Blackwattle Bay

State Significant Precinct

Attachment 33:

Climate Change Adaptation Report

June 2021

NSW GOVERNMENT

Climate Change Adaptation Report -
Blackwattle Bay State Significant Precinct

Infrastructure NSW
26-May-2021

Climate Change Adaptation Report

Blackwattle Bay State Significant Precinct

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Blackwattle Bay State Significant Precinct

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Quality Information

Document Climate Change Adaptation Report

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Revision History

Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
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3	05-Feb-2021	Draft for DPIE review	Suzanna Remmerswaal, Associate Director	
4	26-May-2021	Final for Consultation	Adam Davis Technical Director, Sustainability and Resilience	

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Executive Summary

The Climate Change Adaptation Report outlines historical and future exposure of the Blackwattle Bay State Significant Precinct (SSP) to climate-related shocks; presents the participatory risk assessment process undertaken in preparing this report; outlines adaptation actions that have been integrated into the concept proposal; and provides additional actions that can be considered in future development stages (e.g. detailed design).

The primary objective of the Report is to improve the climate change resilience outcomes of the Precinct by addressing the Study Requirements issued by the NSW Minister for Planning in April 2017:

> ***17. Climate Change Adaptation***
>
> *17.2. Provide a Climate Change Adaptation Report which details how the proposal will address social, environmental and economic effects of climate change on future communities (see NSW and ACT Regional Climate Modelling: NARCLIM), including designing to manage changing temperatures and rainfall patterns through the integration of vegetation (existing and future), permeable and reflective surfaces, and Water Sensitive Urban Design features.*
>
> *17.3. Assess the potential impacts of climate change on vulnerable groups, including older people, and mechanisms for implementing mitigation strategies.*
>
> *17.4. Undertake sensitivity analysis to address the impact of climate change due to increased temperatures, extreme heat events and changing rainfall patterns as informed by the Water Quality, Flooding and Stormwater Study.*

Requirements 17.2 – 17.4 will be addressed in full by the Climate Change Adaptation Report. It is noted that additional requirements exist under the Climate Change Adaptation category, namely Requirements 17.1, 17.5, and 17.6, and these will be addressed in separate reports – notably the Ecologically Sustainable Development Report (AECOM, 2020) and the Urban Forest Strategy Plan (TreeIQ, 2020).

The approach taken to develop the Report was to first review the exposure of the site to climate change-related hazards (such as extreme temperatures, heavy rainfall events, extreme storms, sea level rise, and bushfires). Preliminary risks were then identified by the project team, which were workshopped and validated through a series of stakeholder exercises and community engagement activities. Priority risks were identified and adaptation actions to mitigate risks were developed and integrated into design documentation. The key climate impacts identified through the risk assessment workshop process are outlined below.

Key impacts identified for Blackwattle Bay SSP: Risks arising from climate hazards

Climate hazard	Risk
Changes to mean temperature and the number/severity of hot days	Extreme heat resulting in heat stress outcomes for residents, workers and visitors, particularly for older people and vulnerable members of the community
	Extreme heat events increasing energy demand and reducing energy network capacity resulting in an increased number of black outs causing electrical and communications failure
	Increased energy and water demand for all building types, especially for commercial office buildings when air conditioning units work harder and impact energy network capacity
	In an extreme event where power is lost, the interdependencies between resident's healthcare systems and electrical and communications could fail and cause loss of life and injury

Climate hazard	Risk
Changes to storm conditions (i.e. extreme wind and east coast low storms)	Debris from high winds causing more significant and more frequent damage to external surfaces (e.g. loss of building materials) and exposed plant / equipment (e.g. mechanical air conditioning)
Changes to mean rainfall and drought conditions	Smoke from bushfires causing increase in respiratory and human health impact to workers, visitors, and residents and causing damage from penetration into buildings through unsealed areas and reduced efficiency of equipment (e.g. mechanical air conditioning)
	Reduced rainfall resulting in drought conditions and impacting regional water supply, resulting in increased water restrictions and demand for recycled water
Sea level rise and coastal flooding	Increase in safety issues to personnel, residents, and visitors around hazardous and unpredictable stormwater runoff and flood waters
	Sea level rise exacerbating the impact of flooding from storm surge during an extreme storm causing building damage

Adaptation actions and responses have been identified and integrated into the Precinct Plan to address these climate impacts.

Response to key climate impacts outlined in the Precinct plan

Climate hazard	Adaptation measures: Responses integrated into the Precinct Plan
Changes to mean temperature and the number/severity of hot days	• Canopy coverage over paved surfaces serves as a cost-effective means of mitigating urban heat island effects and additional projected increases in mean temperature and extreme heat events. The Urban Forest Strategy Plan indicates that streets and promenades will have a minimum tree canopy cover of 60%, with a mix of small/medium/large trees (up to 20m high). The open space areas (Bank St Park and Promenade Open Space) will have a minimum tree canopy cover of 30% and will be a mix of tree sizes including those over 20m in height. This will be facilitated by maximising the retention of deep soil areas. These targets represent an increase in the existing canopy coverage on the site. The tree retention and replacement targets will help to reduce the urban heat for pedestrians and residents (including those most vulnerable; elderly, youth, disabled). An increase in vegetation surrounding the site will also help to improve air quality which benefits those with respiratory issues. • The Precinct Plan features several water sensitive urban design (WSUD) measures which provide a means for cooling the microclimate and reducing urban heat island effects. For example, the integration of water into landscapes assists in cooling urban areas via evaporation, provides activities for children, and provides amenity for the community. If designed appropriately, there are also significant co-benefits for flood mitigation. • Facades are planned to have depth and incorporate shading capacity, particularly for ground floor premises. • Natural (passive) ventilation is a key principle of the design of buildings in addition to maximising the orientation of the building to help reduce heat gain and the burden of the HVAC systems.

Climate hazard	Adaptation measures: Responses integrated into the Precinct Plan
Changes to storm conditions (i.e. extreme wind and east coast low storms)	• Building placement will be optimised to the best extent possible (taking into account design constraints such as the Western Distributor, foreshore depth and solar amenity), to consider wind mitigation and reduce the impact of high winds resulting from extreme storms. Design guides should seek to strengthen facades and areas likely to experience high wind affects (e.g. reduce glass facades, external fixtures, unfixed outdoor seating and shading). Wind impact and mitigation measures are explored further in the SLR wind study.
Changes to mean rainfall and drought conditions	• Inclusion of water sensitive urban design features help minimise water use for irrigation.
Sea level rise and coastal flooding	• Specification of podiums / site levels at 3.0m AHD elevation, with non-critical areas (e.g. Promenade) designed at 2.5m AHD accounts for future sea level rise. • Precinct Plan identifies a stepped embankment between promenade and water level to ensure access to water is maintained regardless of sea level.

Sensitivity to climate change assessments were undertaken in two ways. Firstly, the Water, Riparian Land, Flooding and Stormwater Study (Cardno, 2021) ran a sensitivity test of the stormwater infrastructure to climate change by undertaking model runs that consider an increase in rainfall intensity during extreme rainfall events. It was found that the drainage infrastructure has capacity to account for this increase, and as a result there is no significant increase to flood hazards resulting from climate change. Secondly, climate change projections were reviewed across two greenhouse gas emission scenarios (representing medium-low and high rates of emissions towards the end of the century). Both risks and adaptation actions were found to be relevant for the site under all scenarios and were adopted.

It is anticipated that as the proposed development progresses from the master plan planning application to detailed design, further climate risk assessment and review will be undertaken to verify integration of adaptation measures in the design and how that has resulted in changes to the risks previously identified. Furthermore, as integrating adaptation measures can occur throughout the life of the project, additional actions have been identified in this report to pursue and address in subsequent phases of the development of the Blackwattle Bay SSP.

1.0 Introduction

This Climate Change Adaptation report has been prepared by AECOM on behalf of Infrastructure NSW, to form part of the Blackwattle Bay State Significant Precinct Study (SSP Study). Blackwattle Bay presents a significant opportunity for urban renewal across 10.4 hectares of predominantly government owned land less than 1km from the Sydney CBD. The SSP Study seeks a rezoning for new planning controls for the precinct.

In 2015 NSW Government recognised The Bays Precinct as one of the highest potential urban transformation sites in Australia with the release of The Bays Precinct, Sydney Transformation Plan. Following this, the Minister for Planning recognised the renewal of Blackwattle Bay and the broader Bays Precinct as a matter of State planning significance and to be investigated for rezoning through the SSP process. NSW Government is also investigating the delivery of a Metro Station in Pyrmont and has recognised the potential to transform the Pyrmont Peninsula with a new 20-year vision and planning framework through the Pyrmont Peninsula Place Strategy.

