Climate Hazard Scenarios for Banyule Council

A report by Climate Comms for Banyule Council, Victoria



Banyule
City Council

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Disclaimer

Information in this report is based on scientific research and stakeholder engagement. Historical weather data are sourced from the Australian Bureau of Meteorology. Impacts associated with historical weather events are based on published material. CSIRO climate projections for Victoria over the coming decades are based on climate models that have limitations. These projections are used in local storyline narratives for future weather events to guide discussions about plausible risks. No reliance or actions must therefore be made on this information without seeking prior expert advice. Climate Comms excludes all liability for any consequences arising directly or indirectly from using this information in risk management decisions.



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Executive summary

Banyule City Council is creating its first climate adaptation plan. This is mandated under the Local Government Act 2020 which requires local councils to act on climate change and attempt to minimise the Council's contributions to global warming through reducing greenhouse gas emissions and planning for climate risks. The Australian Sustainability Reporting Standard AASB S2 legislation passed in 2024 also mandates entities to disclose information about climate-related financial risks.

The council is following the International Organisation for Standardization guidance on Risk Management (ISO 31000) along with the Victorian Climate Resilient Council's guidance on climate risk assessment and management to:

- Assess capacity and secure support
- Undertake a risk assessment
- Develop a response strategy
- Implement priority responses
- Review and monitor progress

Council has engaged Climate Comms to create climate hazard scenarios that will be utilised throughout the process of creating the climate adaptation plan. Council will integrate the scenarios with additional local GIS and social service information to assess and prioritise current and future climate risks.

Historical climate hazards in Victoria are affected by year-to-year variability and underlying climate change. The variability is due to local weather events and naturally occurring factors such as the El Niño Southern Oscillation, Indian Ocean Dipole and Southern Annular Mode. Climate change due to increases in greenhouse gases is also affecting our weather. Victoria has become hotter and drier. The state has warmed by 1.2°C since 1910, and April-October rainfall has declined 10% in the past 30 years compared to 1961-1990.

We have historical weather data which gives us insights into how extreme weather has tracked over time in Banyule. A Bureau of Meteorology (BoM) weather station is located at Viewbank in the Banyule local government area. Daily temperature and rainfall data were analysed from this station for the years 2000-2025.

Multi-day heatwaves (with temperatures over 35°C in the shade) occurred in January 2006, January 2009, January-February 2014, January-February 2019 and February 2025. For example, 27-30 January 2009 had maximum temperatures of 37.5, 42.9, 44.7, 44.0°C, while 13-17 January 2014 had maximum temperatures of 37.6, 43.1, 42.8, 43.9 and 43.8°C.

Extreme rainfall events (over 50 mm in 24 hours) occurred in April 2001, December 2003, February 2005, October 2010, February, April, November and December 2011, June 2013, December 2016, December 2017, March 2020, January 2021 and April 2024. For example, 83 mm fell on 29 December 2016 (40 mm of which fell in 15 minutes), causing major floods.

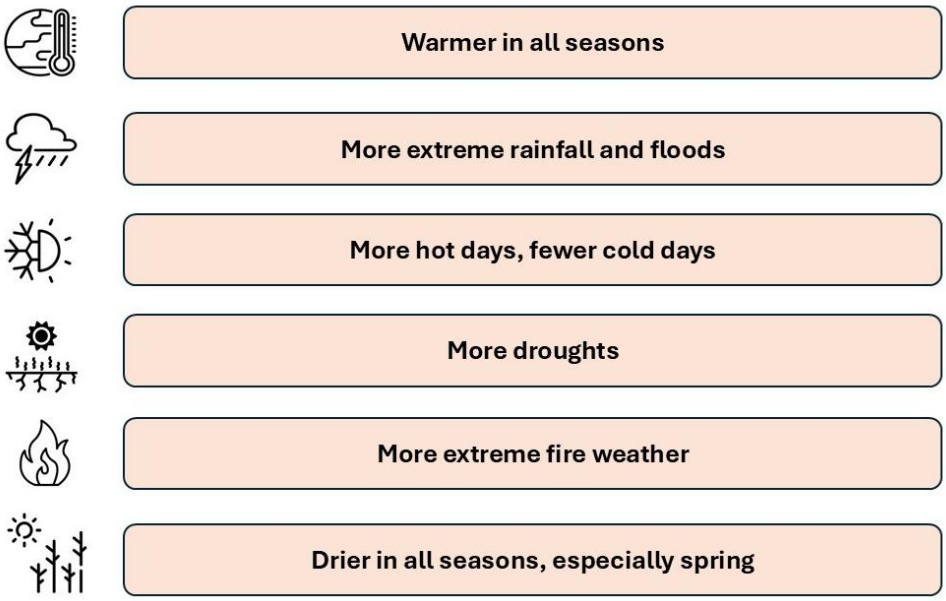
In addition to historical weather data, we can look to climate models for insights into what our future holds. Future climate hazard scenarios are based on simulations from 34 CMIP6 climate models, five-to-eight of which were downscaled (to improve local climate information), for different greenhouse gas emission pathways. For example, a low emissions pathway that assumes significant reductions in global emissions (SSP1-2.6) could result in a global average warming of 1.3-2.4°C by 2081-2100, relative to 1850-1900. A high emissions pathway that assumes weak reductions in global emissions (SSP3-7.0) could result in a global average warming of 2.8-4.6°C by 2081-2100, relative to 1850-1900.

Projections for the Greater Melbourne Region, published by the Commonwealth Science Institute Research Organisation (CSIRO) in 2024, indicate warmer conditions in all seasons over the coming decades. For low emissions, the projected increase in Melbourne annual-average temperature is about 1°C for 2050, 2070 and 2090, relative to 1986-2005. For high emissions, the increase is about 1°C by 2050, 2°C by 2070 and 3°C by 2090. This means more hot days and fewer cold days.

Drier conditions are projected for all seasons, especially spring. For low emissions, annual average rainfall could decrease by about 5% for the years 2050, 2070 and 2090, relative to 1986-2005. For high emissions, the decrease is 5% by 2050, 9% by 2070 and 12% by 2090. This has implications for water supply for environmental, domestic and industrial purposes.

The intensity, frequency and duration of droughts, fires and heatwaves is likely to increase. Despite generally drier conditions, the intensity of extreme daily rainfall and floods is likely to increase because a warmer atmosphere can hold more moisture, which intensifies rainstorms.

Overall Trends for Melbourne in Coming Decades



The information above is quite technical, with limited guidance on what climate change means for local weather in Banyule. This can act as a barrier to uptake in risk assessments. To simplify communication and enhance uptake, local storyline narratives have been developed for Banyule. They describe historical climate hazard events that had major impacts in Banyule in the years 2009 and 2016.

They also include plausible future climate hazard events for the year 2050, but rather as possible pathways which we could experience if we do not act globally to reduce emissions and act locally to adapt to future scenarios.

A historical 'hot and dry' event considered to have most relevance to Banyule Council occurred in summer 2009. It involved the Millennium drought, heatwaves and fires (Black Saturday). Power outages caused disruption to air conditioning, lighting, appliances, transport and telecommunication. Heat-stress and smoke-related respiratory illness led to a spike in hospital admissions and deaths. Water restrictions were imposed, and water recycling and stormwater harvesting were boosted. Vegetation died at many public gardens and sports facilities.

A historical 'hot, wet and windy' event considered to have most relevance to Banyule Council occurred on 29 December 2016. It involved two hot days followed by a storm with strong winds, heavy rain and lightning. Banyule Council Offices were flooded, resulting in lost assets and vehicles which served the community. Flash flooding damaged hundreds of homes, transport was disrupted, and the SES received 1500 calls for help. Power outages also caused disruption to air conditioning, lighting, appliances, transport and telecommunication.

Plausible storylines for 2050 were based on climate projections for a high emissions scenario (SSP3-7.0), for both conservative and stress-test conditions. The 2050 'hot and dry' event and 'hot wet and windy' events have larger impacts than the equivalent historical events, especially for stress-test conditions. These storylines can be used in Council engagement processes to explore potential impacts and management strategies in more detail. This

may involve consideration of risk consequence and likelihood, as well as interactions between hazard, exposure and vulnerability.

The climate science in this report tells us that our local, regional and global climate is changing due to increases in greenhouse gas emissions caused by human activities. Impacts associated with extreme weather events are already significant and likely to get worse. Banyule's climate risk assessment and adaptation plan aim to build resilience.

1 Introduction

Banyule City Council is in Melbourne's north-eastern suburbs, roughly 15 kilometres from the Central Business District (Figure 1). It has a population of 132,000 and an area of 63 square kilometres. Most of the area is residential (76%) with significant open space and parklands (16%). In 2019, following significant community consultation, Banyule City Council joined around 100 other local governments, representing nearly 11.4 million Australians, in declaring a climate emergency. This resolution recognised the need for urgent action and leadership, with an intention to provide stronger support for the community, including transparent communication on the issue of climate change.

