated.

In addition, the following requirements must be met in developing the Climate Adaptation Plan.

DEVELOPING CLIMATE CHANGE SCENARIOS

Prior to undertaking the initial assessment, the Australian Greenhouse Office (AGO) Guide (Section 4.2) calls for climate change scenarios to be developed and reviewed. The scenarios used by the applicant must be sourced from the Intergovernmental Panel on Climate Change (IPCC) endorsed Global Circulation Models (GCMs) and may include:

- CSIRO projections;
- State or Federal climate projections; or
- Projections determined by a more detailed climate model.

The project must justify the selection of the climate scenario and emissions scenario used.

RISK ASSESSMENT

Undertake the 'Initial Assessment' outlined in Section B (Sub-sections 4-6) of the AGO Guide. The ISO 31000 Standard must be used for further guidance in undertaking the risk analysis process prescribed in Section B (Sub-sections 5.1-5.6) of the AGO Guide. The consequence/success criteria in the AGO Guide have been refined to be more applicable at the development scale.

The assessment of climate change impacts must address a minimum of two timescales relevant to anticipated building lifespan for the primary effects of temperature, precipitation, and sea-level rise. The plan must then consider the secondary effects of relative humidity, drought/flood, wind, cyclones, and bushfire as a minimum.

RECOGNISED STANDARDS

For the purposes of this plan, recognised Standards are listed below.

- *AS 5334:2013 Climate Change Adaptation for Settlements and Infrastructure*;
- *ISO 31000-2009 – Risk Management – Principles and Guidance*; and
- *AGO, Climate Change Risks and Impacts: A Guide for Government and Business*.

IMPLEMENTATION OF THE CLIMATE ADAPTATION PLAN

Implementation of the Climate Adaptation Plan must include:

- At least two risk items identified in the risk assessment component of the Climate Adaptation Plan must be addressed by specific design responses.
- All risk items identified as 'high' must be addressed by specific design or future operational responses.
- All risk items identified as 'extreme' must be addressed by specific design responses.

Where no risks are identified by the Climate Adaptation Plan, this criterion is deemed to be met.

3.3 Principles

The following principles are crucial to consider when conducting an assessment on the impacts of climate change. They embody the factors which need to be considered to enable adaptation to the changing climate. This information has been taken from the AS 5334-2013 Standards on climate change adaptation Clause 5.

a) The effects of climate change are not contained within jurisdictional boundaries; adaptation may require policy, planning and action at national, state, regional and local levels;
b) Climate change risk management needs to be an integral part of decision-making concerning settlements and infrastructure;

c) The risk from climate change and the requirement for adaptation needs to be considered for all stages in the lifecycle of settlements and infrastructure;

d) Climate change risk management and adaptation requires the involvement of stakeholders in settlements and infrastructure;

e) When managing the risk from climate change, organisations need to use the best available authoritative and relevant information; and

f) When information about climate change is updated the specification and performance requirements for settlements and infrastructure needs to be reconsidered.

These principles have been considered in the preparation of this Climate Adaptation Plan.

4. Climate Change Trends

Our world is undergoing considerable changes in the climate due to rising greenhouse gas emissions, and the increasing levels of heat absorbed from the sun as a result. The following graphs and figures show the evidence of rising greenhouse gases in the atmosphere, and the various projections of impact this will have on climate. The projections vary considerably, showing the importance of taking proactive action to mitigate the effects of climate change, and how these can reduce the overall impact.

However, this climate adaptation plan will focus primarily on what actions are required to face the challenges climate change will bring, as opposed to the measures that can be taken to reduce it.

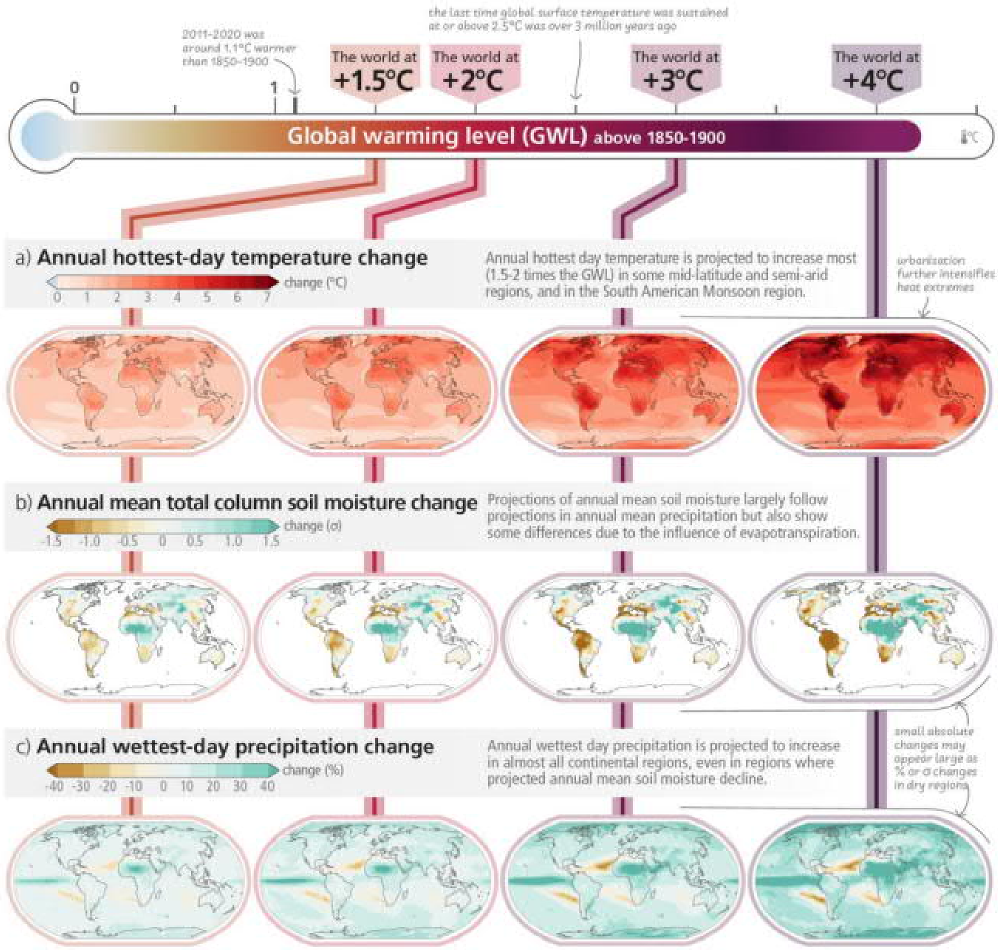

Figure 3: Regional changes in mean climate and extremes (Source: IPCC Sixth Assessment Report (AR6))[2]

Figure 3 shows the regional changes in the mean climate and extremes are predicted to become more pronounced and widespread as global warming levels continue to rise.

[2] IPCC AR6 Synthesis Report

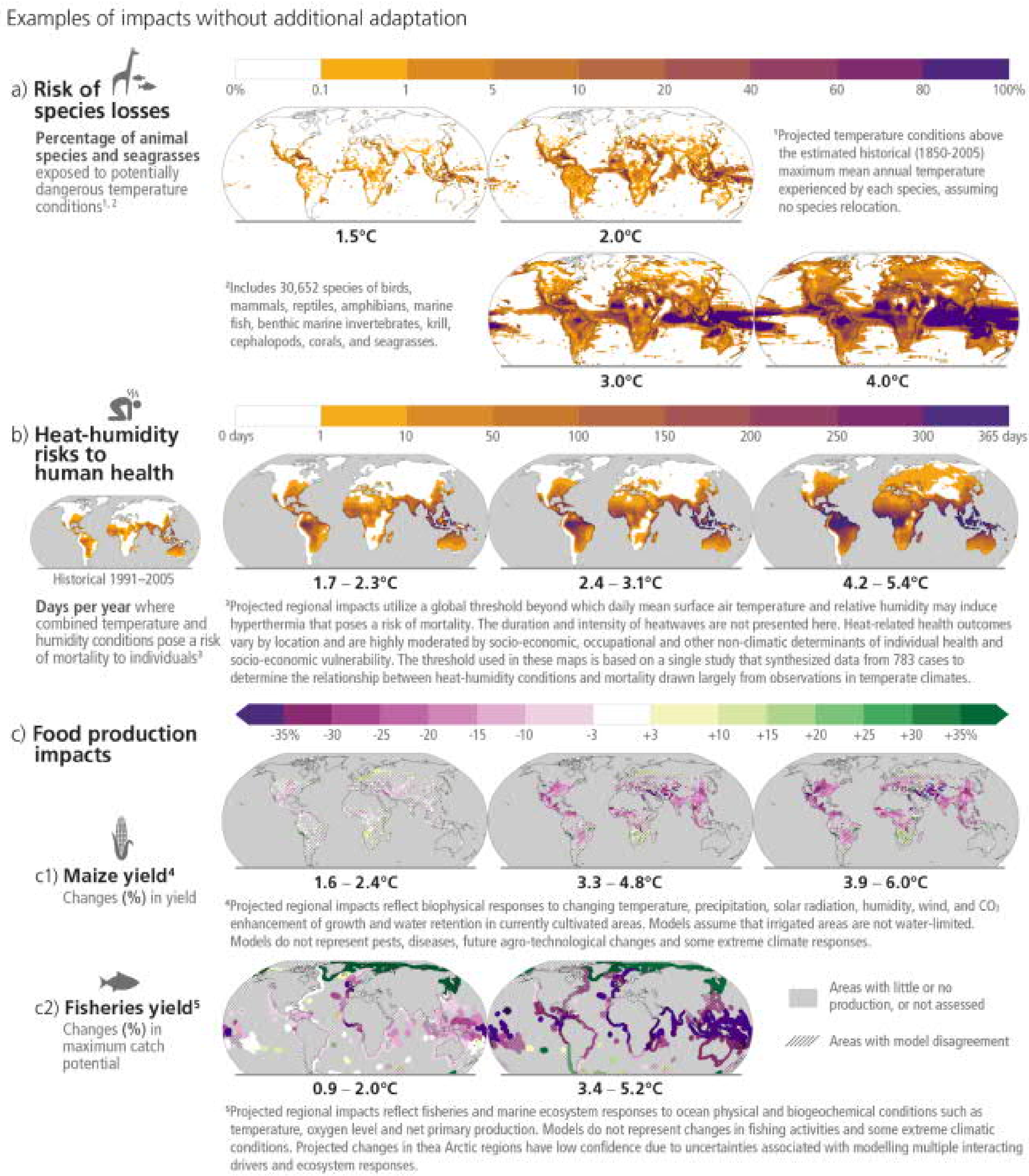

Figure 4: Future climate change projections and impacts across human and natural systems. (Source: IPCC AR6 Climate Synthesis Report)[3]

Figure 4 demonstrates the severity of impacts across human and natural systems in line with future climate change projections.

[3] IPCC AR6 Synthesis Report

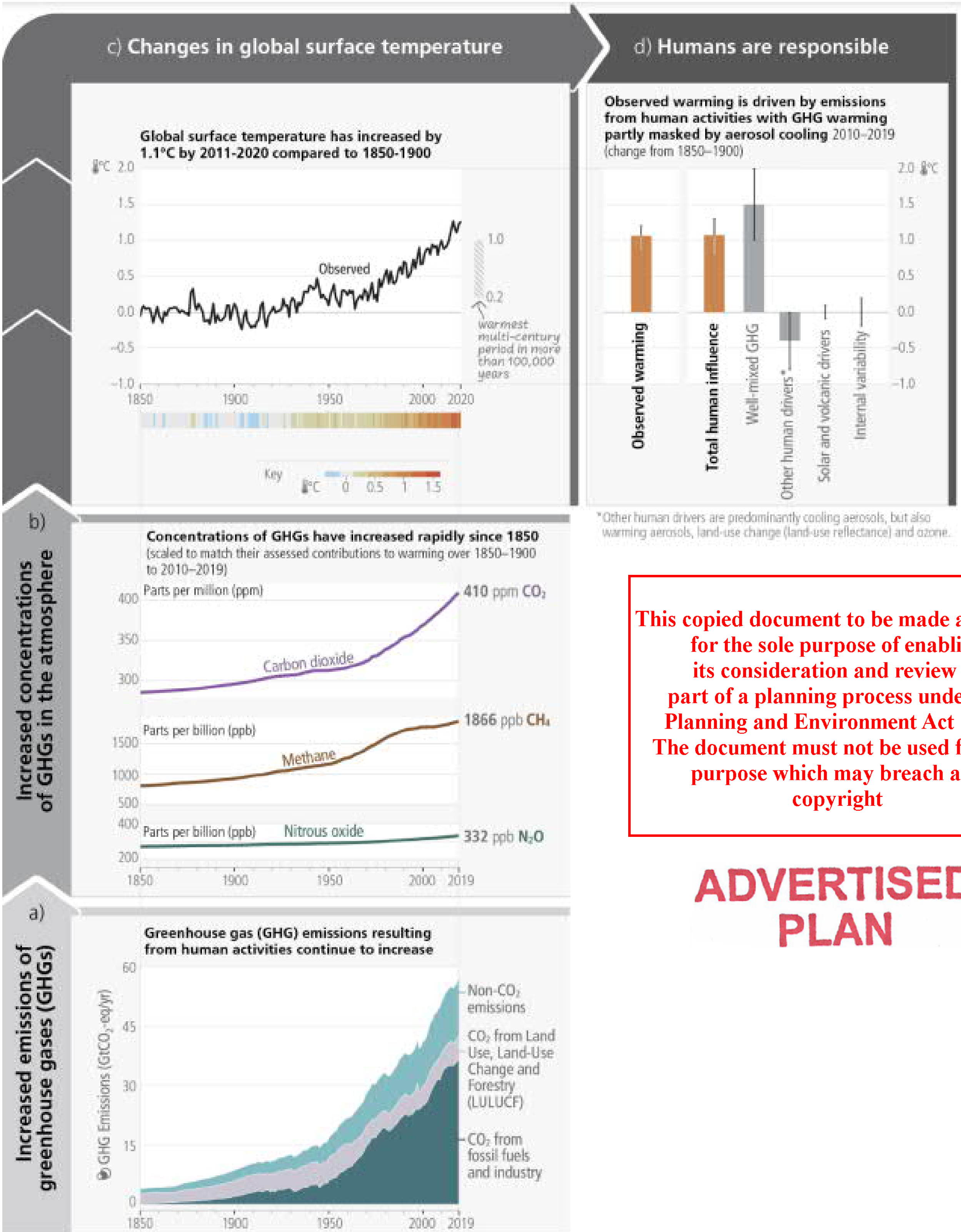

Figure 5: Graphs show the increasing levels of greenhouse gas emissions, and the resulting changes in the environment (Source: IPCC AR6 Climate Synthesis Report)[4]

Figure 5 depicts the causal chain from emissions to resulting warming of the climate system. This chart is best explained within the IPCC AR6 Synthesis Report, excerpt below:

[4] IPCC AR6 Synthesis Report

“The causal chain from emissions to resulting warming of the climate system. Emissions of GHG have increased rapidly over recent decades (panel (a)). Global net anthropogenic GHG emissions include CO2 from fossil fuel combustion and industrial processes (dark green); net CO2 from land use, land-use change and forestry (green); CH4; N2O; and fluorinated gases (HFCs, PFCs, SF6, NF3) (light blue). These emissions have led to increases in the atmospheric concentrations of several GHGs including the three major well-mixed GHGs CO2, CH4 and N2O (panel (b), annual values). To indicate their relative importance each subpanel’s vertical extent for CO2, CH4 and N2O is scaled to match the assessed individual direct effect (and, in the case of CH4 indirect effect via atmospheric chemistry impacts on tropospheric ozone) of historical emissions on temperature change from 1850–1900 to 2010–2019. This estimate arises from an assessment of effective radiative forcing and climate sensitivity. The global surface temperature (shown as annual anomalies from a 1850–1900 baseline) has increased by around 1.1°C since 1850–1900 (panel (c)). The vertical bar on the right shows the estimated temperature (very likely range) during the warmest multicentury period in at least the last 100,000 years, which occurred around 6500 years ago during the current interglacial period (Holocene). Prior to that, the next most recent warm period was about 125,000 years ago, when the assessed multicentury temperature range [0.5°C–1.5℃] overlaps the observations of the most recent decade. These past warm periods were caused by slow (multi-millennial) orbital variations. Formal detection and attribution studies synthesise information from climate models and observations and show that the best estimate is that all the warming observed between 1850– 1900 and 2010–2019 is caused by humans (panel (d)). The panel shows temperature change attributed to: total human influence; its decomposition into changes in GHG concentrations and other human drivers (aerosols, ozone and land-use change (land-use reflectance)); solar and volcanic drivers; and internal climate variability. Whiskers show likely ranges.”[5]

Figure 5 considers all gases that are contributing to climate change (CO_2-equivalent), namely CO_2, methane, hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride, and nitrogen trifluoride.[6]

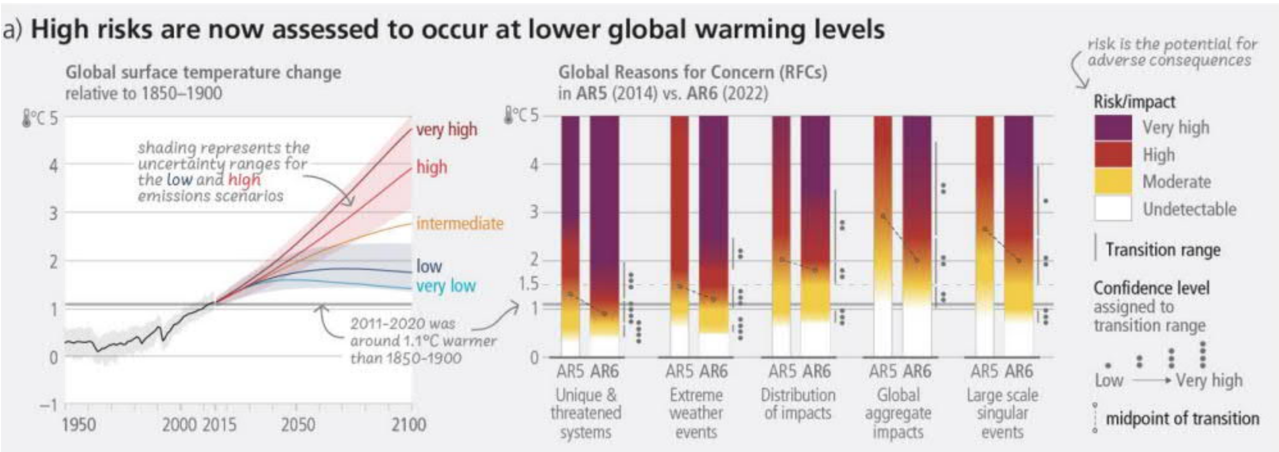

Figure 6: Global surface temperature change projections by 2100 based on low and high emissions scenarios, along with a comparison of cause for concern (Source: IPCC AR6 Climate Synthesis Report)

As shown in Figure 6, the potential for adverse consequences has been revised following further scientific studies, and now indicates higher risk impacts being realised at lower levels of global warming than were predicted in the AR5 predictions (released in 2016).

As the climate is changing, it is crucial that all new developments have the resilience and appropriate measures in place to handle the risks associated with the future projected climate. From this data, it is evident that man-made climate change is impacting the levels of greenhouse gases in the atmosphere and influencing increasing air and water temperatures.

[5] IPCC AR6 Synthesis Report

[6] https://ecometrica.com/assets/GHGs-CO2-CO2e-and-Carbon-What-Do-These-Mean-v2.1.pdf

5. Climate Change Scenarios

The climate change scenarios discussed in this report are based on climate change projections that the Australian Bureau of Meteorology (BOM) have prepared for each Natural Resource Management (NRM) region of the Australian territory. These NRM are generally organised into clusters, comprising Australia's natural landscapes, water and biodiversity assets, and corresponding to the diverse biophysical regions of Australia (see Figure 7). Each cluster differs to the others for its unique history, population, geography and natural resources; therefore, each NRM region will react distinctively to climate change.

The proposed development is located within the Southern Slope (Vic West) sub-cluster, which includes Donnybrook and the northern Melbourne area (Figure 7).

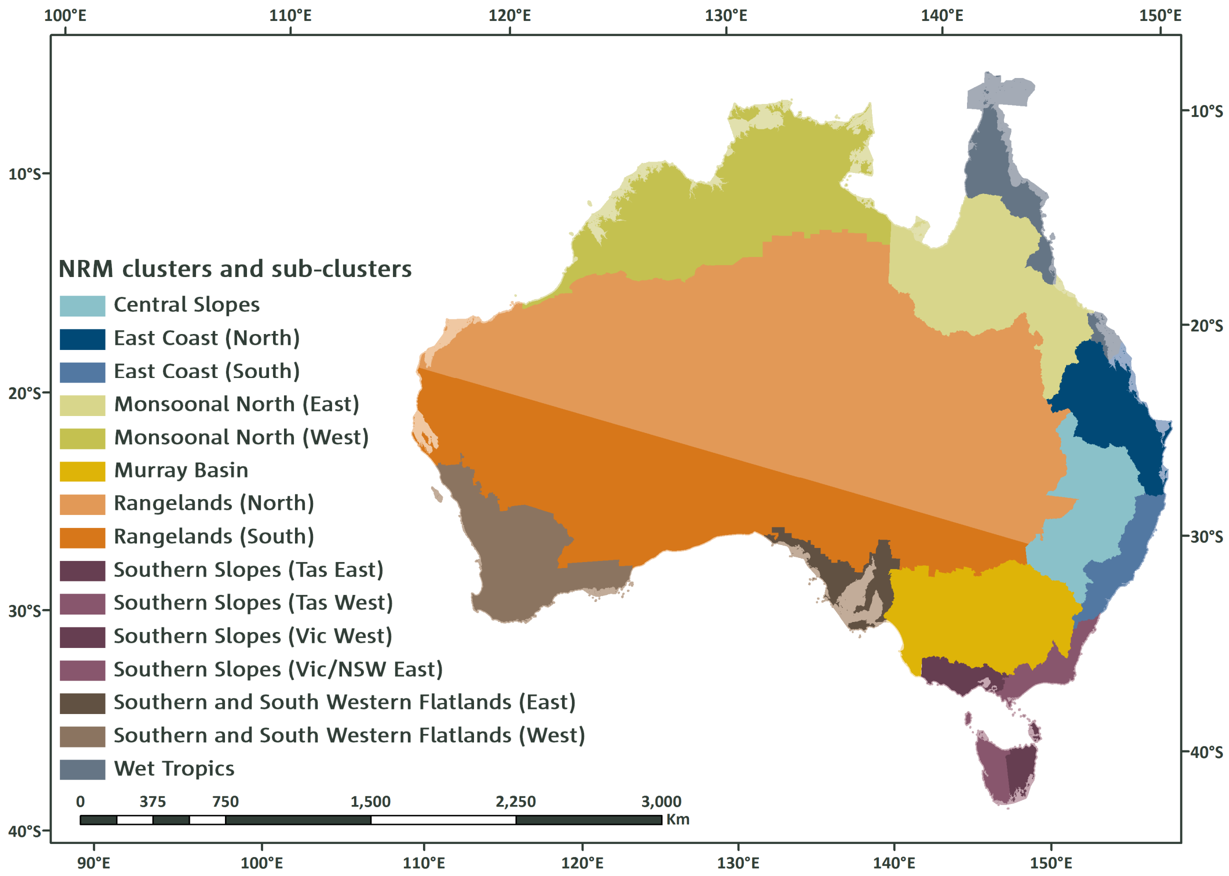

Figure 7: Map showing the eight clusters and sub-clusters of Australia used for climate change projections

5.1 Current Climate Characteristics

The project site is approximately equidistant from the two closest weather stations (Essendon Airport 8.9km away and Latrobe University 12.5km away from North Melbourne). A larger historical dataset was available from the Essendon Airport weather station for temperature and rainfall, whilst the weather station at Latrobe University provides a more recent dataset for wind speed and humidity. This Climate Adaptation Plan references the longer set of data available for each parameter, to be able to provide the best trend comparisons over time.

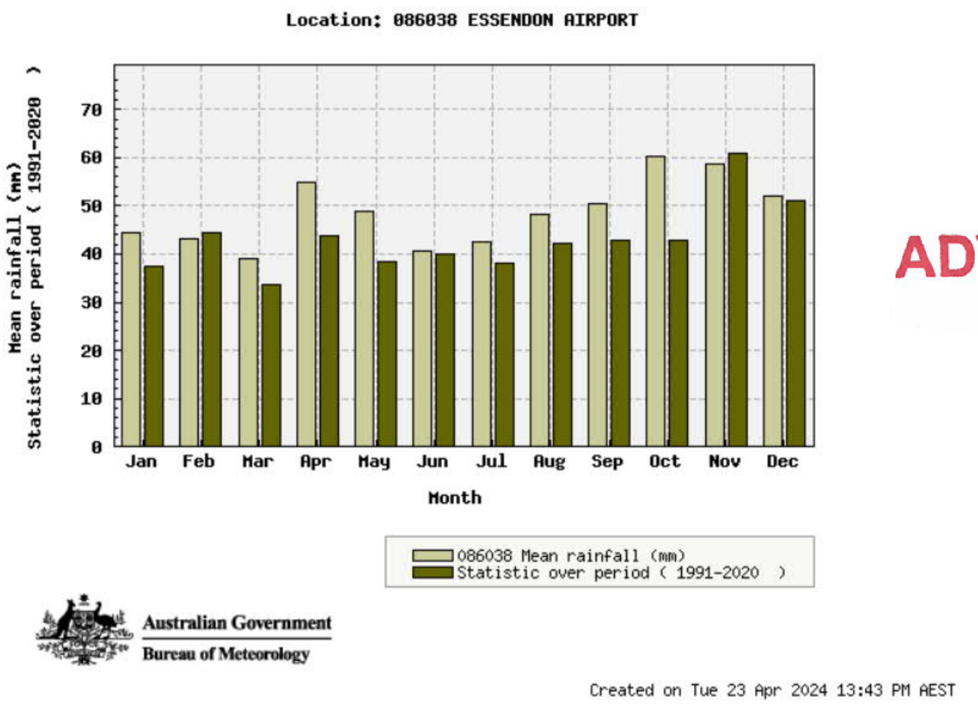

Figure 8: Change in mean rainfall over 30 years (between 1991-2020, dark green) against the historical average (1929-2024, light green) at Essendon Airport[7]

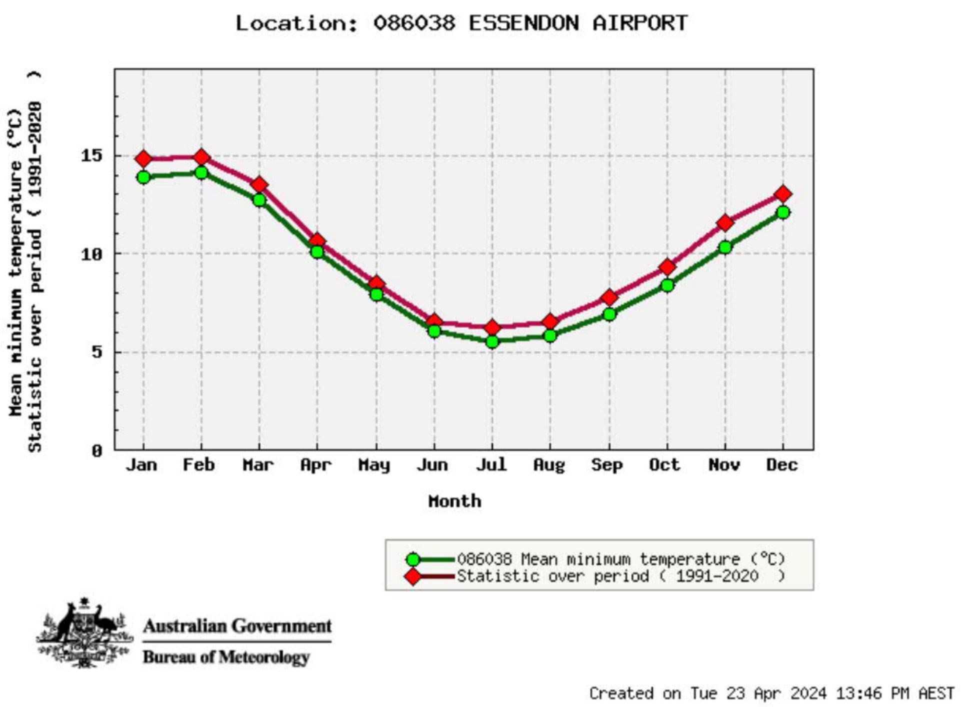

Figure 9: Change in mean minimum temperature over 30 years (between 1991-2020, red line) against the historical average (1939-2024, green line) at Essendon Airport[8]

[7] http://www.bom.gov.au/climate/averages/tables/cw_086282_All.shtml
[8] http://www.bom.gov.au/climate/averages/tables/cw_086282_All.shtml

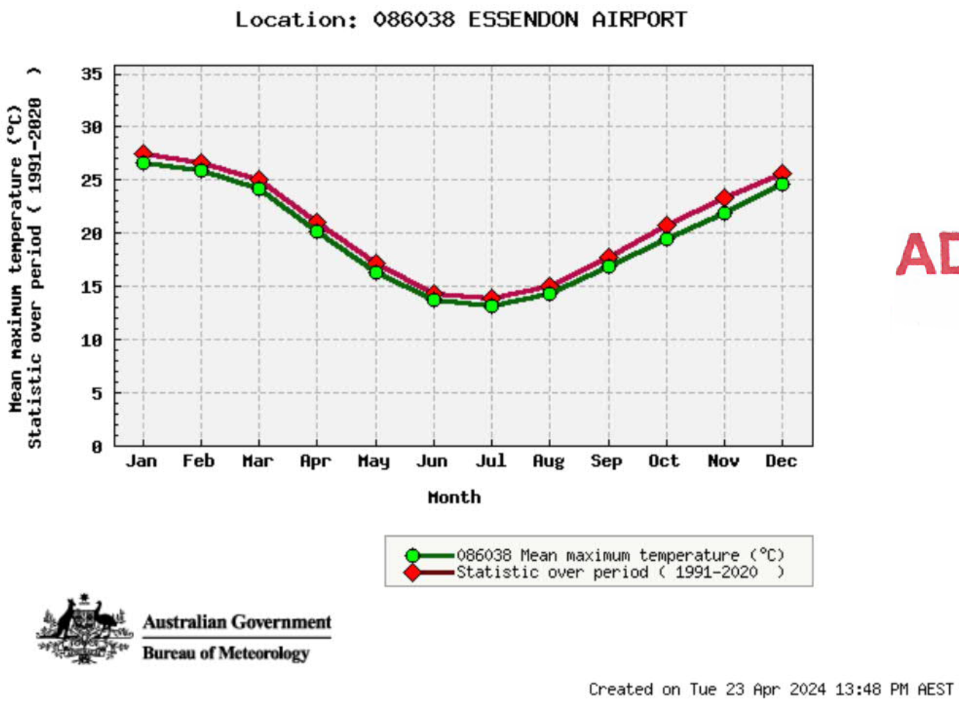

Figure 10: Change in mean maximum temperature over 30 years (between 1991-2020, red line) against the historical average (1939-2024, green line) at Essendon Airport[9]