The Blackwattle Bay SSP Investigation Area ('Study Area') encompasses the land and water area, known as Blackwattle Bay, between Bank Street and the Glebe foreshore shown in Figure 1. The 10.4 hectare land parcel is located within the City of Sydney local government area (LGA). It is largely government owned land containing the Sydney Fish Market (wholesale and retail), recreation and boating operations and facilities. There are three privately owned sites including a concrete batching plant operated by Hymix, wholesaler of seafood Poulos Brothers and Celestino. The Blackwattle Bay land area wraps around the southern and eastern edges of Blackwattle Bay and is bounded by Bridge Road to the south and Bank Street to the east. The Western Distributor road / Anzac Bridge is located adjacent to the eastern boundary before traversing over the northern section of the site. The water area of Blackwattle Bay is approximately 21 hectares.

Figure 1 Blackwattle Bay Precinct overview (source: INSW)

A critical part of Blackwattle Bay's revitalisation and vision has been NSW Government's decision to relocate the Sydney Fish Market from its existing location on Bank Street to the head of Blackwattle Bay. This was sought through a State Significant Development Application (SSDA) process and approved in June 2020. The new Sydney Fish Market was designed alongside the baseline Blackwattle Bay studies to ensure that key aspects of the project are consistent with the vision and objectives for Blackwattle Bay.

The outcome of the SSP process will be a new planning framework that will enable further development applications for the renewal of the Precinct, connected to the harbour and centred around a rejuvenated Sydney Fish Market. The framework will also provide for new public open spaces including a continuous waterfront promenade, community facilities, and other compatible uses.

Study Requirements for the precinct (formerly known as 'Bays Market District') were issued by the Minister on 28 April 2017. This report provides a comprehensive investigation of climate change-related risks to address a part of the Study Requirements and support the development of a new planning framework for Blackwattle Bay.

1.1 State Significant Precinct Study

The SSP Study is proposing to rezone Blackwattle Bay with a new planning framework and planning controls to enable its future urban renewal. The proposal is based on a Blackwattle Bay Precinct Plan ('Precinct Plan') which provides a conceptual layout to guide development of planning controls for the precinct and has informed this assessment. The Precinct Plan is shown in Figure 2 below.

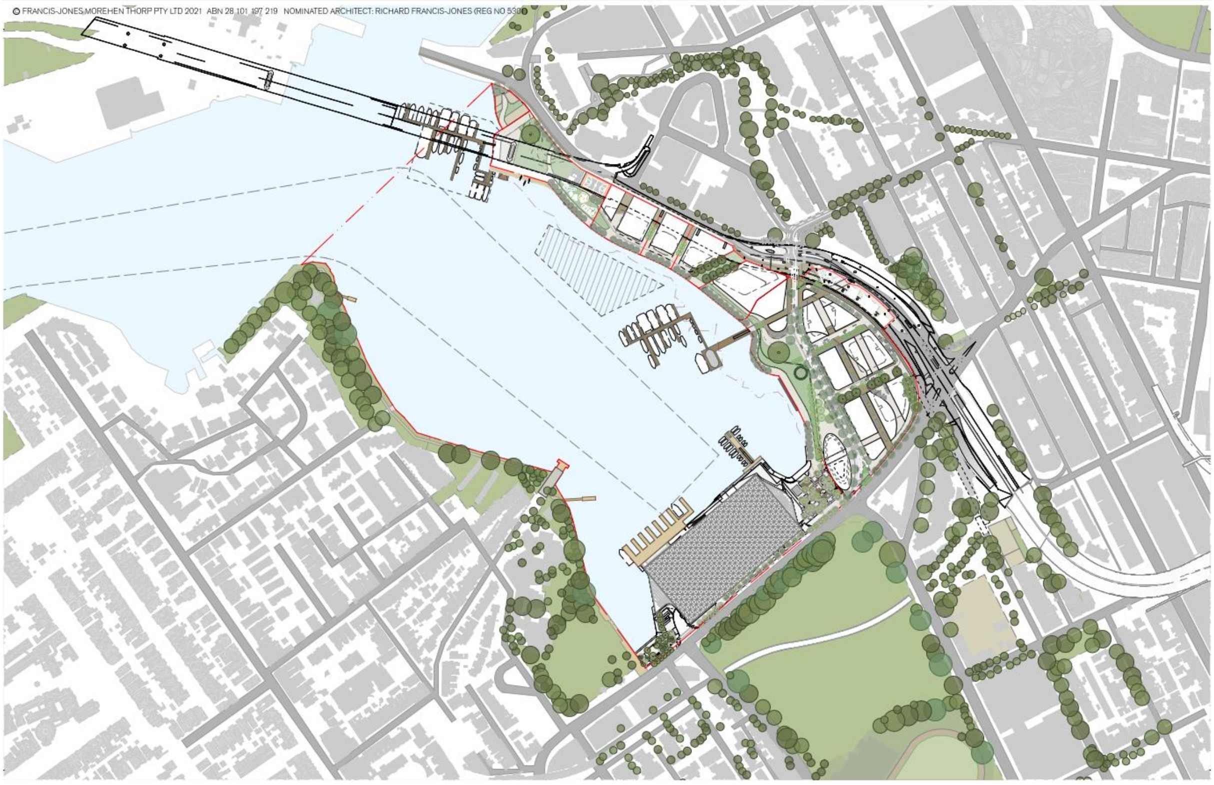

Figure 2 Blackwattle Bay Precinct Master Plan (source: FJMT)

The Precinct Plan provides overarching guidance about how an area should be developed based on local character and place, current and future demographics, economic and social trends, cultural and environmental considerations, and urban renewal aspirations and needs regarding land use, community recreation, transportation, housing, and jobs. Key characteristics of the Precinct Plan include:

- New homes, jobs and services close to the CBD including:
  - 5,636 jobs / or approximately 5,600 jobs
  - 2,795 residents /or approximately 2,800 residents
  - 1546 dwellings
- A continuous waterfront promenade – the missing link in an otherwise 15km walk from Woolloomooloo to Rozelle
- New connections to bring the neighbourhood closer to the harbour through new and improved pedestrian and cycling links

- Improved transport options and minimised vehicle usage strategy including:
  - Minimising car parking spaces provided in basement and limited on street parking.
  - Ferry wharf
  - Opportunity for buses to service through site link
  - Connections to the existing light rail
  - Access to a future Sydney Metro West Station in Pyrmont
- New parks and green space with 50% new public domain and 30% new open space
- An authentic, and world class new Sydney Fish Market at the heart of Blackwattle Bay
- An authentic place, by building on Indigenous and industrial stories and celebrating the local character.

Once the Study Area is rezoned and the new planning controls are in place, future development will need to seek development approval through the relevant approval pathway. This will include detailed development proposals and further associated environmental, social and economic assessments.

1.1.1 A Future Blackwattle Bay

NSW Government recognises the extraordinary opportunity in revitalising Blackwattle Bay, to deliver an authentic, vibrant and sustainable place connected to Sydney's iconic harbour.

Urban renewal must be both responsive and complementary to the new Sydney Fish Market as well as the local community and the Bay's rich identity and history. Within the next 15 years, the new Sydney Fish Market is expected to attract 6 million visitors annually, it will be one of Sydney's most visited areas and must have diverse uses and offerings to enhance its interest and vibrancy from day to night. A new foreshore promenade connecting Blackwattle Bay to Rozelle Bay and Woolloomooloo is also a key outcome of the urban renewal of the SSP Study Area.

1.1.2 Vision and principles

Principles for a future Blackwattle Bay were formed through extensive community consultation in August 2017. These were further developed in 2019, together with a vision for the precinct. Both are provided below. These have guided the development of the Precinct Plan and will continue to guide future development proposals within the Study Area.

> *"Blackwattle Bay offers an extraordinary opportunity to reconnect the harbour, its surrounding neighbourhoods and the city; to showcase Sydney's living culture and stories of Country; to build an inclusive and iconic waterfront destination that celebrates innovation, diversity and community."*

Principles:

1. Improve access to Blackwattle Bay, the foreshore and water activities for all users
2. Minimise additional shadowing to Wentworth Park and Glebe Foreshore (in mid-winter) and create new places with comfortable conditions for people to enjoy.
3. Pursue leading edge sustainability outcomes including climate change resilience, improved water quality and restoration of natural ecosystems.
4. Prioritise movement by walking, cycling and public transport.
5. Balance diverse traffic movement and parking needs for all users.
6. Link the Blackwattle Bay precinct to the City, Glebe Island and White Bay and other surrounding communities and attractors.
7. Mandate Design Excellence in the public and private domain.
8. Integrate housing, employment and mixed uses to create a vibrant, walkable, mixed use precinct on the city's edge.
9. Maintain and enhance water uses and activities.
10. Allow for co-existence and evolution of land uses over time.