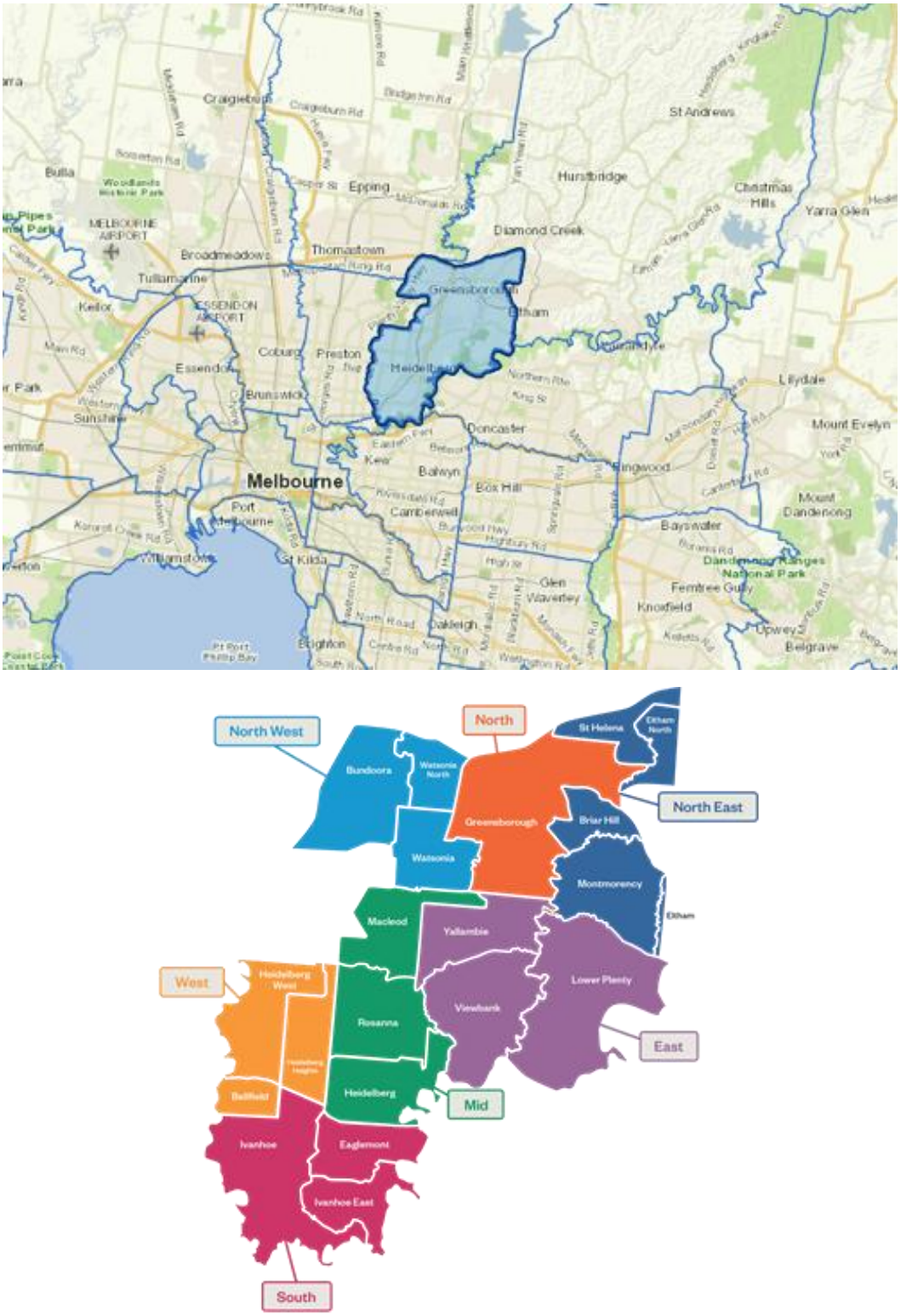


Figure 1: Map of Banyule Council area (top) and suburb boundaries (bottom). Sources: State of Victoria (Department of Energy, Environment and Climate Action) and Banyule Council.

Banyule City Council is creating its first climate adaptation plan as mandated under the Local Government Act 2020 which requires local councils to act on climate change and attempt to minimise the Council's contributions to global warming through reducing greenhouse gas emissions and planning for climate risks. See Risk Concepts in Box 1. The Australian Sustainability Reporting Standard AASB S2 legislation passed in 2024 also mandates entities to disclose information about climate-related financial risks.

Council is following the International Organisation for Standardization guidance on Risk Management (ISO 31000) along with the Victorian Climate Resilient Council's guidance on climate risk assessment and management to:

- Assess capacity and secure support
- Undertake a risk assessment
- Develop a response strategy
- Implement priority responses
- Review and monitor progress

Council approached Climate Comms to assist with local climate hazard scenarios needed in the creation of the climate adaptation plan.

These local scenarios sit within a broader global and national context. The global climate has already changed due to increases in greenhouse gases associated with human activities. Global-average surface temperatures increased 1.1°C between 1850-1900 and 2011-2020. Global-average sea level rose 22 cm between 1900 and 2023.

Australia has warmed by 1.5°C since 1910, with more extremely high temperatures and fewer extremely low temperatures. October to April rainfall in northern Australia has increased 20% since 1994. April to October rainfall has decreased 16% since 1970 in the south-west and 9% since 1994 in the south-east. Annual maximum snow depths have declined since the late 1950s. The number of dangerous fire weather days has increased across most regions since 1950, with an earlier start to the southern fire weather season. Heavy rainfall events have become more intense[1].

This document outlines the technical climate science that is foundational to our understanding of climate change as a risk to our communities, natural environments, and economy. Section 2 provides local/regional information about historical climate averages, variability, trends, extreme events and impacts. Section 3 describes future regional climate scenarios for 2050, 2070 and 2090 for low and high greenhouse gas emissions pathways. Section 4 presents local storyline narratives for a 'hot and dry' event that occurred in January-February 2009 and a 'hot wet and windy' event that occurred in December 2016, plus conservative and stress-test versions of these events in 2050, followed by conclusions in Section 5.

[1] CSIRO and BoM (2024). State of the Climate 2024.

Box 1: A note on risk concepts

How do organisations assess risk? The International Standard ISO 31000 for Risk Management provides guidance. It defines risk as the 'effect of uncertainty on objectives'. The key steps are: 1. Establish the context, scope and criteria, 2. Assess risk (identification, analysis, evaluation), 3. Risk treatment, and 4. Monitoring, reviewing, recording and reporting. ISO 14090 provides guidance on adaptation to climate change, and Australia Standard AS-5334 provides guidance on climate change adaptation for settlements and infrastructure. Common elements are captured in the Victorian Climate Resilient Council guidance on climate risk assessment and management.

Many risk assessments include a risk matrix showing consequence versus likelihood. This helps with risk evaluation and prioritisation, i.e. high risks have greater priority than low risks. For each historical risk, quantification of consequence and likelihood is based on available data. For each future risk, it may be possible to quantify consequence, but it is difficult to quantify likelihood, so the risk matrix could involve qualitative information based on expert judgement.

It is also possible to apply the Intergovernmental Panel on Climate Change (IPCC) definition of risk, which is, "the potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems." Climate risk results from dynamic interactions between climate hazards, exposure and vulnerability.

- Hazards are physical events or trends that may cause death, injury, damage and loss, including heatwaves, droughts, fires, heavy rainfall, storms, and extreme sea level events.
- Exposure is the presence of people, livelihoods, ecosystems, services, resources, infrastructure and assets in places that could be affected.
- Vulnerability is the propensity to be adversely affected, including factors such as age, health, disability, gender, culture, education, socio-economic status, access to essential services, insurance, building standards, planning processes and governance.

	Consequence				
Likelihood	**Insignificant**	**Minor**	**Moderate**	**Major**	**Severe**
Almost Certain	Medium	High	High	Extreme	Extreme
Likely	Medium	Medium	High	Extreme	Extreme
Possible	Medium	Medium	High	High	Extreme
Unlikely	Low	Medium	Medium	High	High
Rare	Low	Low	Medium	High	High



Risk matrix (left) based on an assessment of consequence versus likelihood. An alternative representation of risk (right) based on dynamic interactions between hazard, exposure and vulnerability.

For a given hazard, e.g. daily rainfall of 100 mm, the risk will be higher in a location that has higher exposure and/or vulnerability (e.g. properties in a floodplain with limited insurance). Reducing exposure and/or vulnerability builds resilience, while reducing hazards requires cuts in global greenhouse gas emissions.

2 Historical climate

2.1 Climate averages

Banyule has a temperate climate. At Viewbank, the monthly average maximum temperature ranges from 28.2°C in January to 14.0°C in July (Figure 2). Monthly average minimum temperatures range from 14.7°C in January to 5.9°C in July. Monthly average rainfall ranges from 41.5 mm in February to 73.9 mm in November.

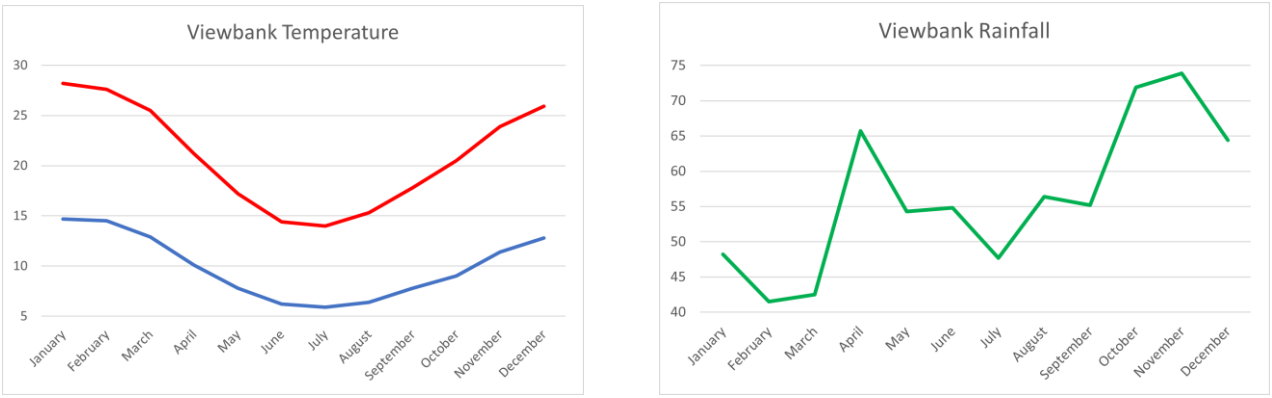


Figure 2: Monthly average maximum temperature (°C, red), minimum temperature (°C, blue) and rainfall (mm, green) for Viewbank, based on data from 2000-2024. Data sourced from Bureau of Meteorology (BoM).

2.2 Climate variability

In Victoria, climate variability from year-to-year is influenced by three naturally-occurring factors: the El Niño Southern Oscillation (ENSO), Indian Ocean Dipole (IOD) and Southern Annular Mode (SAM).

The ENSO is a climate pattern over the Pacific Ocean with three phases: El Niño, La Niña and neutral[2]. El Niño events occur every 3-5 years, developing in autumn or winter and lasting 6-24 months. Over Victoria, they cause drier conditions and warmer daytime temperatures, with increased risk of drought and fire. La Niña events occur every 3-7 years, developing in autumn or winter, and half of all events have lasted 2-3 years. Over Victoria, they cause wetter conditions and cooler daytime temperatures, with increased risk of flood.

The IOD is a climate pattern in the Indian Ocean with three phases: positive, negative and neutral[3]. The main influence is during May to December. It can last 2-7 months. Over Victoria, a positive IOD causes warmer and drier conditions with greater fire risk, while a negative IOD causes cooler and wetter conditions with greater flood risk.

The SAM is a climate pattern in the Southern Ocean with three phases: positive, negative and neutral[4]. It can last from 1 week to several months. Over Victoria, a positive SAM causes cooler and wetter conditions in summer and warmer and drier conditions in winter, while a negative SAM causes warmer and drier conditions in summer and cooler and wetter conditions in winter.