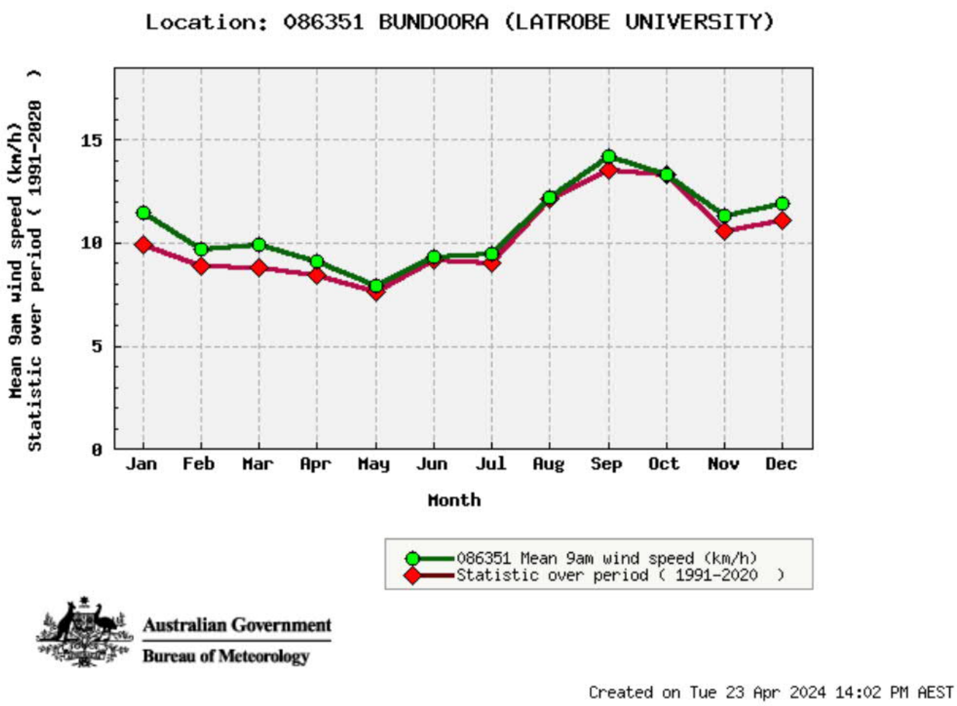

Figure 11: Change in mean 9am wind speed over the last 30 years (1991-2020, red line) against the historical average (1979-2010, green line) at Bundoora (Latrobe University)[10]

[9] http://www.bom.gov.au/climate/averages/tables/cw_086282_All.shtml
[10] http://www.bom.gov.au/climate/averages/tables/cw_086282_All.shtml

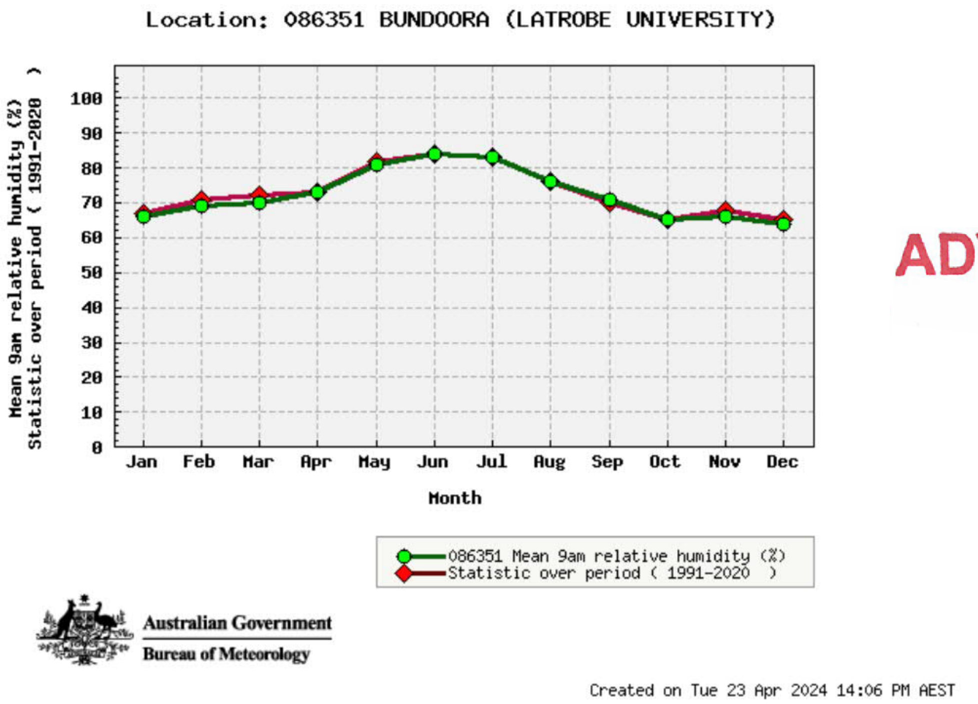

Figure 12: Change in mean 9am relative humidity over the last 30 years (1991-2020, red line) against the historical average (1979-2010, green line) at Bundoora (Latrobe University) [11]

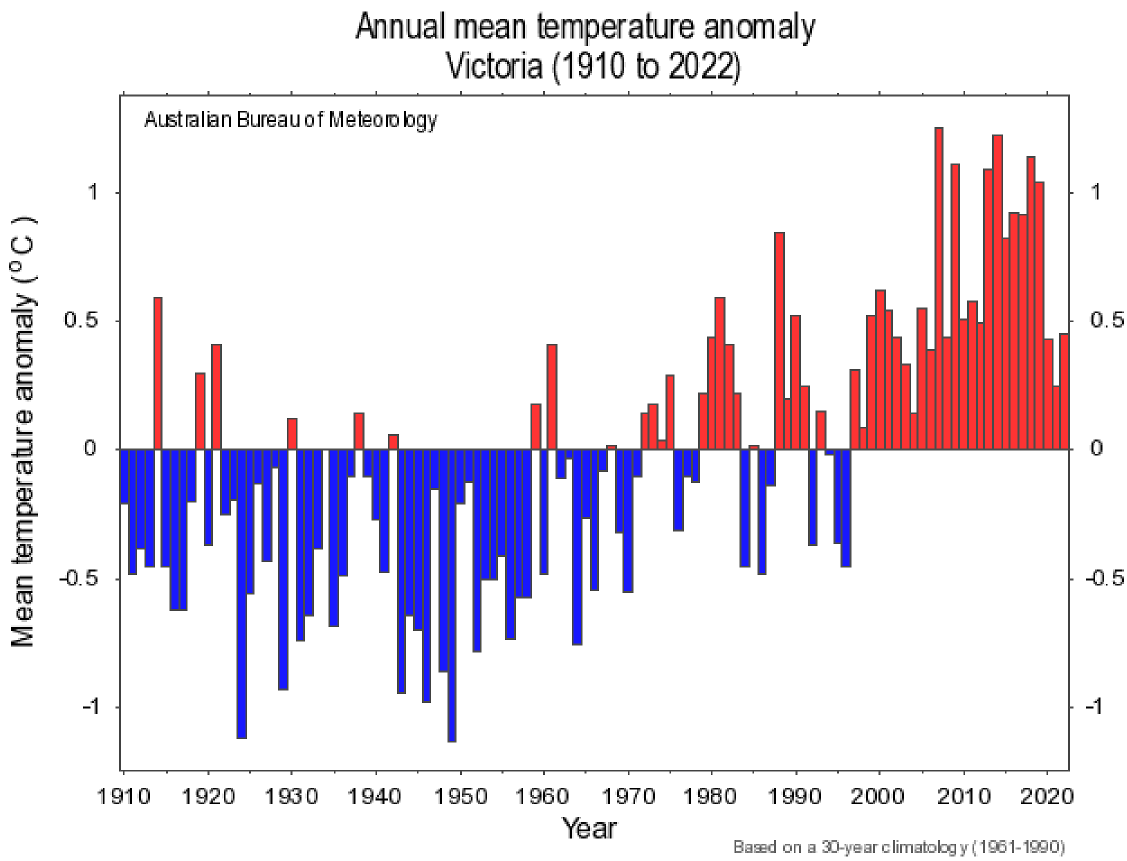

Figure 13: Graph shows the change in mean temperature over the past 113 years, and a clear increase in Victorian mean temperatures in the last 30 years

[11] http://www.bom.gov.au/climate/averages/tables/cw_086282_All.shtml

This data reveals that climate in the Southern Slopes (Victoria West) is temperate oceanic (Köppen *Cfb* climate classification), with cool weather in winter, and warm weather in summer. While there isn't extreme mean temperature and rainfall variation from month to month, the changing climate in Victoria is resulting in increasingly extreme weather conditions. This will only exacerbate over time.

From the rainfall chart (Figure 8), it is evident that there is slightly higher rainfall in spring and slightly lower rainfall in autumn-winter. It is also worth noting that there have been changes in the mean rainfall of Essendon Airport. Based on a comparison of the mean rainfall from 1991-2020, and all available data starting in 1929; mean rainfall has decreased in 10 out of 12 months over the past 30 years compared to the long-term average.

As depicted in Figure 10, mean maximum temperatures recorded at this site have marginally increased for all months of the year when comparing the past 30-year period (1991-2020) to the historical average data. Similarly, the mean minimum temperatures recorded at the Essendon Airport site have marginally increased for all months of the year (Figure 9), an average 0.8C increase across the year.

Further, the Bundoora Latrobe University mean 9am wind speeds have decreased across the year, over the same 30-year period as shown in Figure 11. Mean 9am humidity has dropped in 6/12 months, as depicted in Figure 12.

Higher temperature and low relative humidity all contribute to the phenomenon of 'drying out', threatening agricultural industry and increasing the risk of bushfire[12]. This is indicative of an oceanic climate, and these changes are expected to increase over time as discussed in the sections below.

[12] https://www.smh.com.au/environment/weather/record-evaporation-rates-across-eastern-australia-exacerbate-drought-20180821-p4zys3.html

5.2 Climate Change Projection Scenarios

The climate projection has been modelled at the RCP 4.5 and RCP 8.5 values. This refers to the Representative Concentration Pathways (RCPs) which are the trajectories adopted by the IPCC. It measures the amount of radiative forcing, or 'rate of energy change per unit area at the top of the atmosphere', in terms of how much incoming energy the earth receives from sunlight, minus the energy the earth radiates out to space. Put simply, RCP is an effective measure on how much all greenhouse gases are causing a net heating of the planet. RCP 4.5 refers to the projection of 4.5W/m^2 heat gain in 2100, while RCP 8.5 assumes 8.5W/m^2 by 2100. RCP 4.5 is predictive of a 1.1-2.6°C increase by 2100 and is the target reduction by the Paris Climate Agreement[13]. However, RCP 8.5 would be the result of heating increase at current greenhouse gas emission trends and could see 2.6-4.8°C temperature increases by 2100.

The modelling of these projections has been conducted through an Australian climate model: the Australian Community Climate and Earth System Simulator, or ACCESS. This has been selected as it has consistently been shown by national and international groups to be among the top performing models across a range of climate features important to Australia.

ACCESS was developed jointly by the Bureau of Meteorology (BOM) and CSIRO (Commonwealth Scientific and Industrial Research Organisation) through their research partnership, The Centre for Australian Weather and Climate Research. It was developed in collaboration with Australian universities and the UK Met Office with support from the Department of Environment. ACCESS is specifically designed to be used for both weather prediction and climate simulation.[14]

The Victorian Climate Projections 2019 were also referenced, which compare climate trends against the regional average (relative to 1986-2005). This assessment focussed on the Greater Melbourne Area specifically.

COP27 and the IPCC 6th Assessment Report Review

During COP 27, the Sharm el-Sheikh Climate Change Conference held in November 2022, Heads of State and Government discussed world progress toward the Paris goals, and affirmed that *the world is currently off course to keep 1.5°C within reach*. In order to reach this target, global greenhouse emissions would be required to peak before 2025 at the latest, and be reduced by 43% by 2030. The world is currently on track for a 2.5°C warmer planet by the end of this century, based on current world commitments.[15]

The following dire status was presented by the UN following COP27[16]:

> "The gap between science and actions remains: countries' current plans would lead to an increase of roughly 11% by 2030. According to the IPCC, we would need a 45% reduction to keep the 1.5°C goal within reach."

With global greenhouse gas emissions likely to exceed 1.5°C during the 21st century, it will be more difficult to limit warming below 2°C.[17]

Implementation of policies and processes, to align with global, national and local commitments, is key to limiting further increases in global warming and in turn, the continued survivability of the planet.

A summary of conclusions from the IPCC AR6 Report, along with the associated confidence of each statement, has been provided in the Appendix to provide greater context and purpose for this Climate Adaptation Plan.