11. A place for everyone that is inviting, unique in character, socially inclusive and affordable.
12. Expand the range of recreational, community and cultural facilities.
13. Plan for the future community's education, health, social and cultural needs.
14. Deliver development that is economically, socially, culturally and environmentally viable.
15. Embed and interpret the morphology, heritage and culture of the site to create an authentic and site responsive place.
16. Foster social and cultural understanding and respect to heal and grow relationships.

1.2 Study Requirements

On 28 April 2017 the Minister issued Study Requirements for the Precinct[1]. This report considers and addresses Study Requirements 17.2, 17.3, and 17.4, outlined below.

- *17.2 Provide a Climate Change Adaptation Report which details how the proposal will address social, environmental and economic effects of climate change on future communities (see NSW and ACT Regional Climate Modelling: NARCLIM), including designing to manage changing temperatures and rainfall patterns through the integration of vegetation (existing and future), permeable and reflective surfaces, and Water Sensitive Urban Design features.*
- *17.3 Assess the potential impacts of climate change on vulnerable groups, including older people, and mechanisms for implementing mitigation strategies.*
- *17.4 Undertake sensitivity analysis to address the impact of climate change due to increased temperatures, extreme heat events and changing rainfall patterns as informed by the Water Quality, Flooding and Stormwater Study.*

There are also additional Study Requirements that fall within the Climate Change Adaptation category, but are addressed by separate deliverables:

- Study requirements 17.1 and 17.6 are addressed by the Ecologically Sustainable Development Report (AECOM, 2020).
- While discussed here, it is noted that the accomplishment of item 17.4 will also be assisted by the delivery of the Water, Riparian Land, Flooding and Stormwater Study (Cardno, 2021) to assess the impacts of increased rainfall intensity.
- Study requirement 17.5 is addressed by Urban Forest Strategy Plan (Tree IQ, 2020).

Table 1 summarises the delivery of the Climate Change Adaptation Study Requirements.

Table 1 Study requirements relating to Climate Change Adaptation and how these are addressed

SSP Study Requirement		Addressed by
17	**Climate Adaptation**	
17.1	Undertake a sustainability assessment of the proposal, reflecting the directions outlined in the 'NSW Climate Change Policy Framework', October 2016, and the draft Central District Plan "Creating an efficient Central District" to achieve net-zero carbon emissions by 2050. Investigate options for achieving both net zero buildings and a net zero precinct.	• This Requirement is addressed by the Ecologically Sustainable Development Report (AECOM, 2020)
17.2	Provide a Climate Change Adaptation Report which details how the proposal will address social, environmental and economic effects of climate change on future communities (see NSW and ACT Regional Climate Modelling:	• **Section 3** outlines the exposure of the Precinct to observed and future climate hazards • **Section 4** outlines the key climate-related risks to the Precinct.

[1] NSW Dept Planning and Environment, 2017. Study Requirements for Bays Market District. Available online: https://www.planning.nsw.gov.au/-/media/Files/DPE/Other/study-requirements-for-bays-market-district-2017-04.pdf?la=en

SSP Study Requirement		Addressed by
	NARCLIM), including designing to manage changing temperatures and rainfall patterns through the integration of vegetation (existing and future), permeable and reflective surfaces, and Water Sensitive Urban Design features.	• **Section 5** outlines actions to manage these risks, including challenging temperature and rainfall patterns.
17.3	Assess the potential impacts of climate change on vulnerable groups, including older people, and mechanisms for implementing mitigation strategies.	• **Section 4** outlines the key climate-related risks to the community. • **Section 5** outlines actions to manage these risks.
17.4	Undertake sensitivity analysis to address the impact of climate change due to increased temperatures, extreme heat events and changing rainfall patterns as informed by the Water Quality, Flooding and Stormwater Study.	• **Section 3.2** outlines the findings of the Water, Riparian Land, Flooding and Stormwater Study (Cardno, 2021), including sensitivity analysis of flood conditions. • **Section 3.3** outlines additional sensitivity analysis approach for increased temperatures and extreme heat events.
17.5	Demonstrate consideration of the Urban Green Cover in NSW Technical Guidelines (OEH, 2015)	• This Requirement is addressed by the Urban Forest Strategy (TreeIQ, 2020)
17.6	Demonstrate compliance with BASIX is achievable and investigate opportunities to deliver beyond-compliance BASIX scores: Energy 40 and Water 60 for residential buildings (6+ storeys).	This Requirement is addressed by the Ecologically Sustainable Development Report (AECOM, 2020)

This Report has also been prepared with reference to the NSW Climate Change Policy Framework (NSW OEH, 2016) which aims to maximise the economic, social and environmental wellbeing of NSW in the context of a changing climate. The framework outlines policy directions for implementing the government's long-term objectives of achieving net zero emissions by 2050 and improving the resilience of NSW to a changing climate. Addressing these study requirements will help provide a more resilient Precinct and better account for future changes related to climate change. Recommendations and adaptation measures identified within this report will further serve to support the implementation of the NSW Climate Change Policy Framework and Sustainable Development Goals.

1.3 Structure of this report

To reduce the risk to vulnerable populations from climate change and minimise the effects of climate change on Blackwattle Bay, a climate change adaptation report has been prepared. This report is structured as follows:

- Section 1 outlined the study context and Study Requirements addressed by this report.
- Section 2 outlines the methodology and stakeholder engagement activities undertaken to prepare this report.
- Section 3 provides the climate change projections used as part of the assessment.
- Section 4 provides a summary of the risk assessment undertaken.
- Section 5 provides the adaptation actions that have been integrated and considered in the early planning process.
- Section 6 outlines next steps for consideration in subsequent planning and design phases.

2.0 Methodology

The assessment is designed to provide a deeper understanding of the community's exposure, sensitivity and adaptive capacity to a range of shocks and stresses, with a particular in-depth review of climate change impacts. In addition, community resilience impacts, in terms of vulnerability to climate hazards and emergency planning and preparedness, are identified for future mitigation and action.

The following steps were undertaken to complete the climate change risk assessment in accordance with the relevant standards and guidelines.

2.1 Standards and guidelines

The climate change risk assessment provided in this report has been undertaken in line with the following relevant standards and guidelines:

- The risk assessment approach set out in *AS/NZS ISO 31000:2009 Risk management – Principles and guidelines* and *ISO/IEC 31010 Risk management – Risk assessment techniques*. Both build upon *AS/NZ 4360:2004 Risk management* and its application to climate change risks.
- The climate change projections used in this assessment have been derived and collated in accordance with *AS 5334:2013 Climate change adaptation for settlements and infrastructure*, and as outlined by the Study Requirements.
- The climate change risks to the community have been assessed in line with the methods recommended in *Climate Change Impacts and Risk Management: A Guide for Business and Government*[2].
- The approach undertaken to assess climate and community resilience aligns with the requirements of Version 1.1 of the Green Buildings Council of Australia's *Green Star Communities - Adaptation and Resilience credit (Gov-4)*. The assessment has also been designed to support delivery of the Resilience category outlined in Version 2 of the Infrastructure Sustainability Council of Australia (ISCA) Infrastructure Sustainability Rating Scheme.

2.2 Design documentation and climate hazard modelling

Key literature and design documentation that have informed this study include:

- Draft Precinct Plan [dated 13 Aug 2020] (FJMT, 2020)
- Stormwater Study Title TBC (Cardno, 2020)
- Urban Forest Strategy Plan (TreeIQ, 2020)
- Ecologically Sustainable Development Report (AECOM, 2020)
- Blackwattle Bay Catchment Flood Study (City of Sydney, 2017)3
- Observed climate data relating to the nearest weather station, Observatory Hill (BOM, 2020)4
- Projections for Australia's NRM Regions – East Coast Cluster Report (CSIRO & BOM, 2015)5

[2] Department of the Environment and Heritage, 2006. Climate change impacts and risk management – a guide for government and business. Available online: https://www.environment.gov.au/system/files/resources/21c04298-db93-47a6-a6b0-eaaaae9ef8e4/files/risk-management.pdf
[3] City of Sydney, 2017. Blackwattle Bay catchment floodplain risk management plan. Available online: https://www.cityofsydney.nsw.gov.au/floodplain-management-plans/floodplain-catchment-blackwattle-bay
[4] Bureau of Meteorology, 2020. Climate statistics for Australian locations – monthly climate statistics. Available online: http://www.bom.gov.au/climate/averages/tables/cw_066062_All.shtml
[5] Dowdy, A. et al. 2015, East Coast Cluster Report, Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports, eds. Ekström, M. et al., CSIRO and Bureau of Meteorology, Australia. Available online: https://www.climatechangeinaustralia.gov.au/media/ccia/2.1.6/cms_page_media/172/EAST_COAST_CLUSTER_REPORT_1.pdf

- AdaptNSW's Interactive Maps[6] and Metropolitan Sydney Climate Change Snapshot[7]

2.3 Preliminary risk assessment

A preliminary risk assessment was prepared based on the findings of the desktop review. A risk register was developed, identifying climate risks and initial likelihood and consequence ratings were allocated for each risk statement in line with criteria outlined by the Department of the Environment and Heritage (2006)[8].