Variability in Victorian temperature and rainfall is shown in Figures 3 and 4. The hottest years were 2007 (1.25°C above average), 2009 (1.10°C), 2013 (1.08°C), 2014 (1.21°C), 2018 (1.15°C), 2019 (1.05°C) and 2024 (1.08°C).

The driest years were 1914 (397 mm), 1938 (419 mm), 1940 (439 mm), 1944 (444 mm), 1967 (368 mm), 1982 (377 mm) and 2006 (370 mm). The wettest years were 1952 (879 mm), 1956 (905 mm), 1973 (898 mm), 1974 (906 mm), 1992 (849 mm), 2010 (853 mm) and 2022 (872 mm).

[2] About Australian Climate
[3] Indian Ocean Dipole in Australia
[4] Southern Annular Mode In Australia

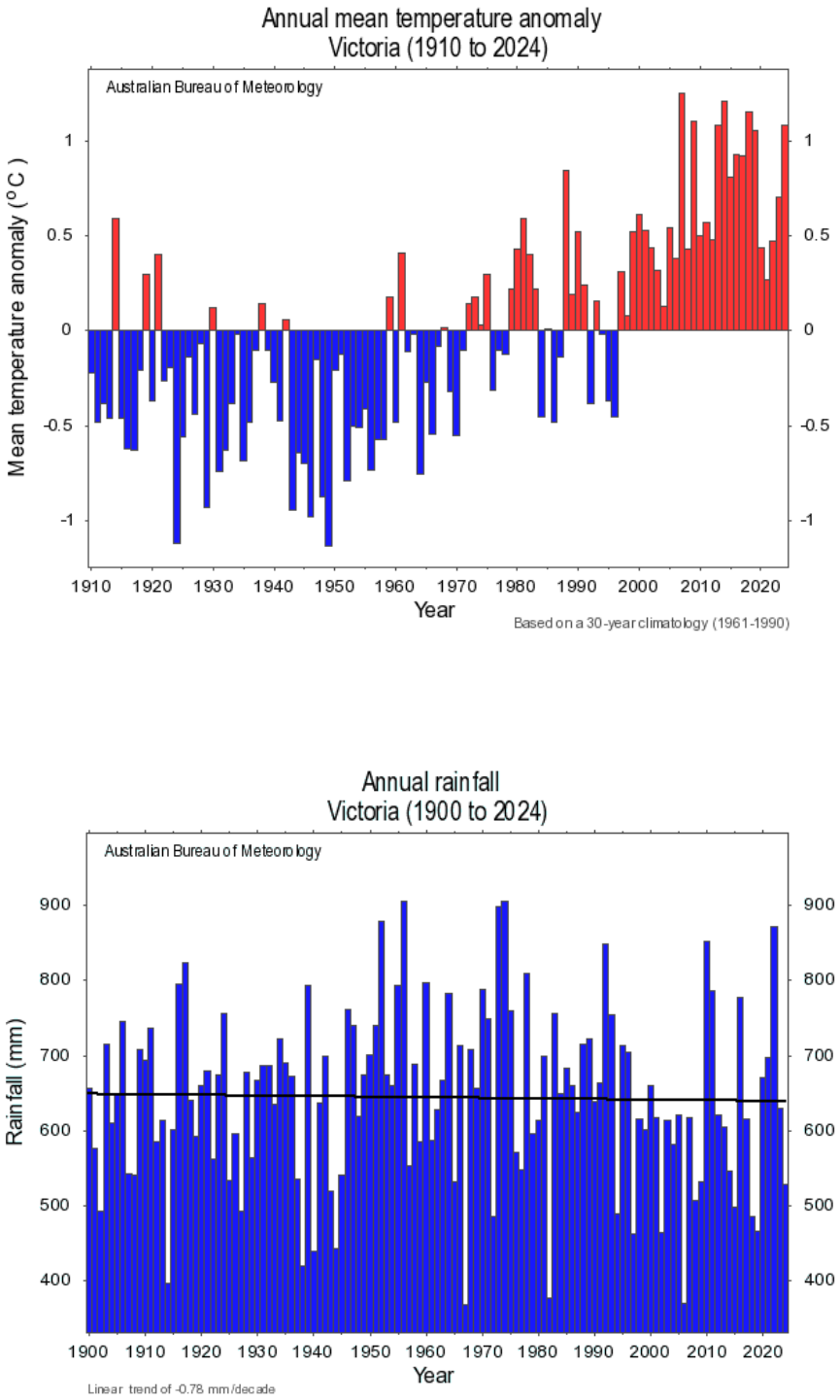


Figure 3: Victorian annual-mean temperature anomalies from 1910-2024, relative to 1961-1990 (top) and annual rainfall from 1910-2024 (bottom). Source: BoM.

Based on data for Viewbank from 2000-2024, the annual-average maximum temperature is 20.9°C, with a low of 19.9°C in 2004 and a high of 21.8°C in 2007 (Figure 4). The annual-average minimum temperature is 10.0°C, with a low of 9.1°C in 2006 and a high of 10.7°C in 2016 (Figure 5). The annual average rainfall is 680 mm, with a low of 474 mm in 2015 and a high of 1075 mm in 2011 (Figure 6).

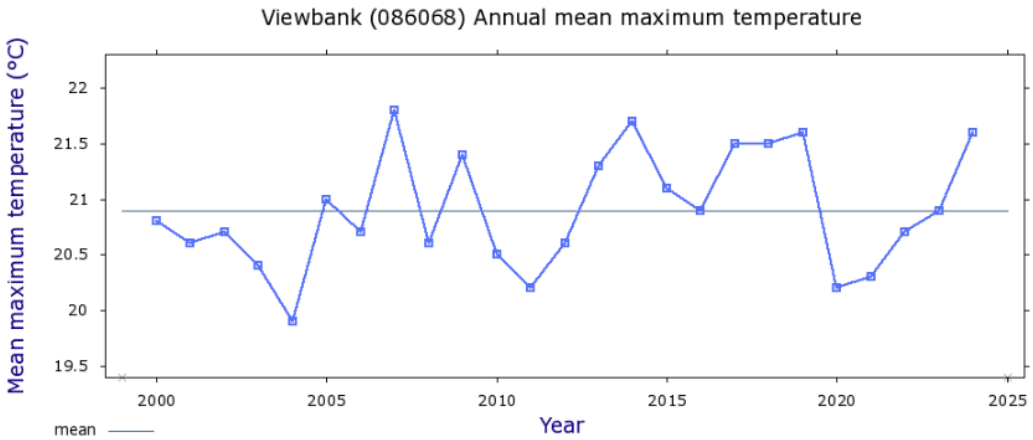


Figure 4: Timeseries of annual-average maximum temperature at Viewbank from 2000-2024. Source: BoM.

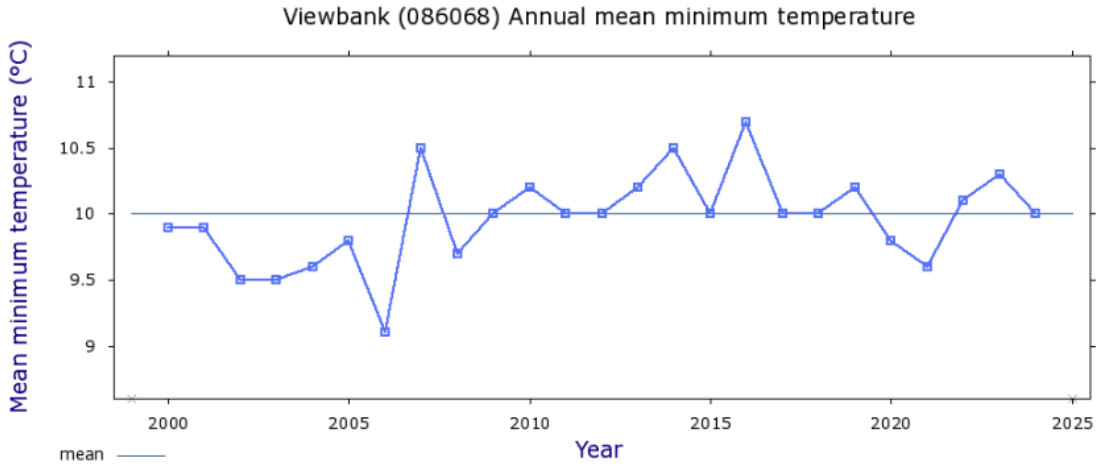


Figure 5: Timeseries of annual-average minimum temperature at Viewbank from 2000-2024. Source: BoM.

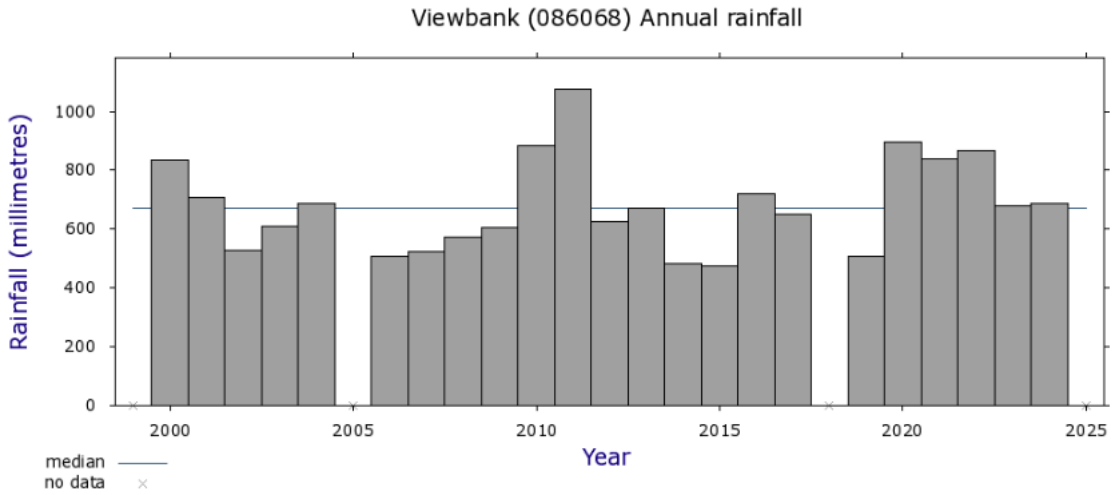


Figure 6: Timeseries of annual total rainfall at Viewbank from 2000-2024. Source: BoM.