[13] UN Climate Change: The Paris Agreement. https://unfccc.int/process-and-meetings/the-paris-agreement
[14] Puri, K., Moise, A., Colman, R., & Hirst, T. (2015). Explainer: the models that help us predict climate change. Accessed at: https://theconversation.com/explainer-the-models-that-help-us-predict-climate-change-39568
[15] https://unfccc.int/maintaining-a-clear-intention-to-keep-15degc-within-reach
[16] United Nations Climate Change. (2022). Maintaining a clear intention to keep 1.5°C within reach. Accessed at: https://unfccc.int/maintaining-a-clear-intention-to-keep-15degc-within-reach
[17] IPCC AR6 Synthesis Report

Table 1: Climate effect of RCP 4.5

Climate Effect	Current (all years)[18]	2050[19]	2070
Annual mean maximum daily temperature (˚C)	19.8˚C	+1.0-2.0 ˚C	+1.6-2.3˚C
Annual mean minimum daily temperature (˚C)	9.5˚C	+0.8-1.5 ˚C	+1.2-1.8˚C
Highest annual temperature (˚C)	47.3˚C	+0.1-0.8˚C	+0.1-2.5˚C
Summer mean maximum temperature (˚C)	24.1˚C	+0.8-1.9˚C	+0.9-2.5˚C
Extreme heat days[20] (over 35˚C) – Melbourne projections	10.2	12.8	14.4
Extreme heat days (over 40˚C) – Melbourne projections	1.7	2.1	2.7
Annual relative humidity (%; current day: average of 9am/3pm)	63.0%	-2.4/+0.2	-2.2/-0.9
Annual mean rainfall (mm, %, %)	582.3	-13.3/+1.2	-12.0/-4.3
Mean summer rainfall (mm, %, %)	46.5	-4.3/+9.9	-9.2/+12.0
Mean autumn rainfall (mm, %, %)	47.6	-13.5/+12.5	-27.9/+2.1
Mean winter rainfall (mm, %, %)	43.7	-11.2/+4.9	-13.2/-2.2
Mean spring rainfall (mm, %, %)	56.5	-27.0/+1.8	-19.7/+1.7
Annual 1-20Y rainfall: wettest day (%)	-	-16.5/+26.7	-16.4/+43.4
Average wind speed (km/h) (current day: average of 9am/3pm)	19.85	-2.5/+0.4	-3.3/-0.3
Annual Bushfire FFDI (Forest Fire Danger Index)[21]	6.7-7.7	6.2-6.7	6.6-7.4
Sea Level Rise (m) relative to the 1986-2005 average[22]	+0.08	+0.23	+0.34

[18] Averages from the Wallan (Kilmore Gap) and Melbourne Airport weather stations were used: http://www.bom.gov.au/climate/averages/tables/cw_088162.shtml and http://www.bom.gov.au/climate/averages/tables/cw_086282.shtml

[19] Climate Change in Australia: https://climatechangeinaustralia.gov.au/en/projects/victorian-climate-projections-2019/vcp19-accessing-datasets/

[20] CSIRO Climate Futures Tool: https://www.climatechangeinaustralia.gov.au/en/projections-tools/threshold-calculator/

[21] Climate Change in Australia, ESCI Climate Data (Summary Data). Accessed at: https://www.climatechangeinaustralia.gov.au/en/projects/esci/esci-climate-data/#SearchResults

[22] Climate Change in Australia, Marine Futures Tool. Accessed at: https://www.climatechangeinaustralia.gov.au/en/projections-tools/coastal-marine-projections/marine-explorer/#

Table 2: Climate effect of RCP 8.5

Climate Effect	Current (all years)[23]	2050	2070
Annual mean maximum daily temperature (˚C)	19.8˚C	+1.5/2.7˚C	+2.4/4.0˚C
Annual mean minimum daily temperature (˚C)	9.5˚C	+1.2/1.9˚C	+1.9/2.7˚C
Highest annual temperature (˚C)	47.3˚C	+0.8/3.1˚C	+2.5/4.2˚C
Summer mean maximum temperature (˚C)	24.1˚C	+1.1-2.6˚C	+1.9-3.8˚C
Extreme heat days[24] (over 35˚C) – Sunbury projections	10.2	14.6	18.2
Extreme heat days (over 40˚C) – Sunbury projections	1.7	2.7	3.9
Annual relative humidity (%; current day: average of 9am/3pm)	63.0%	-3.2/+0.3	-5.5/-0.7
Annual mean rainfall (mm, %, %)	582.3	-19.3/+2.1	-28.4/-3.9
Mean summer rainfall (mm, %, %)	46.5	-13.7/+5.2	-26.8/+11.4
Mean autumn rainfall (mm, %, %)	47.6	-16.1/+4.0	-28.6/-4.0
Mean winter rainfall (mm, %, %)	43.7	-16.3/-1.6	-22.0/+0.3
Mean spring rainfall (mm, %, %)	56.5	-29.5/+14.2	-41.5/+4.6
Annual 1-20Y rainfall: wettest day (%)	-	-18.8/+45.5	-16.0/+36.9
Average wind speed (km/h) (current day: 9am)	19.85	-3.5/-0.5	-3.8/-1.6
Annual Bushfire FFDI (Forest Fire Danger Index)[25]	6.7-7.7	6.9-7.7	6.7-8.1
Sea Level Rise (m) relative to the 1986-2005 average	+0.08	+0.28	+0.44

[23] Averages from the Wallan (Kilmore Gap) and Melbourne Airport weather stations were used: http://www.bom.gov.au/climate/averages/tables/cw_088162.shtml and http://www.bom.gov.au/climate/averages/tables/cw_086282.shtml

[24] CSIRO Climate Futures Tool: https://www.climatechangeinaustralia.gov.au/en/projections-tools/threshold-calculator/

[25] https://www.climatechangeinaustralia.gov.au/en/projects/esci/esci-climate-data/#SearchResults

5.3 Impacts of Climate Change

Weather Extremes:

The El Niño-Southern Oscillation (ENSO) is a quasi-periodic fluctuation of ocean temperatures in the equatorial Pacific due to the rise and fall of trade winds from the Americas across the Pacific towards Australia. This is known as the Walker Circulation[26]. The temperatures generally fluctuate between two states: El Niño and La Niña. El Niño results in warmer than normal central and eastern equatorial Pacific temperatures around the Americas, and La Niña leads to cooler than normal central and eastern equatorial Pacific temperatures.[27] The impact on Australia is that periods of El Niño are associated with higher temperatures in Southern Australia, less rainfall in Eastern Australia, and increased bushfire risk. Seven of the ten hottest years on record in Australia occurred in El Nino events.[28]

As this is the natural cause of which the earth's ecological cycle weather patterns occur, increasing levels of climate temperature will heighten the extremes of these oscillations. As such, the progression in global temperatures and resulting climate change will occur in a non-linear pattern – changes will vary dramatically, but experience a net increase in temperatures, and extreme weather effects.

PRIMARY IMPACTS

Temperature:

There is consensus amongst the literature that the global temperatures are rising – the only variance between the models is to what extent. Based on the RCP 4.5 model, temperatures are expected to rise 1.4-2.6°C by the end of the 21st Century, while the RCP 8.5 model could see temperature rises of 2.6-4.4°C[29]. However, it's important to note that these are averages, so the actual temperature spikes – depending on which part of the globe – could be much higher.

Australia has warmed on average by 1.47 +/- 0.24°C since national records began in 1910, with most warming occurring since 1950 and every decade since then being warmer than the decades before[30]. 2019 was Australia's warmest year on record, with the eight years between 2013 and 2020 all ranking within the ten warmest years. Whilst we have experienced our hottest decade on record 2010-2020, it is projected to be the coolest decade of the coming century[31] Warming is observed throughout Australia across all months, with increases to both day- and night-time temperatures. This change comes with more extreme nationally averaged daily heat events across all months. An example of this is 2019, when 41 extremely warm days were experienced, which is approximately triple the number observed in any year preceding 2000. This increasing trend has been observed in locations throughout Australia. In summer, we now experience a greater frequency of very hot days when compared to previous decades. Focussing on national daily average maximum temperatures, 33 days exceeded 39°C in 2019, which is more than the number observed from the entire period of 1960 to 2018, which totalled 24 days. The frequency of extremely cold days and nights has also declined across Australia.[32]

Victoria's average maximum temperatures are projected to increase 2.8-4.3°C by the 2090s (2080-2099) above those recorded during the period 1986-2005[33], following a high-emissions (RCP 8.5) scenario.

Melbourne's levels of heat waves are expected to increase, with the number of days over 35°C expected to rise from 9 to as many as 26 by 2070 under a 'no global action to reduce emissions' scenario.

[26] Bureau of Meteorology, Climate Driver Update. Accessed at: http://www.bom.gov.au/climate/enso/index.shtml
[27] Models of how the ENSO occurs can be seen from monitoring by NASA ENSO Climate modelling: https://svs.gsfc.nasa.gov/30645
[28] Bureau of Meteorology, El Nino in Australia. Accessed at: http://www.bom.gov.au/climate/enso/images/El-Nino-in-Australia.pdf
[29] IPCC, 2014: Synthesis Report Summary for Policymakers.
[30] CSIRO, Bureau of Meteorology, 2022. State of the Climate 2022. p.4 Accessed at: https://www.csiro.au/en/research/environmental-impacts/climate-change/State-of-the-Climate
[31] CSIRO State of the Climate 2022, p.26
[32] CSIRO State of the Climate 2022, p.4
[33] Department of Environment, Land, Water and Planning, 2019. Victoria's Climate Science Report 2019. Accessed at: https://www.climatechange.vic. gov.au/__data/assets/pdf_file/0029/442964/Victorias-Climate-Science-Report-2019.pdf

This means that the heatwave experienced in 2011, while previously considered a 1 in 100-year event in 1995, is projected to become a 1 in 2-year event by 2070[34]. Temperatures are estimated to increase up to 1.5˚C by 2030 and up to 3˚C by 2050. The magnitude of this change in weather events will affect the environment in the Melbourne region considerably, requiring its population to readjust to living in a completely different climate zone.

Precipitation:

Climate change is impacting the amount of rainfall that occurs across the world, bringing increases in some regions, and decreases in others. Drier conditions have become more prevalent across southwest and southeast Australia, with years of below-average rainfall becoming more frequent, especially during April - October. During 19 of the last 22 years, rainfall in southern Australia during these cooler months has been lower than the average (between 1961-1990). Recent drying across southern Australia is the most sustained large-scale shift in rainfall patterns since the late 1880s. This trend is particularly prevalent from May to July over southwest Western Australia, where a 19% reduction in rainfall since 1970 has been observed compared to the average observed from 1900 to 1969. Rainfall during April-October across southeast Australia, during 2000-2021 has decreased by around 10% compared to that observed during 1900-1999, the period which includes most of the Millennium drought (1997-2009), which brought low annual rainfall across the region. By contrast, northern Australia has experienced increased rainfall across all seasons, in particular during the northern wet season (October - April). Rainfall variability remains high however, with below-average rainfall in northern Australia during the wet seasons of 2018-19 and 2019-20.[35]

Overall, the sub-cluster region of Victoria West, and particularly Melbourne, is expected to have a downward trend in levels of precipitation (-19.3/+2.1 by 2050 and -28.4/-3.9 by 2070 under an RCP 8.5 scenario)[36]; however, there is not complete consensus in the literature as to what extent. Ultimately, decreased levels of rainfall will impact the reliability of water supplies over time. The increasing temperatures and the growing population may lead to a higher demand on water; therefore, larger water storages and greater collection areas will be necessary to withstand longer periods without rain.

Sea level rise:

Sea Level varies both temporally and spatially, due in part to the natural variability of climate systems from the effects of El Niño and La Niña. Globally, sea levels have risen by 25cm since 1880 with half of that rise being recorded since 1970. Satellite altimetry observations taken since 1993 have found that the rate of sea-level rise both to the north and southeast of Australia have been significantly above global averages, whilst rates of sea-level rise along Australia's remaining coastlines have been in line with the global average[37]. The increase in sea levels will result in coastal inundation of surrounding houses and communities.

Tide gauges have recorded average sea level increases along Victoria's coasts of 1.57cm – 5.31cm per decade from 1993-2017, with a 2mm/year increase recorded at Williamstown since 1966 reflecting the impact on Melbourne.[38]. In the Melbourne region, sea levels are predicted to rise 0.8m by 2100 based on a 2010 base measure[39].

The proposed site is not located in a coastal area. Projections for an increasing level of Port Philip Bay show that the site is unlikely to be impacted[40].

What needs to be considered is that the increase of water level will not be linear; extreme weather events or shifts in the climate will see periods of greater increase, while other years will have minimal change. While the short-term risks are limited, it is a risk worthy of ongoing monitoring, to see how and whether it will have flow on effects on the climate affecting the Greater Melbourne Area.

[34] Vic Roads, 2015: Climate Change Risk Assessment.
[35] CSIRO State of the Climate 2022, p.6-7
[36] Climate Change in Australia, Accessing VCP19 Datasets.
[37] CSIRO State of the Climate 2022, p.15-16
[38] Department of Environment, Land, Water and Planning, 2019. Victoria's Climate Science Report 2019.
[39] Vic Roads, 2015: Climate Change Risk Assessment.
[40] Coastal Risk Australia. Accessed at: http://coastalrisk.com.au/viewer

SECONDARY IMPACTS

Floods and Storms Events:

Climate change is likely to affect the magnitude of intense rainfall events in terms of duration, intensity and frequency. This will see increased risks of flooding, and inhibitions for general services to continue to operate.

Increasing intensity of rainfall observed per storm, especially across northern Australia, has resulted in increasing daily rainfall totals linked to thunderstorms since 1979. During the same period fewer low-pressure systems, which bring heavy rainfall, have been observed to the densely populated regions of southern Australia. As a warmer atmosphere is able to hold a greater volume of water vapour than a cooler atmosphere, each degree of global warming can increase atmospheric moisture by 7%. This shift toward heavier rainfall events could have implications for water resource management and recharging water storages.[41]

It is likely there will be increases in other extreme weather events such as winds, hail, and lightning. This will require sufficient consideration in terms of building design, structural integrity, and potential roof materials which could be at risk of large hail damage.

With less annual rainfall, this can cause the soil to have higher surface tension, reducing the amount of water able to be absorbed by the earth, which instead runs off, exacerbating the flooding effect.

In Victoria, extreme, short-duration rainfall events are becoming more intense, and this trend is expected to continue into the future.[42] We expect to see 1 in 50-year events becoming 1 in 20-year events, so we are likely to experience both dry spells and an increase in rainfall intensity.

Relative Humidity:

The relative humidity of the site is predicted to slightly decrease (-5.5 to 0.7% by 2070 based on the RCP 8.5 model). However, the fluctuation of extreme weather events and relative humidity rates will cause higher strains on air conditioning units. Thus, managing the change in humidity and reliability of the grid will be crucial going forward for the Melbourne region.

Drought:

Drought conditions in the regions around Melbourne are expected to arise more often, putting plant growth and survival at risk. According to The Victorian Department of Environment, Land, Water and Planning, average runoff has decreased causing reductions in catchment areas. Due to a decline in rainfall during Victoria's cooler months, extreme, short duration rainfall events will become more intense. [43] This can have an impact on food production, and reliability for the producers and consumers in the region. Moreover, the welfare of animals, including domesticated ones, will be at risk too.

Wind:

Higher fluctuation in weather patterns is causing more extreme events, particularly gale force winds (8+ on the Beaufort scale/over 62km/h). These have the capacity to cause widespread damage to property and infrastructure, especially with damage to tree limbs on overhead powerlines, vehicles, or buildings.

Bushfire:

Since 1910, Australia's climate has warmed, causing an increase in the occurrence of months which are significantly warmer than usual. Very high monthly maximum temperatures were recorded nearly 2% of the time during 1960-1989, and now occur over 11% of the time (period 2007-2021).[44]

[41] CSIRO State of the Climate 2022, p.8
[42] Department of Environment, Land, Water and Planning, 2021. Victoria's water in a changing climate. Accessed at: https://www.water.vic.gov.au/__data/assets/pdf_file/0024/503718/VICWACI_VictoriasWaterInAChangingClimate_FINAL.pdf
[43] Department of Environment, Land, Water and Planning, 2021. Victoria's water in a changing climate.
[44] CSIRO State of the Climate 2022, p.4

There is a significant trend across regions of southern Australia in the number of days exhibiting weather conditions favourable to extreme bushfires capable of generating thunderstorms within their smoke plumes. Such fire-generated thunderstorms deliver extremely dangerous fire conditions, as was observed during the Black Summer of 2019-20, in Canberra during 2003, and the 2009 Victorian Black Saturday bushfires[45].