2.4 Stakeholder engagement

The preliminary risk assessment was followed by series of stakeholder engagement activities. During the engagement activities workshops were conducted with project team members and stakeholders to inform the assessment, validate climate risks with the community, and identify appropriate adaptation responses. A summary of these activities is outlined in Table 2.

Table 2 Stakeholder engagement activities

Stakeholder engagement activities
Stakeholder Workshop 9th October 2017 *Attendees included 17 stakeholders from UrbanGrowth Development Corporation's (UGDC) development and community engagement teams, representatives from the City of Sydney (CoS), NSW Department of Planning and Environment (DPE), NSW Office of Environment and Heritage, and the project consultant team: AECOM, Cardno, TreeIQ and Hassell Architects.*
Community Engagement Workshops 21st, 22nd, and 23rd November 2017 *Three community engagement workshops were run which sought to engage key stakeholders in reviewing and revising the climate risks identified and in developing appropriate adaptation actions to treat all risks rated medium or above. Workshop attendees included representatives from the Sydney Business Chamber, the Blackwattle Bay Community Reference Group, the University of New South Wales (UNSW) Local Carbon Cooperative Research Centre (CRC) and the Australian Built Environment Council (ASBEC).*
Blackwattle Bay SSP Project Team Workshop 14th September 2020 *A final workshop was undertaken to review climate risks and adaptation option following development of the Precinct Plan and ahead of Proposal submission.* *Attendees included representatives from Infrastructure NSW, FJMT, Cardno, and AECOM.*

2.5 Use of Report

While the primary purpose of the Report is to demonstrate the proposal's achievement of the Study Requirements (refer Section 1.2), it is intended that this Climate Change Adaptation Report would act as a document that will be reviewed and updated on a regular basis as design phases progress.

In addition, the Report is intended to be shared with residents, businesses, and other key community stakeholders (e.g. proponents of the individual commercial, residential and community infrastructure projects within development) for consideration in their individual resilience and emergency management planning.

[6] NSW Department of Planning, Industry and Environment. NSW Climate projections map. Available online: https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Interactive-map

[7] NSW Department of Planning, Industry and Environment. Metropolitan Sydney Climate Change Snapshot. Available online: https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Climate-projections-for-your-region/Metro-Sydney-Climate-Change-Downloads

[8] Department of the Environment and Heritage, 2006. Climate change impacts and risk management – a guide for government and business. Available online: https://www.environment.gov.au/system/files/resources/21c04298-db93-47a6-a6b0-eaaaae9ef8e4/files/risk-management.pdf

3.0 Climate context and projections

Climate differs from region to region due to changes in influencing factors such as geographical location, latitude, physical characteristics, variable patterns of atmosphere, ocean circulation and in some cases, human interaction. For the purposes of identifying and evaluating the effects and impacts of climate change it is important to note both the observed global and local climate and its influence on the Blackwattle Bay SSP, as well as how future climate projections may impact the Precinct. The following sections describe the observed conditions as wells as future scenarios across multiple future timeframes to understand how Blackwattle Bay may change or be affected by climate change over the life of the project.

3.1 Observed climate

Local climate for the region is predominantly temperate, which typically results in warm wet summers/autumn and mild, dry winter/spring. The coastal location of the Precinct also influences local climate, with generally lower temperatures experienced when compared with inland areas (e.g. Western Sydney). Rainfall patterns are typically seasonal, with higher rainfall experienced during autumn months and lower rainfall in spring (Table 3). Trends indicate variability in the amount of rainfall received from year to year. Storms result in periods of heavy rainfall and strong winds and may lead to flood events.

Table 3 Climate exposure (Bureau of Meteorology for Observatory Hill weather station[9] - the nearest available with long-term historical data)

Climate variable	Averages (1859-2020)
Average maximum daily temperature	Ranging from 26.0°C (January), to 16.4°C (July)
Average minimum daily temperature	Ranging from 18.9°C (January), to 8.1°C (July)
Extreme temperatures above 35°C	0.9 days per year over 35°C, typically in summer months
Average monthly rainfall	Ranging from 133mm (June) to 68.1mm (September)

3.1.1 Mean temperatures and urban heat island

3.1.1.1 Mean temperature

The local area typically experiences average maximum daily temperatures ranging from 26.0°C in January to 16.4°C in July, and average minimum daily temperatures ranging from 18.9°C in January to 8.1°C in July. Given its coastal location, the average temperatures for the local area are typically milder than those experienced by the Greater Sydney region, particularly Western Sydney which can experience significantly higher averages (e.g. Penrith Lakes Automatic Weather Station shows a January average maximum daily temperature of 32.2°C[10]).

[9] Bureau of Meteorology, 2020. Climate statistics for Australian locations – monthly climate statistics – Observatory Hill. Available online: http://www.bom.gov.au/climate/averages/tables/cw_066062_All.shtml
[10] Bureau of Meteorology, 2020. Climate statistics for Australian locations – monthly climate statistics – Penrith Lakes AWS. Available online: http://www.bom.gov.au/climate/averages/tables/cw_067021.shtml

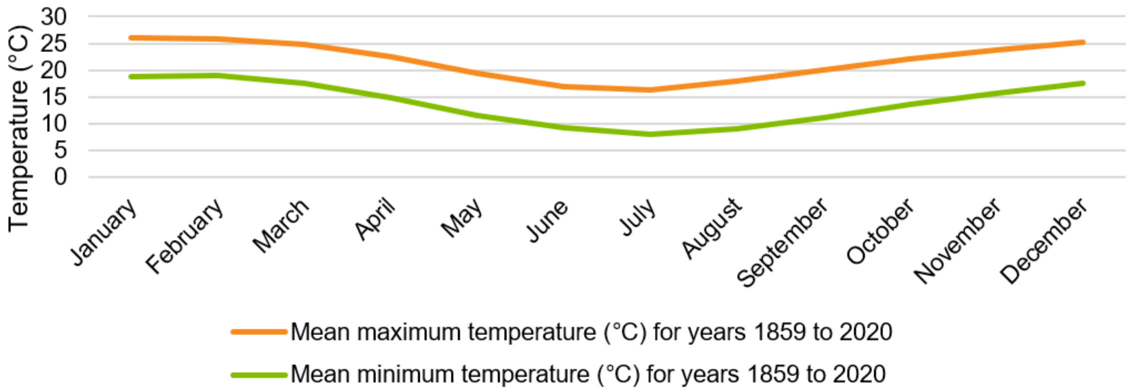

Figure 3 Mean maximum and minimum temperatures recorded at Observatory Hill (1859-2020)

3.1.1.2 Urban heat island effect

Urban heat islands occur in urban areas such cities or industrial sites and lead to consistently higher temperatures than surrounding areas driven by a greater retention of heat. This is caused by the sun's heat being absorbed by hard surfaces with high thermal mass such as buildings, dark roofs, car parks, paved surfaces and roads. Human activities, such as motorised transport and using air conditioning also increase these impacts due to their generation of waste heat.

Figure 4 shows thermal imagery for the City of Sydney local government area (LGA). Higher temperatures are seen in parts of the city that are heavily urbanised and/or characterised by large areas of paved and roofed surfaces, such as industrial areas around Alexandria, while areas of green space (such as the Royal Botanical Gardens) generally experience lower temperatures.

Despite the current industrial/commercial setting of the precinct with – a high proportion of paved surfaces and low-density buildings – the Blackwattle Bay precinct is shown to have average exposure to the impacts of the urban heat island effect, likely driven by its coastal setting. OEH (2015)[11] notes that changes in land use from industrial/commercial to medium or high density is likely to result in a reduction in average temperatures. For the precinct, temperature decreases are potentially due to the combination of shading from increased building height and the effects of afternoon coastal sea breezes.