2.3 Climate trends and extreme events

Victoria has become about 1.2°C warmer since 1910 (Figure 3), with more than half occurring in the past 30 years[5]. This has been mostly attributed to increases in greenhouse gases.

Local weather systems can create extreme events. At Melbourne Airport, the annual-average number of days above 35°C grew from 8.7 in the period between 1971-2000, to 11.4 from 1991–2020[6], an increase of almost 3 days of extreme heat per year.

At Viewbank, based on a much shorter record, the annual average number of days above 35°C was 13.8 from 2000-2012, increasing slightly to 14.0 from 2013-2024 (Figure 7). Similarly, at Viewbank, the annual average number of days above 40°C was 2.0 from 2000-2012, decreasing slightly to 1.8 from 2013-2024 (Figure 7). There is large year-to-year variability. For example, at Viewbank, the minimum number of days over 35°C was only 4 in 2011 and the maximum was 21 in 2013 and 2019 – a new record is likely to be set in 2025 because, from January to March 2025, there were already 21 days over 35°C.

Heatwaves are periods with consecutive days of high temperature, e.g. above 35°C.

Notable heatwaves at Viewbank occurred in 2006, 2009, 2014, 2019 and 2025
2006: 19-27 Jan (34.1, 35.9, 40.8, 42.5, 26.0, 22.8, 35.7, 40.0, 37.3°C)
2009: 27-30 Jan (37.5, 42.9, 44.7, 44.0°C) followed by 46.7°C on 7 February (Black Saturday)
2014: 13-17 Jan (37.6, 43.1, 42.8, 43.9, 43.8°C)
2014: 27 Jan to 9 Feb (35.0, 41.8, 25.8, 33.4, 30.0, 36.1, 42.1, 37.1, 26.2, 31.8, 36.1, 37.6, 41.9, 41.2°C)
2019: 22 Jan to 3 Feb (35.3, 27.7, 42.2, 44.8, 29.5, 28.2, 34.9, 37.3, 38.8, 22.3, 26.5, 36.6, 42.1°C)
2025: 1-6 Feb (38.0, 39.7, 39.3, 39.6, 25.4, 38.2°C)

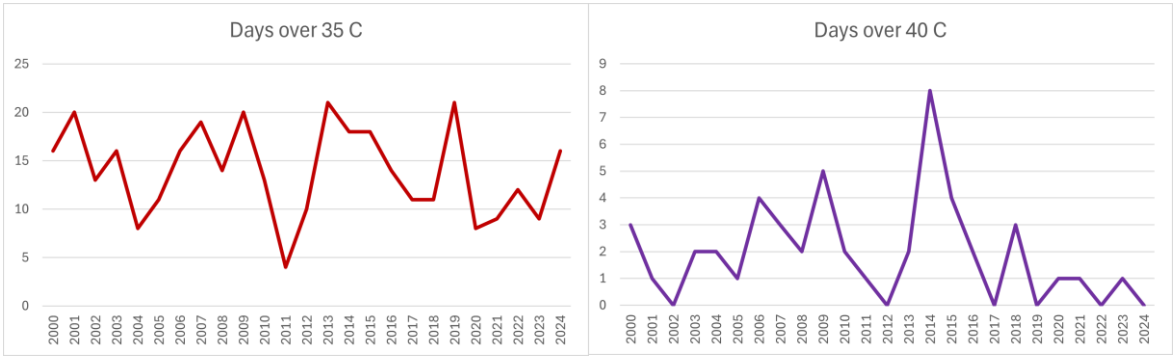


Figure 7: Timeseries of annual number of days over 35°C (left) and 40°C (right) at Viewbank from 2000-2024. Data sourced from Bureau of Meteorology.

Over recent decades Victoria has become drier (Figure 3). April to October rainfall declined by 10% over the past 30 years relative to the average for 1961–1990. This has been mostly attributed to increases in greenhouse gases[7].

[5] CSIRO (2024). Victoria's climate science report 2024. https://www.climatechange.vic.gov.au/victorias-changing-climate
[6] BoM (2025). http://www.bom.gov.au/climate/data
[7] CSIRO (2024). Victoria's climate science report 2024. https://www.climatechange.vic.gov.au/victorias-changing-climate

Fire weather is one of the four ingredients for fire activity. The Forest Fire Danger Index (FFDI) is a measure of fire weather calculated from daily temperature, rainfall, humidity and wind speed data. Since 1950, there has been an increase in the frequency of extreme fire weather days across most of Australia, including Victoria. Increases are largest in spring and summer and associated with an earlier start for the fire season[8].

Despite the general drying trend, extreme rainfall events are becoming more intense. For example, the frequency of extreme rainfall events in Victoria with more than 18 mm per hour has increased almost 90% between 1958–1985 and 1987–2014[9]. Consequently, floods are becoming larger[7]. At Viewbank, the annual-average number of days with 24-hour total rainfall over 25 mm was 3.4 during 2000-2012 and 3.5 during 2013-2024 (Figure 8). However, there is no trend in events exceeding 50 mm (Figure 8).

Extreme rainfall events (exceeding 50 mm in 24 hours)[10] at Viewbank	
53 mm on 24 Apr 2001	60 mm on 26 Dec 2011
108 mm on 3 Dec 2003	87 mm on 1 Jun 2013
103 mm on 3 Feb 2005	83 mm on 30 Dec 2016
59 mm on 31 Oct 2010	60 mm on 3 Dec 2017
84 mm on 5 Feb 2011	54 mm on 5 Mar 2020
76 mm on 12 Apr 2011	52 mm of 30 Jan 2021
52 mm on 27 Nov 2011	70 mm on 2 Apr 2024

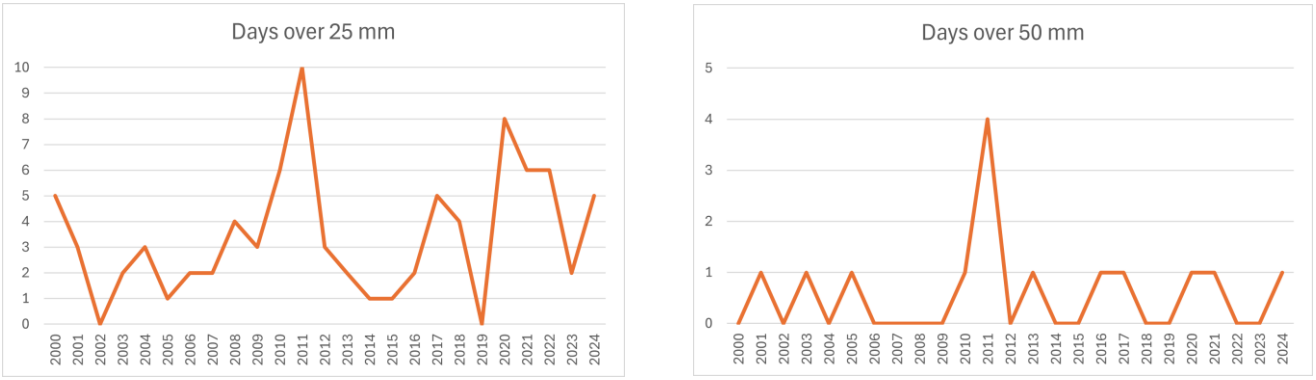


Figure 8: Timeseries of annual number of days with 24-hour total rainfall over 25 mm (left) and 50 mm (right) at Viewbank from 2000-2024. Data sourced from Bureau of Meteorology.

2.4 Impacts

According to the Intergovernmental Panel on Climate Change (IPCC), risk results from dynamic interactions between hazards, exposure and vulnerability (see Box 1). The climate hazards have been described above. Exposure is the presence of people, livelihoods, species or ecosystems, environmental functions, services, resources, infrastructure, and economic, social or cultural assets in places that could be affected. Vulnerability is the propensity to be adversely affected, including factors such as age, health, disability, gender, culture, education, socio-economic status, access to essential services, insurance, building standards, planning processes and governance[11]. Impacts are realised risks.

[8] CSIRO and BoM (2024). State of the Climate 2024.
[9] Osburn, L., Hope, P., & Dowdy, A. (2021). Changes in hourly extreme precipitation in Victoria, Australia, from the observational record. *Weather and Climate Extremes*, 31, 100294. https://doi.org/10.1016/j.wace.2020.100294
[10] Rainfall accumulated from 9 am the day before to 9 am on the current day
[11] IPCC (2022). Working Group 2 report on Impacts, Adaptation and Vulnerability. www.ipcc.ch

Extreme heat

Extreme heat can cause many impacts:

- Heat stress and mortality for humans, plants and animals[12].
- From 1987-2016, heatwaves in Australia caused 509 deaths and 2800 injuries. Extreme heat, low humidity, strong winds and low rainfall increase fire weather risk[13].
- In Victoria, during the Jan 2009 heatwave, there were 374 excess deaths. In the Jan 2014 heatwave, there were 167 excess deaths and a five-fold increase in hospital admissions[14].
- Exposure to high temperatures at work can have health consequences including more accidents, heat stroke and chronic disease[15]. Temperatures above 24–26°C cause reduced labour productivity. At 33–34°C, a person operating at moderate intensity loses 50% of work capacity[16].
- The most vulnerable include the elderly, the very young, outdoor workers, homeless people, poor people, and those with pre-existing health conditions[13]. Illnesses such as angina, kidney disease and diabetes may be exacerbated[17]. Heatwaves are sometimes called the 'silent killer'.
- Hot nights can cause insomnia and increased risk of disease, obesity, chronic illness and reduced psychological and cognitive functioning[18].
- Extreme heat can cause a significant increase in morbidity such as mood disorders, mental disorders, schizophrenia, neurotic and anxiety disorders[19]. It can increase depression and suicide, along with aggression, domestic violence and substance use[20].
- High temperatures increase evaporation from water storage dams[21].
- Transport infrastructure can be affected, e.g. melting of road tar, buckling of train lines[13,22].
- High temperatures reduce electricity transmission efficiency[23].
- Extreme heat increases electricity demand for air conditioning. Wind farm electricity output depends on both wind speed and temperature, and output declines significantly at temperatures over 40°C. Power outages leave consumers vulnerable and can incur large societal impacts[24].
- The coincidence of a heatwave and fire can significantly increase the risk of power outages[25].
- Power outages and the associated loss of air conditioning for a single day in an extreme heatwave scenario could have resulted in 24-47 additional deaths in Melbourne in 2014[26].