The changing climate, through reduced rainfall, increased temperature and CO_2 is also altering the rate and extent of plant growth, affecting fuel loads. Increased frequency and intensity of extreme heat episodes as a result of climate change continue to worsen the risk of extreme fire weather.

Bushfire conditions are expected to increase as the climate becomes hotter and drier. A study on Victorian fire weather trends and variability found that the number of days in Victoria with a Forest Fire Danger Index (FFDI) over 25 for ≥10% of the state each year increased from 66 days (1972-2002) to 94 days (2002-2017)[46]. Climate projections suggest that the numbers of 'very high' fire danger days in southeast Australia could increase by as much as 70% by 2050[47]. This will strain emergency services, and impact air quality in the city areas.

Thus, as the climate is changing, it is imperative that all new buildings have the resilience and appropriate measures in place to handle the ongoing risks.

Given that Designated Bushfire Prone Areas surround the site (refer to Appendix B: Bushfire Prone Areas), bushfires and smoke pollution are considered significant risks.

[45] CSIRO State of the Climate 2022, p.5

[46] Harris, S *et al.,* 2019, Victorian fire weather trends and variability https://mssanz.org.au/modsim2019/H7/harris.pdf

[47] Lucas, C., Hennessy, K., Mills, G., & Bathols, J. (2007). Bushfire weather in southeast Australia: recent trends and projected climate change impacts. Accessed at: http://www.cmar.csiro.au/e-print/open/2007/hennesseykj_c.pdf

6. Identification of Potential Risks

This risk assessment has been conducted in relation to relevant data on climate change projections for the next 50 years. This has been set as the expected life of the proposed development.

The risk priority levels have been considered based upon the Risk Matrix from the Guide for Business and Government B4.5. Moreover, the climate change variables were considered in regards to the AS5334-2013 Australian Standards dealing with climate change adaptation.

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

These likelihoods are based on the following ratings:

Rating	Recurrent risks	Single events
Almost certain	Could occur several times per year	More likely than not, probability >50%
Likely	May arise once a year	As likely as not – 50/50 chance
Possible	May arise once in ten years	Less than 50% but still quite high
Unlikely	May arise in every ten – 25 years	Unlikely but not negligible 5-10%
Rare	Unlikely in the next 25 years	Negligible – probability very small, close to zero

The risks identified in the High to Extreme Categories are listed below in Section 7; the full risk matrix can be found in Appendix A.

CUMULATIVE RISKS

A total of 37 potential risks were identified as part of this climate adaptation plan risk assessment (full risk matrix can be found in Appendix A). The risks identified in the High to Extreme Categories are listed in Section 7 of this report. The diagrams below (Figure 14) highlight the risk assessment results showing the breakdown of risk ratings for all combined climate variables (e.g. temperature, precipitation, floods and storms events) for each time period assessed.

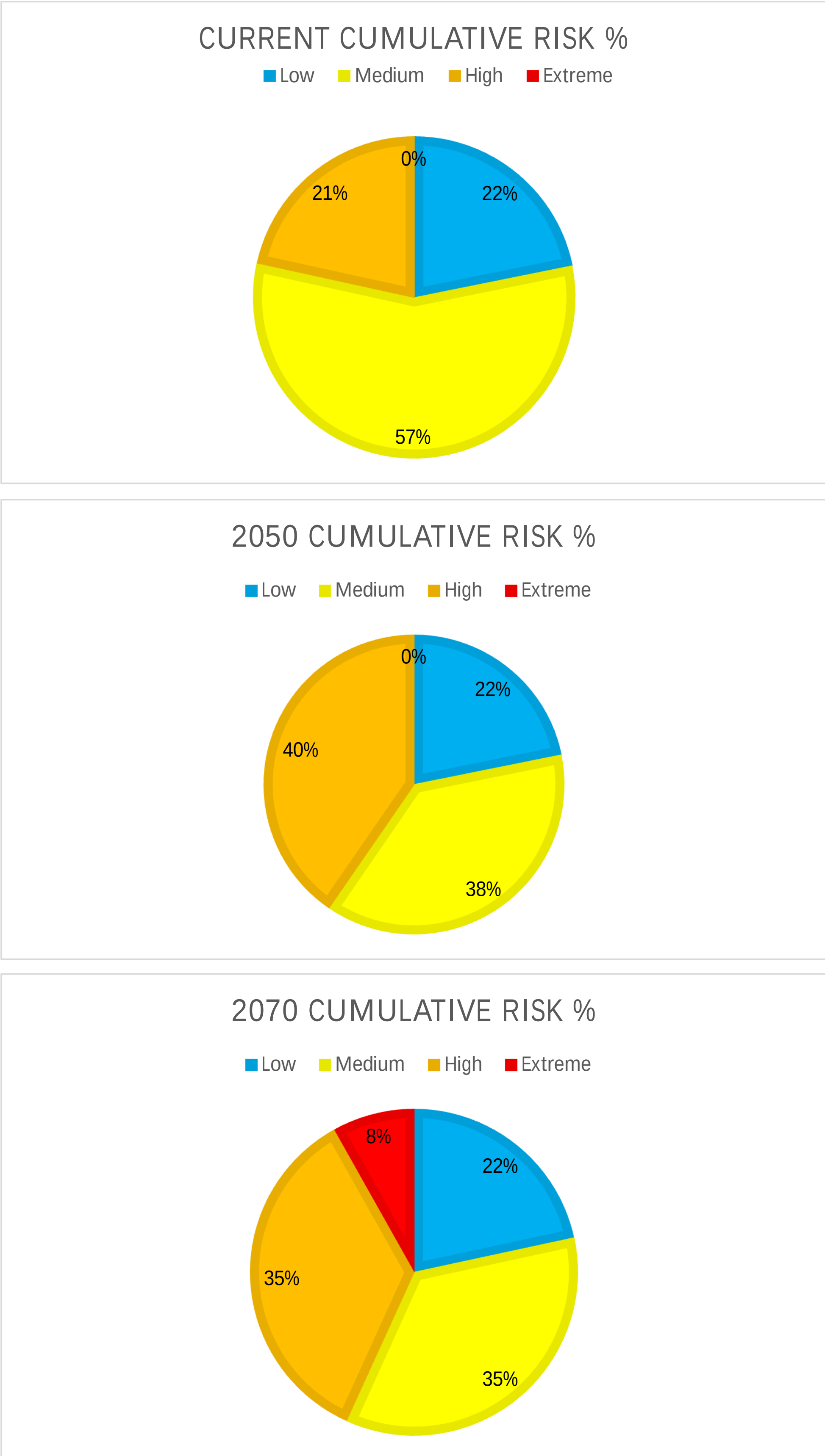

Figure 14: Breakdown of risk ratings for all climate variables

7. Implementation Strategies: Sustainable Design Features, Actions and Responsibilities

The following section outlines those responsible and accountable for implementing the plan. It has been organised in a large table that ***collates all the information around risks deemed 'high' or 'extreme'***, and then provides the specific design measures to counter these risks, and the person(s) responsible for seeing the actions to fruition. The table below will offer the adaptation options available to manage each risk, and explore the reasons for selecting particular adaptation options, including expected benefits to be gained.

Risk	Risk Variable	Climate Risk	Example Adaptation Actions	Actual Responses	Responsibility and Implementation	Evidence
Extreme rainfall events[48]	R3	Increased storm and rainfall intensities could cause property damage if not built to withstand high volumes of water from flooding.	Downpipes will be sized capable of withstanding high volumes of water. Eaves and gutters to be designed to a 5 minute, 20-year ARI of 131mm/hr, and box gutters designed to a 5 minute, 100-year ARI of 185mm/hr. Building floor levels could be raised 300mm (min.) on a 1 in 100yr flood event base level, to provide sufficient freeboard. Ground floor doors could be designed and constructed to be able to withstand flood pressure and water intrusion, to mitigate the risk of stormwater flooding. Ensure that the potential of basement and ground level pluvial flooding from existing stormwater infrastructure being overwhelmed by more extreme storm events is accounted for, by designing systems to allow for drainage.	Eave and gutter design TBC. Commercial tenancy: FFL ≥5.90 Site Boundary levels: RL ≥5.60 (TBC Civil Documentation)	Hydraulic Engineer/ Civil Engineer/ Structural Engineer/ Builder	Civil documentation identifying downpipe and gutter design relevant to storm events. Stormwater Management Strategy and Melbourne Water Flood Advice. Structural documentation showing FFLs.

[48] http://www.bom.gov.au/water/designRainfalls/revised-ifd/?multipoint

Risk	Risk Variable	Climate Risk	Example Adaptation Actions	Actual Responses	Responsibility and Implementation	Evidence
Extreme rainfall events	R4	The increased extreme rainfall event risk impacts on economic productivity due to inability for goods to be transported.	Resilience/Continuity action planning to consider alternate transport routing during extreme events.	Operations Resilience Plan to be prepared for extreme events that includes the need to consider on-going delivery of goods to the commercial areas of the site.	Developer (Owner) / Services Engineer	Operations Resilience Plan
Extreme rainfall events	R6	Increased rainfall events and increased extreme temperatures accelerate deterioration and hence maintenance costs.	External building fabric can be chosen with long lasting properties (such as Brick, Concrete, Colorbond or Zincalume) to maximise lifespan and reduce deterioration.	Concrete roof, and precast concrete / metal clad external walls proposed.	Architect/Builder	Roof plans and elevations.
Drought	R8	The impact of prolonged droughts could cause unreliability to the water supply and require more dependence on the state water supply.	Increasing the capacity of the RWT tank to minimize the impact of prolonged droughts.	60,000L tank installed for a 2,198m2 catchment area.	Hydraulics Engineer	Hydraulic specification.

Risk	Risk Variable	Climate Risk	Example Adaptation Actions	Actual Responses	Responsibility and Implementation	Evidence
Hotter and drier climate	R10	A hotter and drier climate increases the likelihood of bushfires, which would result in increased risk of smoke pollution.	Respond to increased likelihood of smoke pollution by upgrading to MERV 13 or higher filters on fresh air intakes during times of bushfire or heavy smoke pollution. Provide air purifiers with high-capacity carbon filters. The more activated carbon in the filter, the more contact time with the smoke, and the better it will be removed from the air. E.g. the InovaAir[49] E8 model which treats 25m^2, or the E20 model which treats up to 100m^2. The carbon filters are protected with an H13 HEPA filter, so no particles can clog the activated carbon and make it ineffective.	Spatial provisions to be included in the A/C units so that higher performance filters can be swapped over during periods of high smoke/bush fire, OR, HVAC systems to be specified with smoke-rated filters as standard, OR standalone air purifiers to be available during periods of heightened smoke risk.	Mechanical/ Services Engineer	Mechanical specification.

[49] https://inovaairpurifiers.com.au/blogs/air-purifier-blog/best-air-purifiers-for-smoke-removal

Risk	Risk Variable	Climate Risk	Example Adaptation Actions	Actual Responses	Responsibility and Implementation	Evidence
Increased average annual temperature	T1	The mean temperature rise will put a greater strain on HVAC systems, particularly the peak summer cooling demand, potentially causing risk of heat stroke and lost productivity.	Providing shading elements on the north, west and east facades could help in reducing the solar heat gain of the development. Providing shading elements over the exterior units of the HVAC systems can help in reducing the strain on the HVAC systems while still allowing plenty of air circulation. Air conditioners could be designed to handle higher specified conditions than mandated in Victoria (35°C dry bulb/21°C wet bulb), to accommodate rising cooling loads for the development. Heat recovery ventilation systems to be considered, to encourage movement of air and reduce HVAC demand. Increasing the roof and wall insulation beyond what is currently required to meet energy efficiency standards will help improve the thermal comfort the building for residents, and further reduce HVAC system usage, thus reducing greenhouse gas emissions.	Suitable glazing to be selected across the development to reduce temperature impacts. Internal blinds to be provided, improving thermal comfort for building occupants, and also considering glare. All indoor FCU could be selected at 39°C dry bulb temperature, 4°C above minimum requirements. Heat reflective roofing and light-coloured concrete to reduce the impact of increased external temperatures on conditioned areas.	Mechanical/ Services Engineer	Window-glazing elevations, Mechanical specification.

Risk	Risk Variable	Climate Risk	Example Adaptation Actions	Actual Responses	Responsibility and Implementation	Evidence
Increased average annual temperature	T2	The mean temperature rise will put a greater strain on residents and workers, potentially causing the risk of heat stroke and lost productivity from overly strained building occupants. Moreover, any residents or workers entering and leaving the facility will be exposed to the extreme outside air.	Communicating to occupants the nature of heatwave risks, heat stress symptoms, and the importance of staying cool would help mitigate this risk. An electronic board placed in the communal area of the building alerting staff and residents of any incoming extreme weather events or prolonged hot spells, to help keep residents informed and prepared for such events. Providing access to drinking water with water fountains/bottle refill stations can encourage residents, staff and visitors to stay hydrated during heatwaves.	Educate residents and staff on heat stress and dehydration. Establishing a development wide online social network, for occupants to opt into, in which updates on community / building matters could incorporate information about upcoming extreme weather events, directly alerting residents and staff and advising ways to stay safe.	Owner	Copy of education plan or signage
More extreme temperatures	T3	Higher temperatures may lead to heat stress and reduced thermal comfort to staff or occupants of the development. This could lead to increased sickness or absence of staff.	Conditioned areas provide refuge from extreme heat during heatwaves.	The dwellings and commercial spaces will be conditioned, allowing places for refuge for residents and visitors and comfortable working conditions for staff.	Service Engineer/ Facility Manager	Architectural/ Mechanical Plans

Risk	Risk Variable	Climate Risk	Example Adaptation Actions	Actual Responses	Responsibility and Implementation	Evidence
More extreme temperatures	T4	Higher temperatures may lead to loss of efficiencies in solar panels.	Solar panels can be selected at a high quality, capable of operating in extreme conditions (40°+) without significant loss of efficiency. The panels could be raised slightly above the roof to allow air circulation around them for some mild cooling.	PV panels to be selected with operating temperature of -40°C to +85°C and use a nominal cell operating temperature of 45°C +/- 2°C (as is now standard practice).	Service Engineer/ Builder	Solar specification/ plans
More extreme temperatures	T5	Increased solar radiation increases ultra-violet light exposure, leading to higher risk of skin cancer, melanomas and eye diseases among staff and patrons/visitors.	Building to be designed so most activities can be completed undercover, (being inside or under awnings). Pedestrian activities in outdoor / uncovered spaces will be limited. Further shading to be implemented so that staff can spend breaks outside in a shaded environment.	Outdoor covered seating areas provided on ground floor for staff and residents to be protected from the sun while spending breaks outside.	Architect/ Owner	Architectural Plans.