[11] Office of Environment and Heritage, 2015. Urban Heat Climate Change Impact Snapshot. Available online: https://climatechange.environment.nsw.gov.au/-/media/NARCLim/Files/Climate-Change-Impact-Reports/Urban-Heat-Climate-Change-Impact-Snapshot.pdf

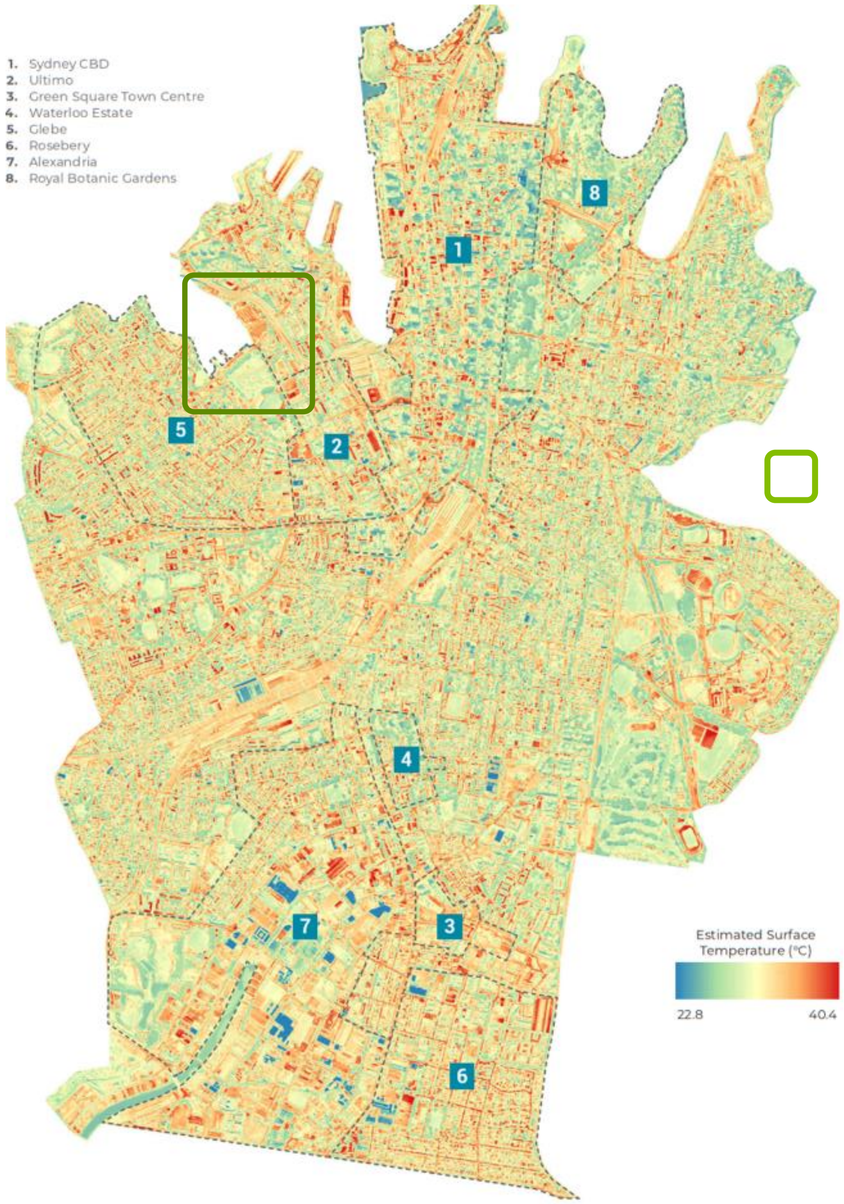

Figure 4 **Urban Heat Mapping (existing condition) for City of Sydney LGA[12]. Blackwattle Bay highlighted by green box.**

3.1.2 Extreme heat

The local area historically experiences an average of 3.2 days above 35°C per year, significantly lower than other areas of Greater Sydney (e.g. Penrith Lakes AWS historically records 22.7 days per year on average). Similar to the mean temperature averages, this is likely driven by the Precinct's coastal setting. Temperature records for Observatory Hill show highest maximum temperatures can typically exceed 40°C between November and February.

[12] City of Sydney, Low Carbon Living CRC, and University of NSW, n.d. Cooling Sydney Strategy – Planning for Sydney 2050. Available online: http://www.lowcarbonlivingcrc.com.au/sites/all/files/publications_file_attachments/sp0012u3_-_cooling_sydney_strategy_final_-_web.pdf

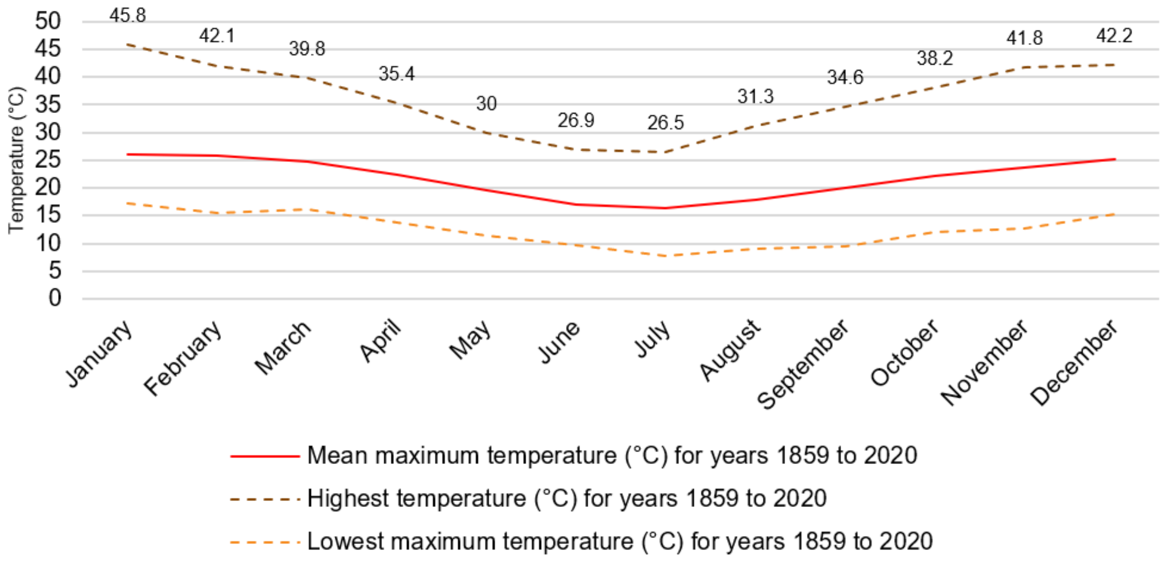

Figure 5 Average maximum average temperatures and historical maximum temperatures recorded at Observatory Hill (1859-2020)

3.1.3 Mean rainfall

Annual rainfall for the local area has averaged 1,213mm over the period 1858-2020. Typically February to June are the wettest months of the year, while August to December receive the lowest average rainfall.

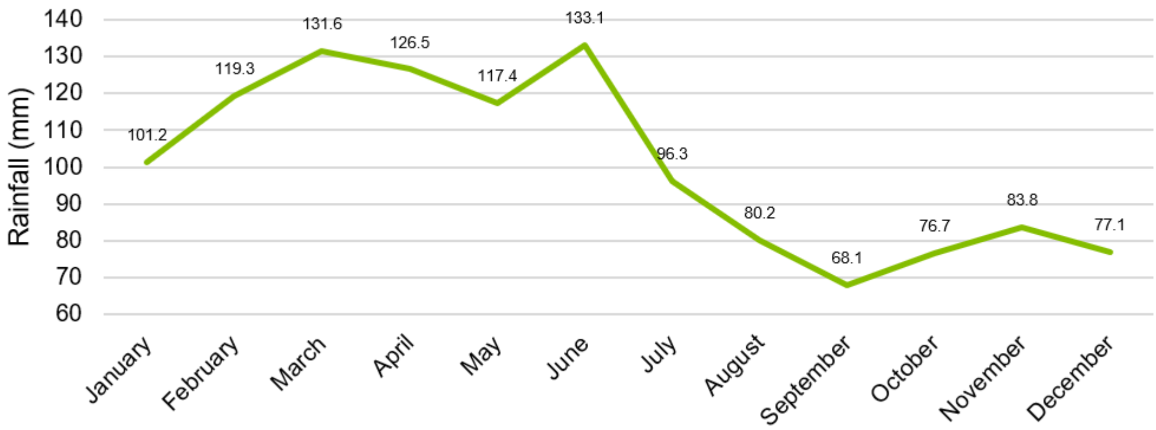

Figure 6 Mean rainfall recorded at Observatory Hill (1858-2020)

3.1.4 Extreme rainfall and flooding

The Water, Riparian Land, Flooding and Stormwater Study (Cardno, 2021) undertook a detailed flood modelling assessment to support the design of the precinct. This assessment included modelling of both existing and climate change conditions including projected sea level rise (refer section 3.2.6). The assessment showed that the precinct is subject to overland flows during large storm events, however these can be appropriately managed through the site. It was also shown that the future precinct could have minor impacts on flooding outside the Study Area, and it is anticipated that these potential impacts can be resolved during the detailed design stage and through inclusion of a modified drainage network.