[12] Lawrence et al (2022). Chapter 11 Australasia. In IPCC Working Group 2 report.
[13] Deloitte (2017). Building resilience to natural disasters in our states and territories.
[14] Victorian Department of Health (2025). Research and reports - extreme heat and heatwaves
[15] Kjellstrom et al., (2016). Heat, Human Performance, and Occupational Health: A Key Issue for the Assessment of Global Climate Change Impacts. doi:10.1146/annurev-publhealth-032315-021740.
[16] ILO (2019). Working on a warmer planet: The impact of heat stress on labour productivity and decent work
[17] Hanna et al. (2016). The silent killer: Climate Change and the Health Impacts of Extreme Heat, The Climate Council, https://research management.mq.edu.au/ws/portalfiles/portal/72578140/72578105.pdf
[18] Obradovich et al. (2017). Nighttime temperature and human sleep loss in a changing climate, *Science Advances* 3
[19] Is there an association between hot weather and poor mental health outcomes? A systematic review and meta-analysis - ScienceDirect
[20] Psychiatry.org - Extreme Heat Can Take a Toll on Mental Health
[21] MDBA (2024). Causes of water losses | Murray–Darling Basin Authority
[22] Climate Council (2014). Heatwaves: Hotter, longer, more often https://www.climatecouncil.org.au/uploads/9901f6614a2cac7b2b888f55b4dff9cc.pdf
[23] ESCI (2021). Extreme heat & transmission
[24] ESCI (2021). Extreme Heat & VRE
[25] ESCI (2021). Impact of extremes
[26] AEMO (2019). power-outages-and-mortality-burden-australian-cities.pdf

Droughts

Droughts can significantly affect ecosystems, water-dependent industries and domestic water supplies. They are also becoming hotter[27].

Major Australian droughts
1895–1902 (Federation Drought)
1914–1915
1937–1945
1965–1968
1982–1983
1997–2009 (Millennium Drought)
2017–2019

Impacts include[28]:

- Poor health, including impacts on nutrition, infectious diseases, air pollution and mental health
- Water scarcity, often managed through water restrictions
- A decline in water bird, fish and aquatic plant populations
- Increased risk of fire, dust storms and soil loss
- Reduced livestock and crop productivity
- Flow-on effects to supply chains, industries, regional employment, domestic food prices and export earnings.

Fires

Fire activity depends on weather, ignition, vegetation type and fuel load[29]. Over recent decades, there has been an increase in the forest area burnt in Australia, associated with climate change[30]. Significant fires in Victoria occurred during 16 February 1983, 19-26 January 2006, 7 February to 14 March 2009, 15 January 2014, 7-14 February 2014, 24-27 December 2015, 3-12 March 2019, 8 November 2019 to 13 February 2020, and 17 December 2024 to 8 February 2025[31]. The 2009 fires occurred north-east of Banyule, and a fire affected the Banyule region in late 2019 (Figure 9).

[27] Kirono et al (2017). Increasing risk of months with low rainfall and high temperature in southeast Australia for the past 150 years. http://dx.doi.org/10.1016/j.crm.2017.04.001
[28] Climate Council (2018). Factsheet: Climate Change and Drought | Climate Council
[29] Bradstock, R. et al., (2014). Divergent responses of fire to recent warming and drying across south-eastern Australia. doi:10.1111/gcb.12449.
[30] Canadell et al (2021). Multi-decadal increase of forest burned area in Australia is linked to climate change | Nature Communications
[31] Insurance Council of Australia (2025). https://insurancecouncil.com.au/industry-members/data-hub

The impacts can be extensive, as illustrated by the Black Summer fires in 2019-2020[32]:

- 33 deaths directly associated with fire, a further 429 deaths and 3230 hospital admissions indirectly related to smoke, with health costs totalling $1.95 billion
- over 3000 properties destroyed, $2.3 billion in insured losses
- $3.6 billion in losses for tourism, hospitality, agriculture and forestry
- 5.8 to 8.1 million hectares of forest burnt in eastern Australia
- loss or displacement of nearly 3 billion vertebrate animals, 114 listed threatened species lost at least 50% of their habitat, and 49 lost 80% of their habitat.





Figure 9: Bundoora fire on 31 Dec 2019 (left) and smoke over Whittlesea on 7 Feb 2009 (right).

Floods

Floods are Australia's most costly natural disaster, averaging $8.8 billion per year[33]. Impacts include deaths, injuries, mental health issues, evacuations, workplace and school closures, and costs associated with damage, disruption, response, recovery and reconstruction.

In Banyule, the three largest waterways are the Yarra River, Darebin Creek and the Plenty River. It is a flood-prone area (Figure 10). Salt Creek runs in a southerly direction through Rosanna and Macleod into the Yarra River at Heidelberg. There are 476 properties at risk during a flood with 1% probability in the Salt Creek/Banyule Creek Catchment. Drains and retarding basins along the creek minimise the impacts of flooding on the surrounding areas. The impacts of a 1% flood for Rosanna and Macleod are shown in Figure 11[34.] On 30 December 2016, Viewbank received 40 mm of rain in 15 minutes and Bundoora had over 100 mm in 24 hours. Flash flooding occurred, with extensive property damage and transport disruption[35].

[32] Lawrence et al (2022). Chapter 11 Australasia. In IPCC Working Group 2 report.
[33] Deloitte (2017) Building resilience to natural disasters in our states and territories. Deloitte Access Economics, Sydney, Australia, 120 pp.

[34] City of Banyule - Victoria State Emergency Service - VICSES
[35] The Age (2016). https://urldefense.com/v3/__https://www.theage.com.au/national/victoria/savage-thunderstorms-leave-widespread-damage-across-melbourne-suburbs-20161229-gtjl5m.html__;!!IyBGEFvroGnO!l4CXKmyU9nkEldSBI7ObQcla3pyXvQo8_QRJffyg7hoJwdPst-Y_z3JOo_DQ0QaWKDLf1CvOGyHnhYPP7UvDjfT5286k$



Figure 10: Flooding in Rosanna in 2016. Source: Banyule City Council (2024). Climate Adaptation in Banyule.

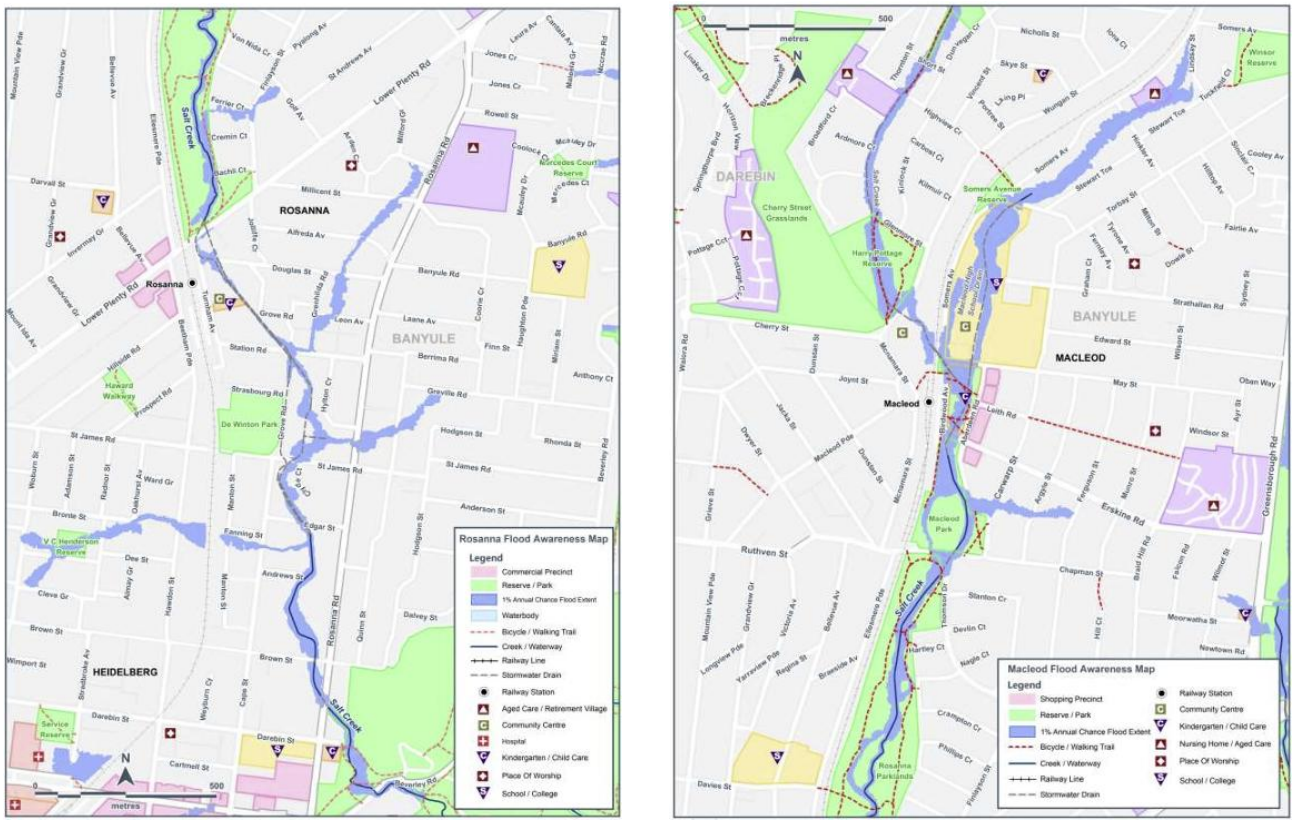


Figure 11: Flood risk map for an event with 1% probability in any given year for Rosanna (left) and Macleod (right). Source: Victoria State Emergency Service[34].

3 Future climate

The IPCC[36] concluded that future increases in greenhouse gas emissions will lead to further global warming, sea level rise, and increases in high temperatures, droughts, fires and heavy rainfall.

Climate projections for the Greater Melbourne Region were published in 2024[37]. The projections are based on simulations from 34 CMIP6 climate models, 5-8 of which were downscaled (to improve local climate information) using four different methods, for low (SSP1-2.6) and high greenhouse gas emissions (SSP3-7.0) pathways. (See Box 2 for more detail on these pathways).

According to the models, Melbourne will become warmer in all seasons. For low emissions (assuming significant reductions in global emissions), the projected increase in annual-average temperature is about 1°C for 2050, 2070 and 2090, relative to 1986-2005 (Table 1). For high emissions (assuming weak reductions in global emissions), the projected increase is about 1°C by 2050, 2°C by 2070 and 3°C by 2090. This means more hot days and fewer cold days.