Risk	Risk Variable	Climate Risk	Example Adaptation Actions	Actual Responses	Responsibility and Implementation	Evidence
Urban heat island effect	T7	Rising temperatures will cause the urban heat island effect to increase, compounding the risk of extreme heat in this development.	Utilising heat reflective roof materials or light-coloured reflective roofs, and light-coloured paving for carparks and/or hardstand areas, will reduce the amount of heat absorbed, and the temperature increase around the development. Shading the roof with a significant solar array as designed will help to reduce heat gain in the development.	A portion of the roof will be shaded by a 60kW solar array. The roof will be light-coloured concrete. Areas of vegetation will help to provide cooling to the development.	Landscape Architect/ Architect/ Builder	Architectural, Solar, Landscape Plans.
Carbon pollution abatement	T9	The site will contribute to climate change through further CO_2 emissions from high electricity consumption.	A large solar array could be included in the development to ensure that a significant portion of the energy required is generated on site from the sun. This will reduce the overall CO_2 emissions from the development. LED dimmable lighting with motion & daylight sensors to be considered across the development. Management can encourage residents to adopt a green power energy provider, by making accessible information on green energy providers and highlighting the benefits of choosing one.	A 60kW solar array will be provided. The building will be fully electric, without gas. External and amenities lighting specified with daylight / motion detectors to minimise consumption during off-peak times (e.g. 11pm-5am).	Electrical Engineer/ Developer (Owner)	Solar and Electrical plans

Risk	Risk Variable	Climate Risk	Example Adaptation Actions	Actual Responses	Responsibility and Implementation	Evidence
Gales and extreme weather events	W1	An increase in gales and wind over 60km/h will see risk of damage to assets.	Roofs and all external facades can be designed to handle extreme weather conditions, including by using appropriate fixings to fasten Colorbond sheets. The fastenings for solar panels can be designed to withstand a 1:500-year wind event for ultimate strength and 1:25 year event for serviceability. Ensuring all landscaping near the building (e.g. trees and large plants) are monitored and controlled as part of the building maintenance to avoid the risk of property damage.	Roofs and external facades will be designed to handle extreme weather conditions. Landscape commitment to monitor and control large plants/trees as part of the building maintenance to avoid the risk of property damage.	Architect / Builder / Landscape Consultant	Specification of fastenings/nails beyond standard practice. Document stating relevant landscape commitment.
Storms	W2	An increase in intense rainfall, wind and hail events may result in extensive damage to property. This will invoke clean-up and maintenance costs.	High quality solar panels with tempered glass would be up to six times stronger than pane glass, and able to withstand most hail events. Furthermore, ensuring comprehensive insurance includes the solar panels and the whole site is a good safeguard.	Solar panels to be selected with tempered glass, and to be fixed to the roof slab. All external steel shall be hot dipped galvanised.	Electrical Engineer/ Builder/Owner	Solar specification

Risk	Risk Variable	Climate Risk	Example Adaptation Actions	Actual Responses	Responsibility and Implementation	Evidence
Storms	W4	Storms could damage the power infrastructure around the building, increasing the risk of an electricity blackout, and loss of time and money. For the food and beverage tenancy, this would result in a large amount of food wastage.	Communication protocols should be put in place with residents to advise for safety in the event of a blackout. A 'Blackout' kit provided for residents (waterproof torch, solar radio's, first aid kit, thermometer (to check food in fridge is safe) and information sheet for how to stay safe during a blackout. Advising and encouraging residents to have batteries or alternative backup power generation to run essentials in the event of a prolonged power outage. This could be mitigated with generator backup provided onsite. The switchboard having provision for a generator to be connected. A whole building surge protector (if feasible) installed, or the supplying of individual surge protectors to tenants by the building owner can protect electronics, appliances and HVAC equipment for extreme storm events.	An Automatic Transfer Switch could be provided on the Main Switchboard, for the provision of a generator, to deal with a blackout situation. Consider implementing solar batteries and system design to operate in island mode as part of the Operations Resilience Plan, to ensure sufficient backup power is available for the food tenancy especially, to be fully resilient in the event of power loss.	Builder Services Engineer/ Developer (Owner)	Electrical SLDs Operations Resilience Plan

Risk	Risk Variable	Climate Risk	Example Adaptation Actions	Actual Responses	Responsibility and Implementation	Evidence
Storms, Floods and Bushfires	W5	More storms, floods and bushfires make it more likely that local emergency management arrangements will be inadequate.	Tenants' primary plan should be to evacuate the development to safety in case of any emergency. However, in the worst-case scenario, if the local emergency arrangement is inadequate, then a secure area/space in the development can be prepared as a shelter against floods/bushfires and store emergency equipment (e.g., fire blankets, air filtering respirator, smoke masks, helmets, inflatable raft, life preservers, etc.). Emergency Drills can be conducted so that all occupants are trained to know where the safe zones are and how to properly use the emergency equipment provided. The site evacuation plan and display prominently both inside and outside all communal areas (lobbies and lifts).	Site Evacuation plan to be displayed inside and outside all communal areas.	Builder/Building Owner	Signage.

Risk	Risk Variable	Climate Risk	Example Adaptation Actions	Actual Responses	Responsibility and Implementation	Evidence
Bushfires	CV6	The risk of bushfires could threaten the site.	Landchecker has been consulted, determining that the development site is at low risk due to large proximity from bushfire-prone areas. Refer Appendix B. The development can be prepared in the event of a bushfire with a water storage tank dedicated to fire sprinklers. This guaranteed water supply would be used to fight fires in the event of a mains supply cut-off. Drenchers along the external walls of the building could provide additional protection from embers.	Fire sprinkler tank location is on the rooftop level. Sprinkler tank provided with high flow connections. Occupant Warning System, consisting of a sound system for emergencies and providing evacuation tones, to be provided.	Fire Services Engineer	Fire Services confirmation.

The sustainable design features, adaptation actions and persons responsible for each risk action will ensure that the proposed development and the surrounding area can be resilient in the face of likely climate change factors.

8. Stakeholder Engagement

Suitable design outcomes have been selected through stakeholder engagement between Blue Earth Group, Point Architects and SDC to arrive at a suitable response for each risk identified.

9. Residual Risk

As detailed within Section 7, all initial high and extreme risks have been addressed with appropriate design and/or operational changes to reduce the residual risk. This was facilitated through stakeholder engagement, to arrive at a suitable response for each risk identified. Whilst some risks will be ever present, such as the threat of extreme weather events, this project has been designed to prepare the occupants, in the face of adversity, to be able to act safely and with sound judgement. Residual risks have been detailed within Section 12.

10. Endnotes

This Climate Adaptation Plan has considered the steps necessary to ensure that the development is resilient to the most extreme impacts projected because of climate change. It is important to note that climate adaptation is contingent on the understanding of evolving climate science, climate data, and global emissions. Thus, maintaining an up-to-date stance and knowledge of climate data will ensure that the 77-83 Sutton Street, North Melbourne development is resilient to whatever impacts the changing climate presents.

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12. Appendices

Appendix A: Risk Register and Residual Risks

Sea Level Rise

Climate Stressor	Risk ID	Risk Description	Risk						Residual Risk	
			NOW		2050		2070		2070	
			Likelihood	Consequence	Likelihood	Consequence	Likelihood	Consequence	Likelihood	Consequence
Sea level rise	SL1	Coastal processes including erosion and accretion could impact the structural integrity of the building.	Rare	Major	Rare	Major	Rare	Major	Rare	Major
Storm surge and storm tide	SL2	Storm surge and storm tides could impact the site through flooding from rising sea levels.	Rare	Major	Rare	Major	Rare	Major	Rare	Major
Sea surface temperature	SL3	Increasing sea surface temperatures promote the development of more intense storms, resulting in property damage.	Rare	Major	Rare	Major	Rare	Major	Rare	Major
Currents and waves	SL4	Rising sea levels will increase the magnitude of wave height and period, putting coastal development sites at risk.	Rare	Major	Rare	Major	Rare	Major	Rare	Major
Atmospheric salt	SL5	Salt spray from more saline oceans could exacerbate rust to the site.	Rare	Minor	Rare	Minor	Rare	Minor	Rare	Minor

Rainfall

Climate Stressor	Risk ID	Risk Description	Risk						Residual Risk	
			NOW		2050		2070		2070	
			Likelihood	Consequence	Likelihood	Consequence	Likelihood	Consequence	Likelihood	Consequence
Reduced average rainfall	R1	The reduced rainfall impacts on the availability of rainwater supply for landscaped areas and toilet flushing, resulting in higher demand on mains potable water.	Possible	Minor	Likely	Minor	Likely	Minor	Likely	Minor
Reduced average rainfall	R2	Reduced rainfall and drier conditions could lead to potential health impacts to workers from increased dust (triggering asthma).	Possible	Minor	Likely	Minor	Likely	Minor	Likely	Minor
Extreme rainfall events	R3	Increased storm and rainfall intensities could cause property damage if not built to withstand high volumes of water from flooding.	Possible	Moderate	Likely	Moderate	Likely	Moderate	Likely	Minor
Extreme rainfall events	R4	The increased extreme rainfall event risk impacts on economic productivity due to inability for stock to be transported.	Possible	Moderate	Possible	Moderate	Possible	Moderate	Likely	Moderate
Extreme rainfall events	R5	Increased extreme rainfall events impact on the accessibility of the site, leading to disruption to transport and emergency access during a critical situation.	Possible	Moderate	Possible	Moderate	Possible	Moderate	Possible	Moderate
Extreme rainfall events	R6	Increased rainfall events and increased extreme temperatures accelerate deterioration and hence maintenance costs.	Likely	Moderate	Almost certain	Moderate	Almost certain	Moderate	Likely	Minor

Climate Stressor	Risk ID	Risk Description	Risk						Residual Risk	
			NOW		2050		2070		2070	
			Likelihood	Consequence	Likelihood	Consequence	Likelihood	Consequence	Likelihood	Consequence
Extreme rainfall events	R7	An increase in rainfall has the potential to cause landslips and property damage.	Unlikely	Moderate	Unlikely	Moderate	Unlikely	Moderate	Unlikely	Moderate
Drought	R8	The impact of prolonged droughts could cause unreliability to the water supply and require more dependence on the state water supply.	Possible	Minor	Likely	Major	Almost Certain	Major	Likely	Moderate
Drought	R9	Increased damage to infrastructure, including roads, pathways, and stormwater pipelines due to the drying out of the ground.	Possible	Minor	Possible	Moderate	Possible	Moderate	Possible	Moderate
Hotter and drier climate	R10	A hotter and drier climate increases the likelihood of bushfires, which would result in increased risk of smoke pollution.	Likely	Moderate	Likely	Major	Almost Certain	Major	Likely	Moderate

Temperature

Climate Stressor	Risk ID	Risk Description	Risk NOW Likelihood	Risk NOW Consequence	Risk 2050 Likelihood	Risk 2050 Consequence	Risk 2070 Likelihood	Risk 2070 Consequence	Residual Risk 2070 Likelihood	Residual Risk 2070 Consequence
Increased average annual temperature	T1	The mean temperature rise will put a greater strain on HVAC systems, potentially causing risk of heat stroke and lost productivity.	Likely	Moderate	Almost Certain	Moderate	Almost Certain	Moderate	Likely	Minor
Increased average annual temperature	T2	The mean temperature rise will put a greater strain on stock/delivery workers, potentially causing the risk of heat stroke and lost productivity from overly strained workers. Moreover, any workers entering and leaving the facility will be exposed to the extreme outside air.	Possible	Moderate	Almost Certain	Moderate	Almost Certain	Moderate	Possible	Moderate
More extreme temperatures	T3	Higher temperatures may lead to heat stress and reduced thermal comfort to staff or occupants of the development. This could lead to increased sickness or absence of staff.	Likely	Moderate	Almost Certain	Moderate	Almost Certain	Major	Likely	Moderate
More extreme temperatures	T4	Higher temperatures may lead to loss of efficiencies in solar panels.	Likely	Moderate	Almost Certain	Moderate	Almost Certain	Moderate	Possible	Moderate
More extreme temperatures	T5	Increased solar radiation increases ultra-violet light exposure, leading to higher risk of skin cancer, melanomas and eye diseases among outdoor workers and patrons/visitors.	Likely	Minor	Likely	Minor	Likely	Moderate	Possible	Moderate

Climate Stressor	Risk ID	Risk Description	Risk						Residual Risk	
			NOW		2050		2070		2070	
			Likelihood	Consequence	Likelihood	Consequence	Likelihood	Consequence	Likelihood	Consequence
Warmer, drier	T6	The reduced rainfall impacts on the reliability of the rainwater supply for potable water.	Likely	Minor	Almost Certain	Moderate	Almost Certain	Moderate	Almost certain	Minor
Urban heat island effect	T7	Rising temperatures will cause the urban heat island effect to increase, compounding the risk of extreme heat in this development.	Likely	Moderate	Almost Certain	Moderate	Almost Certain	Moderate	Possible	Moderate
Changes in fauna distribution	T8	Changes in the climate around the proposed development could see different animals nesting or migrating there, causing property damage, or faeces that requires cleaning costs.	Likely	Minor	Likely	Minor	Likely	Minor	Likely	Minor
Carbon pollution abatement	T9	The site will contribute to climate change through further CO_2 emissions from high electricity consumption.	Likely	Moderate	Likely	Moderate	Likely	Moderate	Unlikely	Minor
More extreme temperatures	T10	Higher temperatures may lead to higher summer cooling loads on building resulting in increased water and energy demand and costs.	Possible	Minor	Likely	Moderate	Almost Certain	Moderate	Likely	Minor

Wind

Climate Stressor	Risk ID	Risk Description	Risk						Residual Risk	
			NOW		2050		2070		2070	
			Likelihood	Consequence	Likelihood	Consequence	Likelihood	Consequence	Likelihood	Consequence
Gales and extreme wind events	W1	An increase in gales and wind over 60km/h will see risk of damage to assets.	Possible	Moderate	Likely	Moderate	Likely	Moderate	Likely	Minor
Storms	W2	An increase in intense rainfall, wind and hail events may result in extensive damage to property. This will invoke clean-up and maintenance costs.	Possible	Moderate	Likely	Moderate	Likely	Moderate	Likely	Moderate
Cyclones	W3	The threat of a tropical cyclone could wreak havoc on the buildings, causing extensive damage.	Rare	Major	Rare	Major	Rare	Major	Rare	Major
Storms	W4	Storms could damage the power infrastructure around the building(s), increasing the risk of an electricity blackout, and loss of time and money.	Possible	Major	Possible	Major	Possible	Major	Possible	Moderate
Storms, Floods and Bushfires	W5	More storms, floods and bushfires make it more likely that local emergency management arrangements will be inadequate.	Possible	Moderate	Possible	Moderate	Possible	Moderate	Possible	Moderate
Prevailing wind direction	W6	Historically, global warming has resulted in westerlies shifting poleward. This is expected to result in changes to wind and precipitation patterns.	Possible	Minor	Possible	Minor	Possible	Minor	Possible	Minor

Other Climate Change Variables

Climate Stressor	Risk ID	Risk Description	Risk						Residual Risk	
			NOW		2050		2070		2070	
			Likelihood	Consequence	Likelihood	Consequence	Likelihood	Consequence	Likelihood	Consequence
Relative humidity	CV1	Changing humidity impacts the structural integrity of the site.	Rare	Minor	Rare	Minor	Rare	Minor	Rare	Minor
Air quality pollution	CV2	Poorer air quality from increasing pollution may have negative health impacts on workers and patrons/visitors, reducing productivity and having long term health implications.	Possible	Moderate	Possible	Moderate	Possible	Moderate	Possible	Moderate
Soil changes	CV3	Changes in soil moisture, salinity, pH, or groundwater level impact the structural integrity of the site. Rapid loss of soil moisture in extreme heat events will put pressure on environmental assets.	Possible	Moderate	Possible	Moderate	Possible	Moderate	Possible	Moderate
Soil	CV4	Warmer drier climate changes the soil moisture causing loss of structural integrity for foundations – leads to increased deterioration of the proposed development over time.	Possible	Moderate	Possible	Moderate	Possible	Moderate	Possible	Moderate
Cyclones	CV5	The threat of cyclones as the climate of Melbourne changes could pose risks to the assets on site.	Rare	Major	Rare	Major	Rare	Major	Rare	Major
Bushfires	CV6	Bushfires could threaten the site.	Possible	Minor	Possible	Minor	Possible	Minor	Possible	Minor

Appendix B: Bushfire Prone Areas

Landchecker, containing information managed by the Department of Transport and Planning, was consulted in order to identify bushfire prone areas within and surrounding the subject site.