Figure 7 Proposed 1% AEP flood depth and water level contours (i.e. present-day sea-level conditions) Source: Cardno

3.1.5 Storm events

The Sydney region is susceptible to storm events, predominantly in the form of east coast lows (ECLs) that develop as a result of ex-tropical cyclones that decay as they move south or interactions between troughs of low pressures/cold fronts with warmer sea surface temperatures. Within the Greater Sydney area a number of recent storm events have been recently observed:

- In June 2016, the East Coast Storms and Flood events resulted in flash flooding and property damage across Sydney
- In March 2017 a severe thunderstorm resulted in 33,000 homes without power across western Sydney and road closures
- In December 2018 a severe thunderstorm impacted Sydney's north west, leading to 3788 calls for assistance to the NSW State Emergency Service, and left 55,000 homes without power throughout nearby Castle Hill, North Parramatta, Winston Hills, and Carlingford.
- In February 2019 45,000 homes in Sydney's north west lost power due to a storm event, with up to 5,000 homes without power for multiple days.
- In February 2020 Sydney experienced two east coast lows (8th and 18th February) with rain up to 400mm falling over three days and winds exceeding 100km/h.

In addition to gale force winds and heavy widespread flooding, ECLs also generate rough seas and storm tides. Storm tides can lead to coastal flooding, particularly when they combine with astronomical high tides or king tides. This was evidenced in 2016 when an east coast low-driven storm tide combined with a king tide affected areas of Greater Sydney such as Collaroy which experienced severe inundation and erosion[13].

3.1.6 Bushfires

The Precinct is not within proximity of bushfire prone land. However, recent experience has shown that the indirect impacts of bushfire – including poor air quality and infrastructure failure – pose significant risks for all communities in the Greater Sydney region.

The Forest Fire Danger Index (FFDI) is used in NSW to quantify fire weather. The FFDI combines observations of temperature, humidity and wind speed with an estimate of the fuel state. AdaptNSW[14] notes that long-term FFDI estimates are available for two weather stations in the region, Sydney Airport and Richmond. The average annual FFDI for the period 1990–2009 is 5.5 at Sydney Airport and 7.1 at Richmond.

Fire weather is classified as 'severe' when the FFDI is above 50, and most of the property loss from major fires in Australia has occurred when the FFDI reached this level. FFDI values below 12 indicate low to moderate fire weather, 12-25 high, 25-49 very high, 50-74 severe, 75-99 extreme and above 100 catastrophic.

Severe fire weather conditions are estimated to occur on average one day per year at Sydney Airport and 1.8 days per year at Richmond. These days are more likely to occur in summer and spring months.

3.2 Climate change projections

3.2.1 Background

The State of the Climate 2020 (BOM and CSIRO, 2020)[15] confirms the long-term warming trend over Australia's land and oceans, showing that of relevance to the Precinct:

- Australia has experienced 1.44°C of warming since 1910, plus or minus 0.24°C and this has led to an increase in the frequency of extreme heat events;
- In the southeast of Australia there has been a decline of around 12 per cent in April to October rainfall since the late 1990s;
- There has been an increase in extreme fire weather, and in the length of the fire season, across large parts of the country since the 1950s;
- Oceans around Australia are acidifying and have warmed by around 1 °C since 1910, contributing to longer and more frequent marine heatwaves; and
- Sea levels are rising around Australia, including more frequent extremes, that are increasing the risk of inundation and damage to coastal infrastructure and communities.

The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (IPCC, 2013) similarly states with high confidence that Australia is already experiencing impacts from recent climate change, including a greater frequency and severity of extreme weather events. Other observed trends include an increase in record hot days, a decrease in record cold days, ocean warming, sea-level rise and increases in global greenhouse gas concentrations.

Due to long lag times associated with climate processes, even if GHG emissions are mitigated and significantly reduced, the warming trend is expected to continue for centuries (IPCC, 2007).

To assess the risk to Blackwattle Bay posed by climate change, the current climate science and model projections have been investigated based on available data sources, which for the purposes of this

[13] Australian Broadcasting Corporation, 2016. NSW weather: Sydney homes evacuated as king tide combines with east coast low. Available online: https://www.abc.net.au/news/2016-06-06/nsw-homes-evacuated-as-king-tide-combines-with-east-coast-low/7479736
[14] NSW Department of Planning, Industry and Environment. Metropolitan Sydney Climate Change Snapshot. Available online: https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Climate-projections-for-your-region/Metro-Sydney-Climate-Change-Downloads
[15] Bureau of Meteorology and CSIRO, 2020. State of the Climate 2020. Available online: http://www.bom.gov.au/state-of-the-climate/

climate change risk assessment have been chosen in accordance with the Study Requirements, and supplemented by the hierarchy presented in the *TfNSW Climate Risk Assessment Guidelines* (Transport for NSW, 2016)[16], as follows:

- AdaptNSW's Interactive Maps[17] and Metropolitan Sydney Climate Change Snapshot[18] which outline results associated with the NARCliM project.
- Projections for Australia's NRM Regions – East Coast Cluster Report (CSIRO & BOM, 2015)[19]

It is important to note the integrity of each climate data set as a whole, as the projections presented by each source represent a range of climate futures based on specific modelling parameters, scenarios and assumptions as described in the following sections. Care has been taken to consider each set of climate projections, to ensure an 'internally consistent climate future' approach.

3.2.1.1 Emission scenarios

Greenhouse gas emission scenarios estimate the quantity of greenhouse gas that may be released into the atmosphere in the future, based on a range of possible future economic, business, social and environmental pathways. The greenhouse emissions scenarios used to inform this climate risk assessment are chosen based on the available climate projections from the following sources and include:

- AdaptNSW/NARCliM
  - The Special Report on Emissions Scenarios (SRES) A2 scenario represents a high emissions pathway driven by economic growth and is projected to result in warming by approximately 3.4ºC by 2100. The SRES A2 emission scenario was selected for use in the NARCliM climate projections as a review of the global emissions trajectory suggests that we are tracking along the higher end of the A2 scenario.
- Projections for Australia's NRM Regions – East Coast Cluster Report
  - Projections are presented for two emission scenarios or possible pathways, referred to as 'Representative Concentration Pathways' (RCPs), each of which reflects a different concentration of global greenhouse gas emissions. Two RCPs were evaluated; the intermediate emissions (RCP4.5) and high emissions (RCP8.5) scenarios. The RCP8.5 pathway, which arises from little effort to reduce emissions and represents a failure to prevent warming by 2100, is similar to the highest SRES scenario, while the RCP 4.5 pathway arises from some effort to reduce emissions.

For the purposes of this assessment, projections associated with high emissions scenarios (i.e. SRES A2 and RCP8.5) have been outlined as global emissions currently does and will continue to follow this trajectory – even if all commitments under the Paris Agreement are met[20].

However, comparing high emission scenarios with medium-low scenarios (i.e. RCP4.5) can also serve as a form of sensitivity testing and scenario planning to understand the impacts based on different projections. Adaptation planning can take into consideration potential changes and how this may influence design actions. A comparison of mean temperature and extreme heat days between RCP 4.5, RCP 8.5, and SRES A2 is provided in Section 3.3.

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[16] Transport for NSW, 2016. TfNSW Climate Risk Assessment Guidelines. Available online: https://www.transport.nsw.gov.au/sites/default/files/media/documents/2017/tfnsw-climate-risk-assessment-guideline-9tp-sd-081-1.pdf

[17] NSW Department of Planning, Industry and Environment. NSW Climate projections map. Available online: https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Interactive-map

[18] NSW Department of Planning, Industry and Environment. Metropolitan Sydney Climate Change Snapshot. Available online: https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Climate-projections-for-your-region/Metro-Sydney-Climate-Change-Downloads

[19] Dowdy, A. et al. 2015, East Coast Cluster Report, Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports, eds. Ekström, M. et al., CSIRO and Bureau of Meteorology, Australia. Available online: https://www.climatechangeinaustralia.gov.au/media/ccia/2.1.6/cms_page_media/172/EAST_COAST_CLUSTER_REPORT_1.pdf

[20] Olhoff, A., Christensen, J.M., 2018. Emissions Gap Report 2018. United Nations Environment Programme. Available online: https://www.unenvironment.org/resources/emissions-gap-report-2018

It is worth noting that NARCliM and Climate Futures are based on different versions of the International Panel on Climate Change (IPCC) Assessment Reports (AR). The NARCliM project downscaled projections based on AR4 data, while Climate Futures utilise models from AR5. While the AR5 data is more recent, the downscaling methodology applied by the NARCliM project produces results that are more regionally-relevant while still producing results in line with AR5 data[21].

3.2.1.2 Time scales

Given the expected design life of the infrastructure within Blackwattle Bay (in excess of 50 years), the general timeframe for the proposed construction works and the available climate data, the time periods which have been used for assessment are 2030 and 2070/2090[22]. Climate change projections for 2030 were identified as appropriate for assessment of short-term impacts of climate change on the proposed works. Climate change projections for 2070/2090 are relevant to the longer-term operation and maintenance stages of the proposed works.