Drier conditions are likely, especially in spring. For low emissions, the projected decrease in annual-average rainfall is about 5% for 2050, 2070 and 2090, relative to 1986-2005 (Table 1). For high emissions, the projected decrease is 5% by 2050, 9% by 2070 and 12% by 2090. Greatest decreases are simulated in spring, which is the period we'd normally receive the most rain for our year.

[36] IPCC (2021). The physical science basis. Working Group 1 contribution to the Sixth Assessment Report.
[37] CSIRO (2024). Greater Melbourne Climate Projections.

Box 2: Climate projections

Climate projections account for three sources of uncertainty:

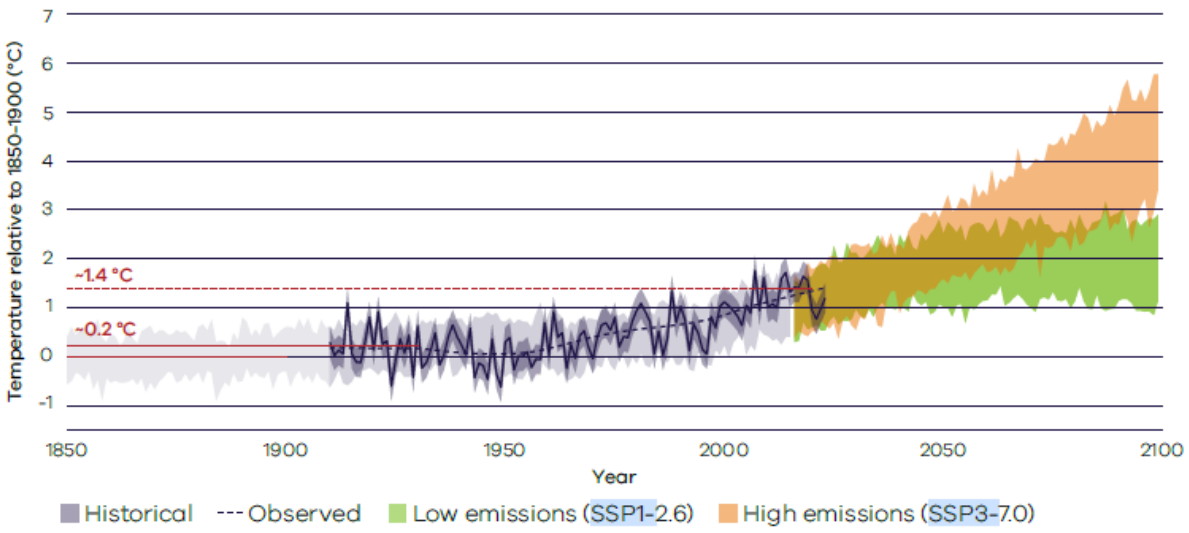
1. Natural climate variability
2. Future greenhouse gas and aerosol emissions pathways
3. Regional climate responses to each emissions pathway

Natural climate variability operates at different spatial and temporal scales. For example, hourly-daily variability is affected by local weather systems, while monthly-yearly variability is affected by large-scale factors such as the El Niño Southern Oscillation (ENSO), Indian Ocean Dipole (IOD) and Southern Annular Mode (SAM). See section 2.2 for more detail.

Future emissions pathways are based on plausible assumptions about future socio-economic development, technological change, energy production, land use, and associated emissions of greenhouse gases and aerosols (fine particles in the air). Shared Socio-economic Pathways (SSPs) have been developed by international experts for use in future climate simulations.

- SSP1-2.6 would involve a rapid global shift to sustainability, with deep emission cuts, leading to a global warming of 1.3-2.4°C by 2081-2100, relative to 1850-1900.
- SSP2-4.5 would involve a gradual global shift to sustainability, with moderate emission cuts, leading to a global warming of 2.1-3.5°C by 2081-2100, relative to 1850-1900.
- SSP3-7.0 would involve continued reliance on fossil fuels, with weak emission cuts, leading to a global warming of 2.8-4.6°C by 2081-2100, relative to 1850-1900.
- SSP5-8.5 would involve growing reliance on fossil fuels, with no emission cuts, leading to a global warming of 3.3-5.7°C by 2081-2100, relative to 1850-1900.

Regional climate responses to each emissions pathway are simulated by global climate models. These models represent biophysical processes mathematically over a three-dimensional grid of points across the globe, including the surface, oceans, cryosphere and atmosphere. The models can be driven by changes in the Earth's energy balance caused by natural factors (e.g. volcanic eruptions, changes in the Earth's orbit) or human-caused factors (e.g. greenhouse gas increases, land-use change). Calculations are made for hundreds of climate parameters, at sub-hourly time steps, over thousands of grid points, over hundreds of years, which requires super-computers with massive data storage. When driven by each SSP, climate models simulate how the regional climate may change in future.



Observed and simulated historical temperature anomalies over Victoria from 1850-2020, relative to a baseline of 1850-1900. Simulated future temperature anomalies to 2100 are shown for low and high emissions pathways. Source: CSIRO (2024).

Limitations to climate models

There are 78 CMIP6 global climate models – the latest set of models assessed by the Intergovernmental Panel on Climate Change (IPCC).

The future climate hazard scenarios have confidence ratings, uncertainties and limitations. Confidence is high for the temperature scenarios, moderate for the rainfall/drought and fire scenarios, and low for the wind scenarios. Uncertainties have been quantified and account for natural climate variability, plausible emissions pathways, and different regional climate responses simulated by global climate models.

Even with the most powerful supercomputers, however, the spacing of data points is typically 150–200 km. This limitation means that global climate models perform well at large scales, but exhibit weaknesses at small scales, e.g. simulating extreme weather events. To address this issue, dynamical and statistical downscaling are used. Dynamical downscaling involves using a regional climate model with 10-50 km between data points. This improves the simulation of regional climate features and extreme weather events. Statistical downscaling involves using statistical methods to reduce any remaining biases (e.g. too hot/cold, wet/dry) and produce future weather data that can be used in impact assessments.

Table 1: Projected changes in annual-average temperature and annual/seasonal-average rainfall for Greater Melbourne for 20-year periods centred on 2050, 2070 and 2090, relative to a 20-year period centred on 1995 (1986-2005), for low (SSP1-2.6) and high (SSP3-7.0) greenhouse gas emissions pathways, based on downscaled CMIP6 climate model simulations. The median change is shown, with the 10-90 percentile range in brackets[38].

	2050		**2070**		**2090**	
	SSP1-2.6	SSP3-7.0	SSP1-2.6	SSP3-7.0	SSP1-2.6	SSP3-7.0
Annual-average temperature (°C)	+0.9 (0.4 to 1.2)	+1.1 (0.4 to 1.4)	+1.1 (0.4 to 1.4)	+2.1 (1.5 to 2.4)	+1.0 (0.4 to 1.4)	+3.0 (2.1 to 3.6)
Annual-average rainfall (%)	-6 (-14 to +6)	-5 (-15 to +3)	-5 (-14 to +4)	-9 (-17 to +10)	-5 (-14 to +4)	-12 (-23 to +11)
Summer-average rainfall (%)	-7 (-29 to +19)	-2 (-29 to +13)	-11 (-27 to +8)	-2 (-25 to +22)	-1 (-22 to +13)	-5 (-32 to +32)
Autumn-average rainfall (%)	-6 (-16 to +13)	-6 (-21 to +14)	-3 (-17 to +16)	-11 (-26 to +17)	-8 (-17 to +12)	-10 (-26 to +16)
Winter-average rainfall (%)	-1 (-9 to +9)	-3 (-9 to +5)	-3 (-13 to +4)	-2 (-18 to +6)	-2 (-11 to +7)	-8 (-20 to 0)
Spring-average rainfall (%)	-6 (-18 to +7)	-9 (-23 to +2)	-6 (-18 to +8)	-9 (-30 to +7)	-9 (-24 to +7)	-17 (-36 to +2)

The intensity, frequency and duration of droughts, heatwaves, fires and floods is likely to increase (Table 2).

Drought projections for Victoria are limited to one downscaling method (NARCliM 2.0) for ten CMIP6 climate simulations. Drought is defined as dry months with total rainfall below the 10th percentile during 1986-2005 (which had 24 dry months). By 2050, it is 35 months (uncertainty range 27-43) for low emissions and 40 (29-50) for high emissions. By 2090, it is 36 months (29-44) for low emissions and 50 (37-65) for high emissions[39].

[38] CSIRO (2024). Greater Melbourne climate projections 2024.

[39] CSIRO (2024). Victoria climate projections 2024 technical report.

Heatwaves can be defined in different ways, based on a number of consecutive days over a specified threshold temperature. CSIRO defined the threshold for a heatwave day as the 95th percentile of daily average temperature, and a heatwave event had three consecutive heatwave days. Over Victoria, the annual-average number of heatwave days was 20 during 1986-2005. By 2050, this increases to 29 days (uncertainty range 20-38) for low emissions and 37 days (27-47) for high emissions scenarios. By 2090, it's 30 days (22-38) for low emissions and 60 days (45-75) for high emissions[39].

Fire weather is projected to increase in south-east Australia. While downscaled CMIP6 fire projections are not available, CMIP5 projections indicate that by 2050, a 20% (uncertainty range 5-35%) increase in the average frequency of extreme fire weather days above the 95th percentile is likely for low emissions, with a 40% (10-70%) increase for high emissions[40,41]. By 2090, the increase is 20% (5-35%) for low emissions and 75% (20-130%) for high emissions. In the baseline period, the 95th percentile is exceeded on 18 days per year. Therefore, by 2050 this could become 22 (19-24) days for low emissions and 25 (20-30) days for high emissions, and by 2090 this could become 22 (19-24) days for low emissions and 31 (21-41) days for high emissions.

Extreme daily rainfall intensity is likely to increase because a warmer atmosphere can hold more moisture. By 2050, the intensity of extreme rainfall (99th percentile, exceeded 3-4 times per year) is projected to change by 0% (uncertainty range -10 to +12%) for low emissions and 0% (-10 to +15%) for high emissions. By 2090, the change is +2% (-9 to +11%) for low emissions and +1% (-7 to +29%) for high emissions[39].

Changes in seasonal-average wind-speed are likely to be small (±3%) with decreases in autumn, winter and spring in south-east Australia by 2090. Changes in extreme daily wind-speed are also likely to be small[42].