The development site is shown to be surrounded by Designated Bushfire Prone Areas. The map below (Figure 15) shows the extent of the Designated Bushfire Prone Areas (purple), with the development site marked by the red balloon.

The site is at low risk of bushfires due to its location within inner Melbourne. However, it is at considerable risk of smoke pollution due to being surrounded by large swathes of bushfire-prone land.

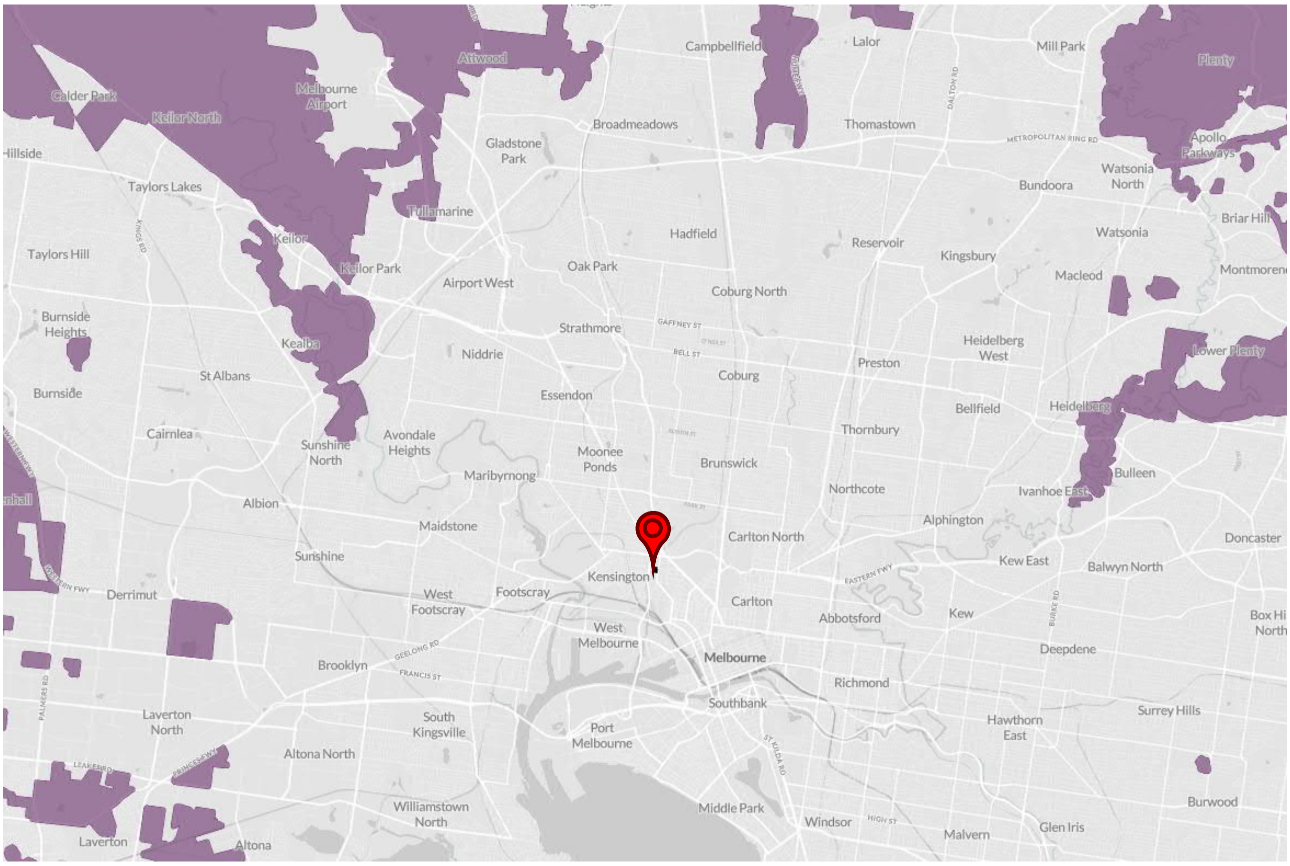

Figure 15: Bushfire risk at 77-83 Sutton Street, North Melbourne (Source: Landchecker)

Appendix C: Areas of Flood Risk

Landchecker and the *Land Subject to Inundation, Urban Floodway* and *Rural Floodway* overlays of the Melbourne Planning Scheme were consulted to identify areas subject to flooding (shaded aqua) within context of the subject site. Figure 16 below shows that the site is at low risk to inundation.

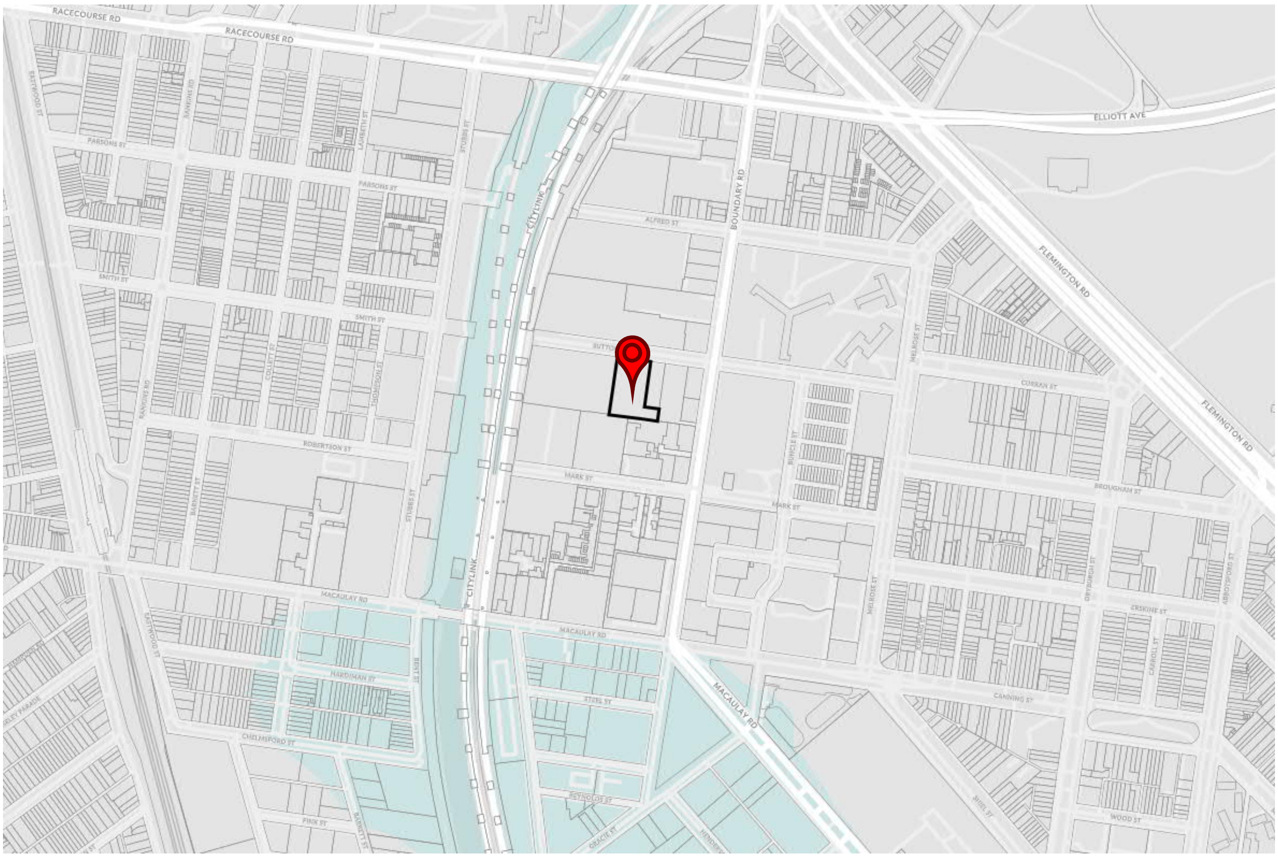

Figure 16: Flood risk at 77-83 Sutton Street, North Melbourne (Source: Landchecker)

Appendix D: Ecologically Important Areas

Landchecker was consulted in order to identify important vegetated areas within and surrounding the subject site.

The *Vegetation Protection Overlay* and the *Environmental Significance Overlay* are shown on the map below, indicating that there are no important vegetated sites directly neighbouring the development.

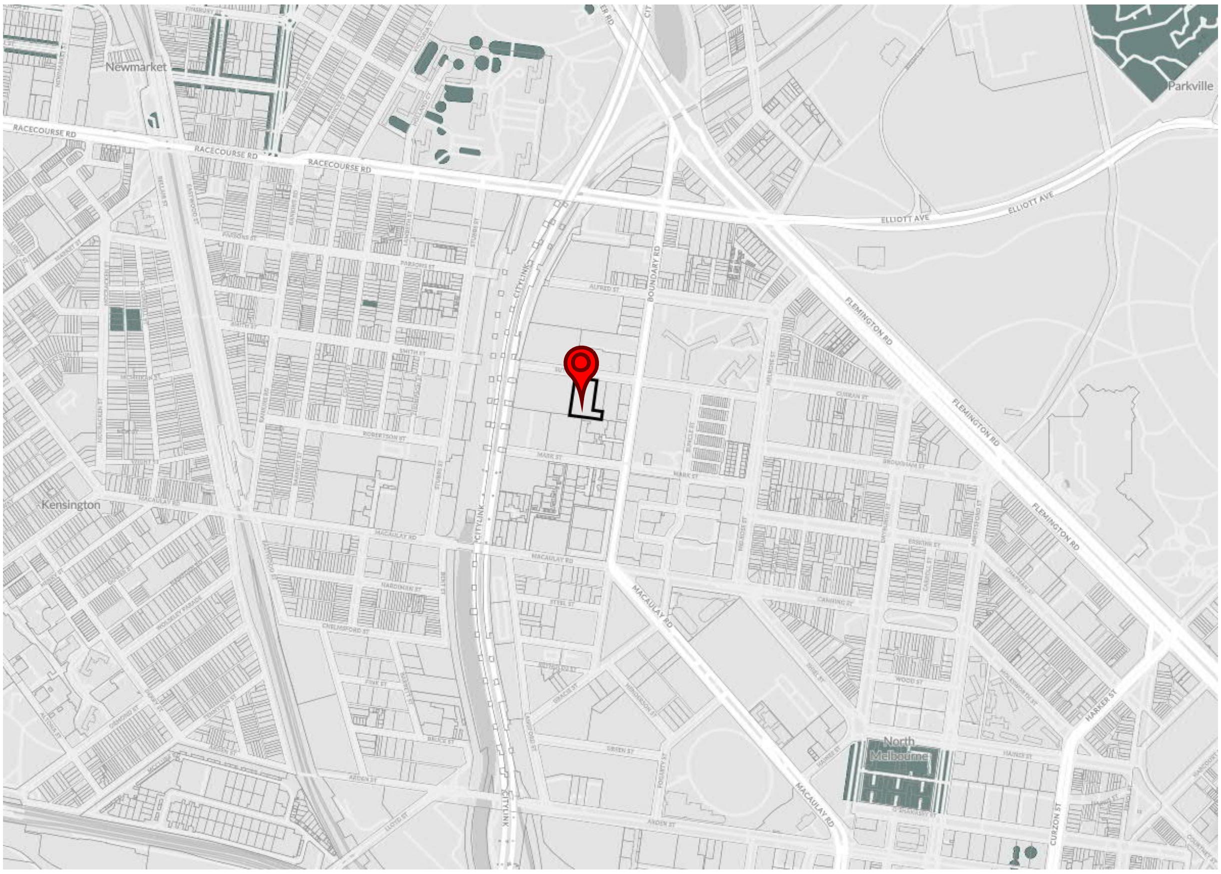

Figure 17: Significant environmental areas (shaded green) surrounding 77-83 Sutton Street, North Melbourne (Source: Landchecker)

Appendix E: IPCC 6th Assessment Report Summary

B1	Observed and Projected Impacts and Risks	Confidence
B1.1	Widespread, pervasive impacts to ecosystems, people, settlements, and infrastructure have resulted from observed increases in the frequency and intensity of climate and weather extremes, including hot extremes on land and in the ocean, heavy precipitation events, drought, and fire weather.	High
	Increased heat-related human mortality.	Medium
	Warm-water coral bleaching.	High
	Increased drought-related tree mortality.	High
	Observed increases in areas burned by wildfires attributed to human-induced climate change.	Medium-High
	Adverse impacts from tropical cyclones, with related losses and damages, have increased due to sea level rise and the increase in heavy precipitation.	Medium
	Impacts in natural and human systems from slow-onset processes, such as ocean acidification, sea level rise or regional decreases in precipitation have been attributable to human induced climate change.	High
B1.2	Substantial damages, and increasingly irreversible losses, in terrestrial, freshwater and coastal and open ocean marine ecosystems.	High
	The extent and magnitude of climate change impacts are larger than estimated in previous assessments.	High
	Widespread deterioration of ecosystem structure and function, resilience, and natural adaptive capacity, as well as shifts in seasonal timing have occurred due to climate change, with adverse socioeconomic consequences.	High
	Approximately half of the species assessed globally have shifted poleward or, on land, also to higher elevations.	Very High
	Hundreds of local losses of species have been driven by increases in the magnitude of heat extremes.	High
	Species loss driven by mass mortality events on land and in the ocean, and loss of kelp forests.	Very High (High)
	Irreversible losses such as the first species extinctions driven by climate change.	Medium
	Impacts approaching irreversibility such as the impacts of hydrological changes resulting from the retreat of glaciers, or the changes in some mountain and artic ecosystems driven by permafrost thaw.	Medium (High)
B1.3	Increased frequency and intensity of extremes have reduced food and water security, hindering efforts to meet Sustainable Development Goals.	High
	Slowed agricultural growth over the past 50 years, despite increases in productivity.	High
	Ocean warming and ocean acidification have adversely affected food production from shellfish aquaculture and fisheries in some oceanic regions.	High
	Increasing weather and climate extreme events have exposed millions of people to acute food insecurity and reduced water security, with the largest impacts observed in many locations and/or communities in Africa, Asia, Central and South America, small islands and the Arctic.	High