Climate projections for the selected time scales represent averages over a 20-year period:

- Projections for 2030 represent the average for the 20-year period between 2020 – 2039.
- Projections for 2070 represent the average for the 20-year period between 2060 and 2079.
- Projections for 2090 represent the average for the 20-year period between 2080 – 2099.

3.2.2 Summary of projections

Table 4 Climate change projections for 2030 and 2090 (relative to 1986-2005 under RCP8.5 outlined by CSIRO & BOM, 2015)

Climate Variable	Baseline (1981-2010)	2030	2090
Mean annual temperature	22.5°C (max) 14.5°C (min)	Increase of 0.7°C to 1.3°C	Increase of 2.9°C to 4.6°C
Extreme temperature (number of days per year above 35°C)	3.1 days	4.3 days[23]	11 days
Mean annual rainfall	1,222mm	Decrease of 11% to increase of 6%	Decrease of 20% to increase of 16%
Average increase in rainfall intensity	N/A	Increase of 4.9%[24]	Increase of 18.6%
Extreme rainfall (5% AEP event)	N/A	Projections not available	Increase by 5% to 40%
Mean annual wind speed	8.3km/h (9am) 13.9km/h (3pm)	Decrease of 2.3% to increase of 1.9%	Decrease of 6.9% to increase of 4.2%
Annual bushfire weather (number of days with a 'severe' fire danger rating)	N/A	Increase by 45%	Increase by 130%
Sea level rise	N/A	Increase of 0.10 metres to 0.19 metres	Increase of 0.45 metres to 0.88 metres
FFDI (sum of all daily FFDI values over a year)	2359	2634	3077

[21] AdaptNSW, 2014. CMIP3 vs CMIP5. Available online: https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/About-NARCliM/CMIP3-vs-CMIP5
[22] Projections available from NARCliM are provided for 2070, while projections sourced from BOM & CSIRO (2015) are provided for 2090
[23] Data for RCP 4.5 as data for RCP 8.5 not available
[24] AR&R (2016) uses CSIRO data to determine a nominal 5% increase in rainfall intensity per degree of temperature increase

Table 5 Climate change projections for 2030 and 2070 for the Sydney region (under SRES A2 outlined by AdaptNSW, 2013)

	Baseline	2030	2070
Change in average temperature (°C)	N/A	0.6°C increase	2.0°C increase
Change in annual rainfall (%)	500-700mm	1.9% increase	11.8% increase
Changes in number of days a year FFDI > 50	1 day (Sydney Airport) 1.8 days (Richmond)	+0.1 days	+0.4 days
Change in number of days a year max temp > 35ºC	<10 days	+2.3 days	+6.1 days
Change in number of cold nights (min temp < 2ºC)	<10 days	-	-0.3 days

3.2.3 Mean temperature

There is a very high level of confidence in temperature projections as all models show increases in mean temperatures across the Sydney Metropolitan region for both the near future and far future. Under SRES A2, mean temperatures are projected to rise by 0.63 ºC by 2030 above the baseline climate of 1986-2005 for the Sydney Metropolitan region, with the greatest change projected during spring months. Mean temperatures are projected to rise by 1.95 ºC by 2070[25] above the baseline climate of 1986-2005.

Similarly, under RCP8.5 there is very high confidence in projections relating to average temperatures – all climate models show increases in mean temperatures across the region for both the near future and far future. By 2030, mean warming is around 0.6 to 1.3°C above the baseline climate of 1986-2005. By 2090, mean warming is projected to increase by 2.9 to 4.6°C above the 1986-2005 baseline[26].

As discussed, urban heat island effects and the ongoing development of greenfield sites throughout the Sydney region exacerbate stresses of climate change related temperature increases discussed above. Section 3.1.1.2 noted that suburbs transitioning from industrial/commercial to medium/high density are likely to experience a decrease in annual temperatures as effects of overshadowing and localised wind tunnelling effects come into play. What the outcome will be for the Precinct is uncertain, however there is a clear opportunity for the development to reduce and better manage its own ambient temperature, as well as minimise (and provide a positive contribution to) its cumulative impacts on the surrounding City of Sydney LGA.

3.2.4 Extreme temperatures

The area is expected to experience more hot days in both the near future and far future. In the period 1981-2101 Observatory Hill experienced 3.4 days above 35°C per year. The local area is, on average, projected to experience 2.9 additional hot days in 2030, increasing to an additional 7.5 hot days in 2070 under SRES A2[27] compared to a baseline of 1986-2005.

[25] NSW Department of Planning, Industry and Environment. NSW Climate projections map. Available online: https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Interactive-map
[26] Dowdy, A. et al. 2015, East Coast Cluster Report, Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports, eds. Ekström, M. et al., CSIRO and Bureau of Meteorology, Australia. Available online: https://www.climatechangeinaustralia.gov.au/media/ccia/2.1.6/cms_page_media/172/EAST_COAST_CLUSTER_REPORT_1.pdf
[27] NSW Department of Planning, Industry and Environment. NSW Climate projections map. Available online: https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Interactive-map

The increased frequency and duration of hot days and heatwaves is projected for the East Coast in general with very high confidence under RCP4.5 and RCP8.5 (CSIRO & BOM, 2015).

These additional days are not spread throughout the year, with the greatest increases projected during spring and summer, while also extending into autumn. Given the Precinct only currently experiences 3.4 days on average above 35°C (which occur during the summer months), an 85.2% and 220.6% increase in these conditions respectively represents a very large increase. There are significant health impacts associated with heatwaves and extreme heat days, particularly for vulnerable members of the community (e.g. children, the elderly, and those experiencing illness).

3.2.5 Mean rainfall and drought

The local area currently experiences considerable rainfall variability from year-to-year and this variability is also reflected in the projections under both SRES A2 and RCP8.5.

By 2030 the local area is projected to have a slight increase in annual rainfall (2.0%), with rainfall projected to increase in autumn (5.8%) and projected to decrease in the spring (-0.02%).

By 2070 annual rainfall is projected to increase for the area (10.8%). The largest increase occurs along the coast and seasonally during autumn (14.6%).

CSIRO & BOM (2015) project less confidence in rainfall modelling for the East Coast of NSW under RCP4.5 and RCP8.5 as natural climate variability is considered to remain the key driver for rainfall. Models suggest a decrease in winter rainfall, but other changes are unclear. The range of results demonstrates the need to consider a range of climate futures and assess potential risks of both drier and wetter conditions.

Projected changes in drought would be influenced by changes to mean rainfall. Projections for the region indicate that drought will continue to be a regular feature of the regional climate and that time spent in drought will increase, particularly for the 2090 time period.

3.2.6 Extreme rainfall, flooding, and sea level rise

NARCliM-generated projections for SRES A2 (OEH, 2014 & 2015) are not yet available for extreme rainfall events. CSIRO & BOM (2015) indicate with high confidence a future increase in the intensity of extreme rainfall events across the East Coast using an understanding of the physical processes that cause extreme rainfall, coupled with modelled projections for RCP4.5 and RCP8.5. However, given the natural variability of rainfall the frequency and magnitude of increases in extreme rainfall cannot be confidently projected.

To understand the implications of climate change on flooding, the Water, Riparian Land, Flooding and Stormwater Study (Cardno, 2021) adopts the NSW Government's Floodplain Risk Management Guideline Practical Consideration of Climate Change (2007) recommendations on assessing the impact of climate change on flood behaviour.

In regard to increasing rainfall intensities, Cardno (2021) assessed the 0.5% and 0.2% annual exceedance probability (AEP) flood events as proxies for future rainfall events (approximately 7% and 27% for 2050 and 2100 respectively). This approach is consistent with the sensitivity analysis undertaken for the New Sydney Fish Market Flooding and Water Quality Assessment (Cardno 2019). It is noted that the Interim Climate Change Factors published by Australian Rainfall and Runoff (2018) recommend increasing rainfall intensities of 9.0% and 19.7% for under RCP8.5 2050 and 2090 respectively. The levels adopted by Cardno for the end-of century represent a more conservative scenario which will provide an increased level of protection when incorporated into further design stages.

Cardno (2021) notes that for the 0.5% AEP event, increases in flood levels of less than 0.05 m are observed within the study site and also along Bank Street, Saunders Street and Pyrmont Bridge Road. Increases of up to 0.10 m are observed along the railway line. Extents of flooding will remain the same within and outside the study area (Figure 8).

For the 0.2% AEP event, increases in flood levels of less than 0.1 m are observed within the study site and along Pyrmont Bridge Road. Increases of up to 0.20 m are observed along Bank Street and Saunders Street. Extents of flooding within and outside the study area will change slightly (Figure 9).