Table 2: Estimates of drought (dry months per 20 years below 10th percentile), heatwave days (at least 3 days above 95th percentile), extreme fire weather days (above 95th percentile) and extreme daily rainfall intensity (above 99th percentile) for Victoria for 20-year periods centred on 1995 (1986-2005), 2050 (2041-2060) and 2090 (2081-2100) for low (SSP1-2.6) and high (SSP3-7.0) greenhouse gas emissions pathways. The median change is shown, with the 10-90 percentile range in brackets [39 40].

	1995	2050		2090	
		SSP1-2.6	SSP3-7.0	SSP1-2.6	SSP3-7.0
Dry months per 20 years	24	35 (27-43)	40 (29-50)	36 (29-44)	50 (37-65)
Annual heatwave days	20	29 (20-38)	37 (27-47)	30 (22-38)	60 (45-74)
Annual extreme fire weather days	18	22 (19-24)	25 (20-30)	22 (19-24)	31 (21-41)
Extreme rainfall intensity (% change)		0 (-10 to +12)	0 (-10 to +15)	+2 (-9 to +11)	+1 (-7 to +29)

[40] NESP ESCC Hub (2020). Scenario analysis of climate related physical risk for buildings and infrastructure: climate science guidance

[41] Clark et al (2024). Downscaled GCM climate projections of fire weather over Victoria, Australia. Part 2: a multi-model ensemble of 21st century trends. DOI:10.1071/WF20175

[42] CSIRO and BoM (2015). Climate change in Australia: Technical Report. Section 7.3.1.



4 Local storyline narratives

The preceding information is quite technical, with limited guidance on what climate change means for local weather in Banyule. This can act as a barrier to uptake in risk assessments planning [43]. To simplify communication and enhance uptake, local storyline narratives have been developed for Banyule. They describe historical climate hazard events that had major impacts in Banyule in the years 2009 and 2016.

They also describe plausible future climate hazard events. Anchoring future events in the context of historical events that have been experienced by stakeholders improves credibility, traceability and relevance[44]. Storyline narratives fit within the well-established scenario analysis framework. This requires scenarios that are plausible, distinctive, consistent, relevant and challenging[45]. They allow exploration of events that have severe consequences, including low-likelihood-high-impact events[46].

The historical hazard events were based on daily temperature and rainfall data from the Viewbank weather station. Two types of hazard events were used to illustrate different impacts: a 'hot and dry' event and a 'hot, wet and windy' event. Impacts associated with those events were noted where possible. The storylines are presented in a concise format for simplicity. Experience has shown that a few dot-points on a page or a slide are sufficient to start a broader conversation about potential implications for climate risk management.

[43] IPCC (2022). Box 10.2: Storylines for Constructing and Communicating Regional Climate Information. In IPCC Working Group 1 AR6.
[44] Van den Hurk et al (2023) Climate impact storylines for assessing socio-economic responses to remote events - ScienceDirect
[45] TCFD (2017). Taskforce for Climate-related Financial Disclosure: Technical Supplement.
[46] Baldissera Pacchetti et al (2024). Varieties of approaches to constructing physical climate storylines: A review - Baldissera Pacchetti - 2024 - WIREs Climate Change - Wiley Online Library

Historical

Hot & dry storyline

Historical: January-February 2009

The historical 'hot and dry' event considered to have most relevance to Banyule Council occurred in summer 2009. It included a drought, a heatwave in late January 2009 and a fire in early February 2009.

Extreme weather and climate

- The Millennium drought affected Australia from 1997-2009.
- High temperatures and low rainfall hit Victoria in late January and early Feb 2009.
- Melbourne had 3 consecutive days over 43°C from 28-30 Jan 2009, a new record.
- Viewbank reached 42.9°C on 28 Jan, 44.7°C on 29 Jan and 44.0°C on 30 Jan 2009, after negligible rain over the past month.
- Melbourne had 6 consecutive nights over 20°C from 29 Jan to 3 Feb 2009, a new record.
- Melbourne's 45.1°C on 30 Jan 2009 was the second-highest on record.
- The extremely high day and night temperatures combined for a record high average temperature of 35.4°C at Melbourne on 30 Jan 2009.
- On 7 Feb 2009, Melbourne had a record high temperature of 46.4°C and Viewbank reached 46.7°C.

Impacts on electricity and health

- On 31 Jan 2009, 500,000 people were without electricity in Victoria due to load-shedding and a power station explosion.
- Traffic lights, public transport and telecommunication were affected.
- Businesses were disrupted, causing loss of services and income.
- Many people had no power for air conditioning, lights or appliances.
- Outdoor labour productivity decreased 20% due to the heat, which hampered efforts to repair damaged infrastructure.
- Victorian hospital emergency departments recorded a 12% increase in total cases (a 37% increase in those 75 years or older), and an 8 fold increase in heat-related cases (46% in those aged 75 years and over).
- 374 excess deaths in Victoria were due to heat stress (a 64% increase in those aged 75 or older).
- 1213 flying foxes in Yarra Bend Park (2 km from Banyule) died during 27–30 Jan 2009, and another 3539 died on 7 Feb 2009.

Impacts on fire and water

- Major bushfires engulfed Kinglake, Strathewen and St Andrews to the northeast of Melbourne.
- Smoke from the fires drifted south, affecting many people in Melbourne.
- Fires damaged 30% of Melbourne's water supply catchments.
- Melbourne's water storage fell to 25% in June 2009.
- Melbourne recycled 23% of sewage to boost water supply.
- Stormwater harvesting was used to irrigate gardens, sports fields and golf courses.
- Subsidies were provided for rainwater tanks.
- Stage 3a water restrictions were imposed from April 2007 to April 2010.
- Vegetation at many public gardens and sports facilities died.

References

- BoM Special Climate Statement 17
- Victoria Department of Health
- Low et al (2015) Fighting drought with innovation.
- Drought finally ends
- Flying_Fox_Scientific_Research.pdf
- Melbourne blackout causes chaos - ABC News

Hot, wet & windy storyline

Historical: December 2016

The historical 'hot, wet and windy' event considered to have most relevance to Banyule Council occurred on 29 December 2016. It was a hot day with a severe storm including strong winds, heavy rainfall and lightning.

Extreme weather

- In late December 2016, a low-pressure system from the Northern Territory brought tropical conditions over much of Australia, including South Australia and Victoria.
- On 28 December, Melbourne reached 37°C and had one of the hottest nights on record (27°C at 12.37 am on 29 December).
- On 29 December, Melbourne's temperature climbed to 33.4°C at 2.30 pm.
- A violent storm hit Melbourne around 3 pm, with strong winds, heavy rain and lightning.
- Viewbank reached 33.8°C on 29 December before recording 57.8 mm of rain between 4.00-4.30 pm, and a total of 82 mm up to 11 pm (highest total in Melbourne that day).

Flood impacts

- The SES received 1500 calls for help, including 41 people needing to be rescued from cars or buildings that had been flooded.
- La Trobe University in Bundoora was flooded.
- Hundreds of homes were damaged.
- Transport was severely disrupted.
- The multi-lane Western Ring Road was closed in both directions in Bundoora, near Plenty Road, due to flooding from Darebin Creek.
- 7 train lines were closed, including the Hurstbridge line between Greensborough and Hurstbridge.

Wind and lightning impacts

- Flights were disrupted at Melbourne airport due to wind and lightning.
- Hundreds of trees were down.
- Due to strong winds and fallen trees, about 2500 homes and businesses across Victoria were without power at 9.30pm.
- Telecommunication services were disrupted.
- National Disaster Relief and Recovery Arrangements were implemented for 19 Victorian LGAs including Banyule.

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- Vic residents clean up after heavy storms | SBS News
- Violent storm, flash floods hit Melbourne, Australia - The Watchers
- Savage thunderstorms leave widespread damage across Melbourne suburbs
- Relief for Victoria after storms, floods, heat | SBS News
- BoM scs59.pdf
- Victoria Storms and Floods: 29 December 2016

Future Scenarios

Storylines for 2050 were also developed for a 'hot and dry' event and a 'hot, wet and windy' event. The high emissions scenario (SSP3-7.0) was used in the storylines rather than the low emissions scenario (SSP1-2.6) because (a) SSP3-7.0 is more challenging and (b) SSP3-7.0 is more closely aligned with global warming estimates based on current global emission reduction policies (see Box 2)[47]. For each storyline, two scenarios were considered- one conservative and one stress test. The Conservative scenario is based on *mid-range* projected changes for 2050 SSP3-7.0 from Tables 1 and 2: 1.1ºC warming, 5% rainfall decrease, 40 dry months per 20 years, 37 annual heatwave days, 25 extreme fire weather days and no change in extreme rainfall intensity. The Stress-test scenario is based on *upper-limit* projected changes for 2050 SSP3-7.0 from Tables 1 and 2: 1.4ºC warming, 15% rainfall decrease, 50 dry months per 20 years, 47 annual heatwave days, 30 extreme fire weather days and 15% increase in extreme rainfall intensity.

Hot & dry storyline (conservative)

Future Possible Scenario: January-February 2050

Extreme weather and climate

- A 3-year drought affected Australia from 2048-2050.
- High temperatures and low rainfall hit Victoria in late January and early Feb 2050.
- Melbourne had 3 consecutive days over 44°C from 28-30 Jan, a new record.
- Viewbank reached 44.0°C on 28 Jan, 45.8°C on 29 Jan and 45.1°C on 30 Jan, after negligible rain over the past month.
- Melbourne had 6 consecutive nights over 21°C from 29 Jan to 3 Feb, a new record.
- The extremely high day and night temperatures combined for a record high average temperature of 36.5°C at Melbourne on 30 Jan.
- On 7 Feb, Melbourne had a record high temperature of 47.5°C and Viewbank reached 47.8°C.

Impacts on electricity and health

- On 31 Jan 2050, 700,000 people were without electricity in Victoria due to load-shedding and a power station explosion.
- Traffic lights, public transport and telecommunication were affected.
- Businesses were disrupted, causing loss of services and income.
- Many people had no power for air conditioning, lights or appliances.
- Outdoor labour productivity decreased 30% due to the heat, which hampered efforts to repair damaged infrastructure.
- Some people were able to seek refuge in cool facilities such as libraries, community centres and shopping precincts that had battery or generator back-up electricity.
- Victorian hospital emergency departments recorded a 20% increase in total cases (a 50% increase in those 75 years or older), and an 11-fold increase in heat-related cases (60% in those aged 75 years and over).
- 400 deaths in Victoria were due to heat, fire and smoke-related respiratory illness.