	Sudden losses of food production and access to food compounded by decreased diet diversity have increased malnutrition in many communities, especially for Indigenous Peoples, small-scale food producers and low-income households, with children, elderly people and pregnant women particularly impacted.	High
	Roughly half of the world's population currently experience severe water scarcity for at least some part of the year due to climatic and non-climatic drivers.	Medium
B1.4	Climate change has adversely affected physical and mental health of people globally.	Very High Very High
	More frequent economic and social disruptions resulting in human health impacts.	Very High
	Extreme heat events have resulted in human mortality and morbidity.	Very High
	The occurrence of climate-related food-borne and water-borne diseases has increased.	Very High
	The incidence of vector-borne diseases has increased from range expansion and/or increased reproduction of disease vectors.	High
	Animal/Human diseases (including zoonoses) emergence in new areas.	High
	Water/food-borne diseases increased regionally from climate-sensitive aquatic pathogens, and from toxic substances from harmful freshwater cyanobacteria.	High
	Water/food borne diseases increased regionally from toxic substances from harmful freshwater cyanobacteria.	Medium
	Increased occurrence of diarrheal diseases, including cholera and other gastrointestinal diseases, due to high temperatures, increased rain and flooding.	Very High
	Mental Health challenges associated with increased temperatures.	High
	Trauma from weather and climate extreme events.	Very High
	Loss of Livelihoods and Culture.	High
	Increased Exposure to wildlfire smoke, atmospheric dust, and aeroallergens have been associated with climate-sensitive cardiovascular and respiratory distress.	High
	Disruption of Health Services by extreme events such as floods.	High
B1.5	In urban settings, observed climate change has caused impacts on human health, livelihoods, and key infrastructure.	High
	Multiple climate and non-climate hazards impact cities, settlements and infrastructure and sometimes coincide, magnifying damage.	High
	Hot extremes including heatwaves have intensified in cities.	High
	Aggravation of air pollution events due to intensification of hot extremes and heatwaves in cities.	Medium
	Limited function of key infrastructure due to hot extremes and heatwaves in cities.	High
	Observed impacts of hot extremes concentrated amongst the economically and socially marginalized urban residents.	High
	Infrastructure, including transportation, water, sanitation, and energy systems have been compromised by extreme and slow-onset events, with resulting economic losses, disruptions of services and impacts to well-being.	High

B1.6	Adverse economic impacts attributable to climate change, including slow-onset and extreme weather events, have been increasingly identified.	Medium
	Some positive economic effects have been identified in regions that have benefited from lower energy demand as well as comparative advantages in agricultural markets and tourism.	High
	Economic damages from climate change have been detected in climate-exposed sectors, with regional effects to agriculture, forestry, fishery, energy, and tourism.	High
	Some extreme weather events, such as tropical cyclones, have reduced economic growth in the short-term.	High
	Non-climatic factors including some patterns of settlement, and siting of infrastructure have contributed to the exposure of more assets to extreme climate hazards increasing the magnitude of the losses.	High
	Individual livelihoods have been affected through changes in agricultural productivity, impacts on human health and food security, destruction of homes and infrastructure, and loss of property and income, with adverse effects on gender and social equity.	High
B1.7	Climate change is contributing to humanitarian crises where climate hazards interact with high vulnerability.	High
	Climate and weather extremes are increasingly driving displacement in all regions, with small island states disproportionately affected.	High
	Flood and drought-related acute food insecurity and malnutrition have increased in Africa and Central and South America.	High
	Through displacement and involuntary migration from extreme weather and climate events, climate change has generated and perpetuated vulnerability.	Medium

B2	Vulnerability and Exposure of Ecosystems and People	
B2.1	Increasing evidence that degradation and destruction of ecosystems by humans increases the vulnerability of people.	High
	Unsustainable land-use and land cover change, unsustainable use of natural resources, deforestation, loss of biodiversity, pollution, and their interactions, adversely affect the capacities of ecosystems, societies, communities, and individuals to adapt to climate change.	High
	Loss of ecosystems and their services has cascading and long-term impacts on people globally, especially for Indigenous Peoples and local communities who are directly dependent on ecosystems, to meet basic needs.	High
B2.2	Non-climatic human-induced factors exacerbate current ecosystem vulnerability to climate change.	Very High
	Globally, and even within protected areas, unsustainable use of natural resources, habitat fragmentation, and ecosystem damage by pollutants increase ecosystem vulnerability to climate change.	High
	Globally, less than 15% of the land, 21% of the freshwater and 8% of the ocean are protected areas. In most protected areas, there is insufficient stewardship to contribute to reducing damage from, or increasing resilience to, climate change.	High

B2.3	Future vulnerability of ecosystems to climate change will be strongly influenced by the past, present and future development of human society, including persistent unsustainable use and management of land, ocean, and water.	High
	Loss and degradation of the majority of the world's forests.	High
	Loss and degradation of coral reefs, and low-lying coastal wetlands.	Very High
	Unsustainable agricultural expansion, driven in part by unbalanced diets, increases ecosystem and human vulnerability and leads to competition for land and/or water resources.	High
B2.4	Regions and people with considerable development constraints have high vulnerability to climatic hazards.	High
	Vulnerability is higher in locations with poverty, governance challenges and limited access to basic services and resources, violent conflict, and high levels of climate-sensitive livelihoods.	High
	Between 2010–2020, human mortality from floods, droughts and storms was 15 times higher in highly vulnerable regions, compared to regions with very low vulnerability.	High
	Vulnerability at different spatial levels is exacerbated by inequity and marginalization linked to gender, ethnicity, low income or combinations thereof, especially for many Indigenous Peoples and local communities.	High
B2.5	Future human vulnerability will continue to concentrate where the capacities of local, municipal and national governments, communities and the private sector are least able to provide infrastructure and basic services.	High
	Under the global trend of urbanization, human vulnerability will also concentrate in informal settlements and rapidly growing smaller settlements.	High
	In rural areas vulnerability will be heightened by compounding processes including high emigration, reduced habitability and high reliance on climate-sensitive livelihoods.	High
	Key infrastructure systems including sanitation, water, health, transport, communications and energy will be increasingly vulnerable if design standards do not account for changing climate conditions.	High
	Future exposure to climatic hazards is also increasing globally due to socioeconomic development trends including migration, growing inequality and urbanization.	High

B3	Risks in the near term (2021-2040)	
B3.0	Global warming, reaching 1.5°C in the near-term, would cause unavoidable increases in multiple climate hazards and present multiple risks to ecosystems and humans	Very High
	The level of risk will depend on concurrent near-term trends in vulnerability, exposure, level of socioeconomic development and adaptation	High
	Near-term actions that limit global warming to close to 1.5°C would substantially reduce projected losses and damages related to climate change in human systems and ecosystems, compared to higher warming levels, but cannot eliminate them all.	Very High

B3.1	Near-term warming and increased frequency, severity and duration of extreme events will place many terrestrial, freshwater, coastal and marine ecosystems at high or very high risk of biodiversity loss.	Medium-Very High
	Continued and accelerating sea level rise will encroach on coastal settlements and infrastructure.	Very High
	If trends in urbanization in exposed areas continue, this will exacerbate the impacts, with more challenges where energy, water and other services are constrained.	Medium
	The number of people at risk from climate change and associated loss of biodiversity will progressively increase.	Medium
B3.2	Climate-associated risks to natural and human systems depend more strongly on changes in their vulnerability and exposure than on differences in climate hazards between emissions scenarios.	High
	Risks are highest where species and people exist close to their upper thermal limits, along coastlines, in close association with ice or seasonal rivers.	High
	Many of these risks are unavoidable in the near-term, irrespective of emissions scenario.	High
B3.3	Levels of risk for all Reasons for Concern (RFC) are assessed to become high to very high at lower global warming levels than in AR5.	High
	Near-term actions that limit global warming to close to 1.5°C would substantially reduce projected losses and damages related to climate change in human systems and ecosystems, compared to higher warming levels, but cannot eliminate them all.	Very High

B4	Mid to Long-term Risks (2041-2100)	
B4.0	For 127 identified key risks, assessed mid- and long-term impacts are up to multiple times higher than currently observed.	High
	The magnitude and rate of climate change and associated risks depend strongly on near-term mitigation and adaptation actions, and projected adverse impacts and related losses and damages escalate with every increment of global warming.	Very High
B4.1	Biodiversity loss and degradation, damages to and transformation of ecosystems are already key risks for every region due to past global warming and will continue to escalate with every increment of global warming.	Very High
	In terrestrial ecosystems, up to 14% of species assessed will likely face very high risk of extinction at global warming levels of 1.5°C, increasing up to 18% at 2°C, to 29% at 3°C, to 39% at 4°C, and to 48% at 5°C.	High
	Very high extinction risk for endemic species in biodiversity hotspots is projected to at least double from 2% between 1.5°C and 2°C global warming levels and to increase at least tenfold if warming rises from 1.5°C to 3°C.	Medium
B4.2	Risks in physical water availability and water-related hazards will continue to increase by the mid- to long-term in all assessed regions, with greater risk at higher global warming levels.	High

B4.3	Climate change will increasingly put pressure on food production and access, especially in vulnerable regions, undermining food security and nutrition.	High
	Climate change will increasingly put pressure on food production and access, especially in vulnerable regions, undermining food security and nutrition.	High
	Global warming will progressively weaken soil health and ecosystem services such as pollination, increase pressure from pests and diseases, and reduce marine animal biomass, undermining food productivity in many regions on land and in the ocean.	Medium
B4.4	Climate change and related extreme events will significantly increase ill health and premature deaths from the near- to long-term.	High
	Globally, population exposure to heatwaves will continue to increase with additional warming, with strong geographical differences in heat-related mortality without additional adaptation.	Very High
	Mental health challenges, including anxiety and stress, are expected to increase under further global warming in all assessed regions, particularly for children, adolescents, elderly, and those with underlying health conditions.	Very High
B4.5	Globally, population change in low-lying cities and settlements will lead to approximately a billion people projected to be at risk from coastal-specific climate hazards in the mid-term under all scenarios.	High
	The population potentially exposed to a 100-year coastal flood is projected to increase by about 20% if global mean sea level rises by 0.15 m relative to 2020 levels.	Medium
	By 2100 the value of global assets within the future 1-in-100-year coastal floodplains is projected to be between US$7.9 and US$12.7 trillion (2011 value) under RCP4.5, rising to between US$8.8 and US$14.2 trillion under RCP8.5.	Medium
	Costs for maintenance and reconstruction of urban infrastructure, including building, transportation, and energy will increase with global warming level.	Medium
B4.6	Projected estimates of global aggregate net economic damages generally increase non-linearly with global warming levels.	High
	Significant regional variation in aggregate economic damages from climate change is projected with estimated economic damages per capita for developing countries often higher as a fraction of income	High
B4.7	In the mid- to long-term, displacement will increase with intensification of heavy precipitation and associated flooding, tropical cyclones, drought and, increasingly, sea level rise.	High
	At progressive levels of warming, involuntary migration from regions with high exposure and low adaptive capacity would occur.	Medium
	At higher global warming levels, impacts of weather and climate extremes, particularly drought, by increasing vulnerability will increasingly affect violent intrastate conflict.	Medium

B5	Complex, Compound and Cascading Risks	
B5.0	Climate change impacts and risks are becoming increasingly complex and more difficult to manage. Multiple climate hazards will occur simultaneously, and multiple climatic and non-climatic risks will interact, resulting in compounding overall risk and risks cascading across sectors and regions. Some responses to climate change result in new impacts and risks.	High
B5.1	Concurrent and repeated climate hazards occur in all regions, increasing impacts and risks to health, ecosystems, infrastructure, livelihoods, and food.	High
	Above 1.5°C global warming increasing concurrent climate extremes will increase risk of simultaneous crop losses of maize in major food-producing regions, with this risk increasing further with higher global warming levels.	Medium
	Future sea level rise combined with storm surge and heavy rainfall will increase compound flood risks.	High
	Risks to health and food production will be made more severe from the interaction of sudden food production losses from heat and drought, exacerbated by heat-induced labour productivity losses.	High
	These interacting impacts will increase food prices, reduce household incomes, and lead to health risks of malnutrition and climate-related mortality with no or low levels of adaptation, especially in tropical regions.	High
	Risks to food safety from climate change will further compound the risks to health by increasing food contamination of crops from mycotoxins and contamination of seafood from harmful algal blooms, mycotoxins, and chemical contaminants.	High
B5.2	Adverse impacts from climate hazards and resulting risks are cascading across sectors and regions, propagating impacts along coasts and urban centres (medium confidence) and in mountain regions (high confidence).	High
	These hazards and cascading risks also trigger tipping points in sensitive ecosystems and in significantly and rapidly changing social-ecological systems impacted by ice melt, permafrost thaw and changing hydrology in polar regions.	High
	Wildfires, in many regions, have affected ecosystems and species, people and their built assets, economic activity, and health.	High
	Unavoidable sea level rise will bring cascading and compounding impacts resulting in losses of coastal ecosystems and ecosystem services, groundwater salinization, flooding and damages to coastal infrastructure that cascade into risks to livelihoods, settlements, health, well-being, food and water security, and cultural values in the near to long-term.	High
B5.3	Weather and climate extremes are causing economic and societal impacts across national boundaries through supply-chains, markets, and natural resource flows, with increasing transboundary risks projected across the water, energy and food sectors.	High
	Climate change causes the redistribution of marine fish stocks, increasing risk of transboundary management conflicts among fisheries users, and negatively affecting equitable distribution of food provisioning services as fish stocks shift from lower to higher latitude regions, thereby increasing the need for climate-informed transboundary management and cooperation.	High
	Precipitation and water availability changes increases the risk of planned infrastructure projects, such as hydropower in some regions, having reduced productivity for food and energy sectors including across countries that share river basins.	Medium

B5.4	Risks arise from some responses that are intended to reduce the risks of climate change, including risks from maladaptation and adverse side effects of some emissions reduction and carbon dioxide removal measures.	High
	Deployment of afforestation of naturally unforested land, or poorly implemented bioenergy, with or without carbon capture and storage, can compound climate-related risks to biodiversity, water and food security, and livelihoods, especially if implemented at large scales, especially in regions with insecure land tenure.	High
B5.5	Solar radiation modification approaches, if they were to be implemented, introduce a widespread range of new risks to people and ecosystems, which are not well understood.	High
	Large uncertainties and knowledge gaps are associated with the potential of solar radiation modification approaches to reduce climate change risks. Solar radiation modification would not stop atmospheric CO_2 concentrations from increasing or reduce resulting ocean acidification under continued anthropogenic emissions.	High

B6	Impacts of Temporary Overshoot	
B6.0	If global warming transiently exceeds 1.5°C in the coming decades or later (overshoot), then many human and natural systems will face additional severe risks, compared to remaining below 1.5°C.	High
	Depending on the magnitude and duration of overshoot, some impacts will cause release of additional greenhouse gases.	Medium
B6.1	Additional warming, e.g., above 1.5°C during an overshoot period this century, will result in irreversible impacts on certain ecosystems with low resilience, such as polar, mountain, and coastal ecosystems, impacted by icesheet, glacier melt, or by accelerating and higher committed sea level rise.	High
	Risks to human systems will increase, including those to infrastructure, low-lying coastal settlements, some ecosystem-based adaptation measures, and associated livelihoods.	High
B6.2	Risk of severe impacts increase with every additional increment of global warming during overshoot.	High
	In high-carbon ecosystems such impacts are already observed and are projected to increase with every additional increment of global warming, such as increased wildfires, mass mortality of trees, drying of peatlands, and thawing of permafrost, weakening natural land carbon sinks and increasing releases of greenhouse gases.	Medium