Impacts on fire and water

- Major bushfires, ignited by dry lightning, engulfed Plenty Gorge Parklands, Ironbark Conservation Reserve and Warrandyte State Park to the northeast of Melbourne.
- Embers started a fire in Gresswell Forest Nature Reserve bordering the Banyule Council area.
- Smoke affected many people in Banyule.
- Melbourne's water storage fell to 20% in June 2050.
- Melbourne recycled 30% of sewage to boost water supply.
- Stormwater harvesting was used to irrigate gardens, sports fields and golf courses.
- Subsidies were provided for rainwater tanks.
- Stage 4 water restrictions were imposed from June to December 2050.
- Vegetation at many public gardens and sports facilities died.

[47] According to Home | Climate Action Tracker, current global policies and action would lead to a global warming of 2.2-3.4ºC by 2100, which is closer to the IPCC estimate of 2.8-4.6ºC for SSP3-7.0 compared to 1.3-2.4ºC for SSP1-2.6.

Hot & dry storyline (stress test)

Future Possible Scenario: January-February 2050

Extreme weather and climate

- A 3-year drought affected Australia from 2048-2050.
- High temperatures and low rainfall hit Victoria in late January and early Feb 2050.
- Melbourne had 3 consecutive days over 44°C from 28-30 Jan, a new record.
- Viewbank reached 44.3°C on 28 Jan, 46.1°C on 29 Jan and 45.4°C on 30 Jan, after negligible rain over the past month.
- Melbourne had 6 consecutive nights over 21°C from 29 Jan to 3 Feb, a new record.
- The extremely high day and night temperatures combined for a record high average temperature of 37°C at Melbourne on 30 Jan.
- On 7 Feb, Melbourne had a record high temperature of 47.8°C and Viewbank reached 48.1°C.

Impacts on electricity and health

- On 31 Jan 2050, 800,000 people were without electricity in Victoria due to load-shedding and a power station explosion.
- Traffic lights, public transport and telecommunication were affected.
- Businesses were disrupted, causing loss of services and income.
- Many people had no power for air conditioning, lights or appliances.
- Outdoor labour productivity decreased 40% due to the heat, which hampered efforts to repair damaged infrastructure.
- Some people were able to seek refuge in cool facilities such as libraries, community centres and shopping precincts that had battery or generator back-up electricity.
- Victorian hospital emergency departments recorded a 30% increase in total cases (a 60% increase in those 75 years or older), and an 11-fold increase in heat-related cases (70% in those aged 75 years and over).
- 500 deaths in Victoria were due to heat, fire and smoke-related respiratory illness.

Impacts on fire and water

- Major bushfires, ignited by dry lightning, engulfed Plenty Gorge Parklands, Ironbark Conservation Reserve, Warrandyte-Kinglake Nature Reserve and Warrandyte State Park to the northeast of Melbourne.
- Embers started a fire in Gresswell Forest Nature Reserve bordering Banyule Council, and Banyule Flats Reserve within the Council area.
- Fire Rescue Victoria, SES and Council resources were deployed to manage the Banyule Flats fire.
- Smoke affected many people in Banyule.
- Melbourne's water storage fell to 15% in January 2050.
- Melbourne recycled 40% of sewage to boost water supply.
- Stormwater harvesting was used to irrigate gardens, sports fields and golf courses.
- Subsidies were provided for rainwater tanks.
- Stage 4 water restrictions were imposed from January to December 2050.
- Vegetation at many public gardens and sports facilities died.

Hot, wet & windy storyline (conservative)

Future Possible Scenario: December 2050

Extreme weather

- In late December 2050, a low-pressure system from the Northern Territory brought tropical conditions over much of Australia, including South Australia and Victoria.
- On 28 December, Melbourne reached 38.1°C and had one of the hottest nights on record (28.1°C at midnight on 29 December).
- On 29 December, Melbourne's temperature climbed to 34.5°C at 2.30 pm.
- A violent storm hit Melbourne around 3 pm, with strong winds, heavy rain and lightning.
- Viewbank reached 34.9°C on 29 December before recording 60 mm of rain between 4.00-4.30 pm, and a total of 85 mm up to 11 pm.

Flood impacts

- The SES received 1500 calls for help related flood damage.
- Over 400 properties were flooded in Rosanna, Macleod and Heidelberg West near Salt Creek and Darebin Creek.
- Transport was severely disrupted.
- The multi-lane Western Ring Road was closed in both directions in Bundoora, near Plenty Road, due to flooding from Darebin Creek.
- 7 train lines were closed, including the Hurstbridge line between Greensborough and Hurstbridge.

Wind and lightning impacts

- Flights were disrupted at Melbourne airport due to wind and lightning.
- Hundreds of trees were down.
- Due to strong winds and fallen trees, about 2500 homes and businesses across Victoria were still without power for 2 days.
- Telecommunication services were disrupted for 2 days.
- National Disaster Relief and Recovery Arrangements were implemented for 19 Victorian LGAs including Banyule.

Hot, wet & windy storyline (stress test)

Future Possible Scenario: December 2050

Extreme weather

- In late December 2050, a low-pressure system from the Northern Territory brought tropical conditions over much of Australia, including South Australia and Victoria.
- On 28 December, Melbourne reached 38.4°C and had one of the hottest nights on record (28.4°C at midnight on 29 December).
- On 29 December, Melbourne's temperature climbed to 34.8°C at 2.30 pm.
- A violent storm hit Melbourne around 3 pm, with strong winds, heavy rain and lightning.
- Viewbank reached 35.2°C on 29 December before recording 70 mm of rain between 4.00-4.30 pm, and a total of 100 mm up to 11 pm.

Flood impacts

- The SES received 1700 calls for help related flood damage.
- Over 600 properties were flooded in Rosanna, Macleod, Heidelberg West, Yallambie and Greensborough near Salt Creek, Darebin Creek and Plenty River.
- Transport was severely disrupted.
- The multi-lane Western Ring Road was closed in both directions in Bundoora, near Plenty Road, due to flooding from Darebin Creek.
- 7 train lines were closed, including the Hurstbridge line between Rosanna and Hurstbridge.

Wind and lightning impacts

- Flights were disrupted at Melbourne airport due to wind and lightning.
- Over 1,000 trees were down.
- Due to strong winds and fallen trees, about 3000 homes and businesses across Victoria were still without power for 4 days.
- Telecommunication services were disrupted for 4 days.
- Emergency shelter was provided for 200 people by Banyule Council.
- National Disaster Relief and Recovery Arrangements were implemented for 25 Victorian LGAs including Banyule.

These storyline narratives can be used in Council engagement processes to explore potential impacts and management strategies in more detail. It is important to consider direct impacts (e.g. electricity disruption) and cascading impacts (e.g. loss of cooling, lighting, appliances, telecommunication, transport, etc) that affect multiple objectives (e.g. health, safety, business productivity, livelihoods, financial sustainability, ecosystems, etc). This requires consultation with external parties such as state government agencies, private sector service providers, non-government organisations and local communities.

Engagement with Victorian local councils and a review of climate change risk management guidance has shown that most councils start with their own enterprise risk framework, which assesses risk in terms of consequence and likelihood[48]. While this is straight-forward for historical risks, it is difficult for future risks because likelihoods are not quantified (see Box 1). It is therefore worth considering the IPCC risk framework, based on hazard, exposure and vulnerability. This has been used in a climate risk assessment undertaken for the City of Melbourne[48], as well as Sunshine Coast and Noosa Councils. This approach will also be incorporated into Banyule City Council's climate adaptation plan.

[48] Nation Partners (2024). *VCRC Tool Scoping Research Findings Report V3.0 (clean)

5 Conclusions

Historical climate hazards (weather events Victoria has experienced) are affected by year-to-year variability and underlying climate change. Victoria's seven hottest years occurred in the last 18 years (2007, 2009, 2013, 2014, 2018, 2019 and 2024). Victoria's driest years were 1914, 1938, 1940, 1944, 1967, 1982 and 2006. The wettest years were 1952, 1956, 1973, 1974, 1992, 2010 and 2022. Climate change due to increases in global greenhouse gas emissions has contributed to warmer and drier conditions over recent decades. The state has warmed by 1.2°C since 1910, and April-October rainfall has declined 10% in the past 30 years compared to 1961-1990.

Future climate hazard scenarios are based on simulations from downscaled CMIP6 climate models, for low (SSP1-2.6) and high (SSP3-7.0) greenhouse gas emissions pathways. Projections for the Greater Melbourne Region, published by CSIRO in 2024, indicate warmer conditions in all seasons over the coming decades. For low emissions, the projected increase in annual-average temperature is about 1°C for 2050, 2070 and 2090. For high emissions, the increase is about 1°C by 2050, 2°C by 2070 and 3°C by 2090. This means more hot days and fewer cold days. Drier conditions are projected for all seasons, especially spring. For low emissions, the projected decrease in annual-average rainfall is about 5% for 2050, 2070 and 2090. For high emissions, the decrease is 5% by 2050, 9% by 2070 and 12% by 2090. The intensity, frequency and duration of droughts, fires and heatwaves is likely to increase. Despite generally drier conditions, the intensity of extreme daily rainfall and floods is likely to increase because a warmer atmosphere can hold more moisture, which intensifies rainstorms when they occur.

Over Victoria, the annual-average number of heatwave days was 20 during 1986-2005. By 2050, this increases to 29 days (uncertainty range 20-38) for low emissions and 37 days (27-47) for high emissions scenarios. By 2050, the intensity of extreme rainfall (99th percentile, exceeded 3-4 times per year) is projected to change by 0% (uncertainty range -10 to +12%) for low emissions and 0% (-10 to +15%) for high emissions.

As evidenced by the local storylines, significant impacts are already occurring locally and are expected to become worse in future. For example, power outages have caused disruptions to air conditioning, lighting, appliances, transport and telecommunication. Impacts from heat and smoke have harmed public health. Floods have impacted local infrastructure and property. These storylines can help staff and stakeholders determine who might be most impacted in the municipality and what the Council should prioritise in terms of risk.

In summary, climate science provides the evidence-based foundation for assessing current and future climate risks. The science tells us that our local, regional and global climate is changing due to increases in greenhouse gas emissions caused by human activities. Impacts associated with extreme weather events are already significant for the environment, society and economy. Future increases in greenhouse gas emissions will exacerbate impacts associated with extreme weather events. Banyule's climate risk assessment and adaptation plan aims to build resilience to current and future impacts.