Overall, the results show that increased rainfall as a result of climate change will result in increased flood levels at and around the study site. Of the events, the impacts of increased rainfall intensity on flood levels within the study site and surrounds in the 0.5% AEP (i.e. 2050 rainfall conditions) are not significant. The impacts in the 0.2% AEP (i.e. 2100 rainfall conditions) event will be more significant, however overland flows are still expected to be contained within road reserves / open spaces and flood risk able to be appropriately managed.

To assess the impacts of sea level rise the Water, Riparian Land, Flooding and Stormwater Study (Cardno, 2021) adopts the NSW Sea Level Rise Policy Statement's (NSW Government, 2009) sea level rise increases of 0.4m and 0.9m by 2050 and 2100 respectively. This results in sea levels of 1.78m AHD and 2.28m AHD respectively. These sea levels were modelled in combination with the 1% AEP flood event to also understand the impacts of sea level rise on the precinct's drainage system (Figure 10 and Figure 11 respectively). Cardno (2021) notes the impacts of sea level rise on the proposed development will be limited due to the proposed terrain being above the raised sea level. For example, the grading plan shows site levels of 3.0m AHD, with non-critical areas (e.g. Promenade) designed at 2.5m AHD (subject to further design development and detailed modelling). The western corner of the site is an exception with proposed terrain levels lower than this, however the use of these areas is designed to provide water connectivity (i.e. boating related uses / launch area) and as such are not sensitive to the impacts of flooding.

Figure 8 Proposed 0.5% AEP flood depth and water level contours (i.e. 2050 conditions)

Figure 9 Proposed 0.2% AEP flood depth and water level contours (i.e. 2100 conditions)

Figure 10 0.4m sea level rise and 1% AEP flood depth and water level contours (i.e. 2050 sea level conditions)

Figure 11 0.9m sea level rise and 1% AEP flood depth and water level contours (i.e. 2100 sea level conditions)

3.2.7 Storm events

The National Environmental Science Programme's Earth Systems and Climate Change Hub[28] note that east coast low storms (ECLs)[29] can cause extreme wind, ocean waves, rainfall and flooding which can have severe impacts on coastal communities, businesses and ecosystems. ECLs have been observed to occur on average about 22 times per year, for 36 days per year (as some events last longer than a day). Of the 22 ECLs observed per year, on average 2–3 cause extreme daily rainfall above 100 mm, 7–8 cause widespread daily rain above 25 mm, and one will intensify rapidly. There is large variability from year to year in the number of ECLs that occur, with observations in recent decades showing no clear trend in ECL numbers.

Climate projections based on modelling indicate that fewer ECLs are expected to occur in the future, particularly during the cooler months of the year. The model results show larger reductions associated with higher greenhouse gas emissions scenarios. These reductions in ECL numbers are due to changes in conditions at higher levels in the atmosphere associated with ECL development.

Although fewer ECLs are projected to occur in the future under a changing climate, other important changes in our climate will affect the impacts of future ECLs on eastern Australia. For example, rising sea levels are likely to increase the impacts of large waves on coastal regions, and extreme rainfall is predicted to increase in intensity resulting in increased risk factors for flooding in some cases. In addition, changes in storm characteristics under climate change can potentially have significant influences on various coastal processes, such as changes in the intensity, frequency and duration of extreme wind and wave events caused by ECLs. Changes in the intensity and duration of ECLs, and associated extreme wind events, are not clear based on current knowledge.

NARCliM projections for SRES A2 are not specifically available storms, ECLs, or extreme wind speed. However, a related project, the Eastern Seaboard Climate Change Initiative, used NARCliM models to project ECLs into the future. It found that there will be increased seasonal variability with a decrease in the number of small to moderate ECLs in the cool season with little change in these storms during the warm season. However extreme ECLs in the warmer months may increase in number.

CSIRO and BOM also found that global and regional studies suggest that extreme storms are projected to become less frequent but increases in the proportion of the most intense storms are anticipated with medium confidence for the East Coast region. While uncertainty exists with the prediction of east coast lows, literature suggests a decline in the number of east coast lows in the future.

CSIRO and BOM (2015) also project little change in mean surface wind speed under all RCPs with high confidence, particularly by 2030, and with medium confidence by 2070 for the East Coast. However, under RCP8.5 in East Coast South, winter decreases in mean wind speed (associated with southward shift of storms) are projected. Decreases are also suggested for extreme wind speeds, particularly for the rarer extremes under both RCP4.5 and 8.5 with medium confidence.

3.2.8 Bushfires

Modelling shows more severe bushfire weather in the future for the region, however the magnitude of the increase due to uncertainties around projections in rainfall variability is uncertain. The Forest Fire Danger Index (FFDI) is used in NSW to quantify fire weather. FFDI combines observations of temperature, humidity and wind speed with an estimate of the fuel state. Fire weather (or FFDI) was assessed using the NARCliM climate projections for each State Planning Region of NSW and ACT.

Specific projections for Sydney show high variability, however general trends[30] include:

- Average and severe fire weather is projected to increase in NSW in the future.

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[28] National Earth Science Programme Earth Systems and Climate Change. East coast lows and climate change in Australia. Available online: http://nespclimate.com.au/wp-content/uploads/2019/11/A4_4pp_brochure_NESP_ESCC_East_Coast_Lows_Nov11_2019_WEB.pdf

[29] East coast lows (ECLs) are intense low-pressure systems that occur off the east coast of Australia. They can form at any time of the year and significant ECLs occur on average about 10 times each year. These storms can bring damaging winds and surf and heavy rainfall. They can cause coastal erosion and flooding (AdaptNSW, 2014)

[30] NSW Office of the Environment and Heritage, 2015. Climate Change Impacts on Bushfire Risk in NSW. Available online: https://climatechange.environment.nsw.gov.au/Impacts-of-climate-change/Bushfires

- Increases in average and severe fire weather are projected to occur mainly in summer and spring, with the largest increases by 2070 to occur in spring.
- Changes are greatest for the west of the state where fire weather increases are projected to occur across all seasons.
- A relatively small change in severe fire weather is projected for coastal regions, the south-east and the Southern Tablelands.
- Increasing fire weather conditions suggest that when fires do occur, they will be harder to control.

3.3 Sensitivity analysis

Given historical trends relating to greenhouse gas emissions and likely future pathways, it is important to understand the 'most likely' and 'worst case' implications of climate change on high-value infrastructure. Consideration and integration of these projections early in the planning will allow the design to manage these changes and incorporate flexible mitigation strategies.

In accordance with SR 17.4 sensitivity analysis has been undertaken as described below:

- *17.4 Undertake sensitivity analysis to address the impact of climate change due to increased temperatures, extreme heat events and changing rainfall patterns as informed by the Water Quality, Flooding and Stormwater Study.*

3.3.1 Increased temperatures, extreme heat events

The range and relative scale of projections for increased temperatures and extreme heat events mean that sensitivity testing is undertaken at a high level, by comparing NARCliM projections to the latest AR5 representative concentration pathways, RCP 4.5 and 8.5 data have been used as a comparison point for key climate variables to serve as sensitivity testing and scenario planning to understand the impacts based on different projections. A comparison of mean temperature and extreme heat days between SRES A2, RCP 4.5, and RCP 8.5 is provided in Table 6

Table 6 Change in average temperature and extreme heat days associated with SRES A2, RCP 4.5 and RCP 8.5

		Emissions scenario		
Climate hazard	**Time period**	**RCP4.5[31] *(AR5 medium-low emissions scenario)***	**SRES A2[32] *(AR4 high emissions scenario)***	**RCP8.5[33] *(AR5 high emissions scenario)***
Change to annual average temperature	2030	0.9°C *(likely range +0.6°C to +1.1°C)*	+0.7°C	-
	2090	1.8°C *(likely range +1.3°C to +2.5°C)*	+1.9°C (2070)	3.75°C *(likely range* +2.9°C to +4.6°C)
Number days above 35°C *(baseline: 3.4 days)*	2030	+4.3 days *(likely range 4.0 to 5.0)*	+4 days	-
	2090	+6 days *(likely range 4.9 to 8.2)*	+11 days (2070)	+11 days *(likely range* 8.2 to 15 days)

It is also important to note that Sydney has a variable topography, and significant local variance is present given that the above projections encompass the city's coast through to the western suburbs. In terms of exposure to heat, Blackwattle Bay's coastal location within these regional projections is

[31] https://www.climatechangeinaustralia.gov.au/media/ccia/2.1.6/cms_page_media/176/CCIA_Australian_cities_1.pdf
[32] NSW Department of Planning, Industry and Environment. Metropolitan Sydney Climate Change Snapshot. Available online: https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Climate-projections-for-your-region/Metro-Sydney-Climate-Change-Downloads
[33] https://www.climatechangeinaustralia.gov.au/media/ccia/2.1.6/cms_page_media/176/CCIA_Australian_cities_1.pdf

likely to mean the site is spared from the extreme end of the projections, while the western suburbs of Sydney are expected to experience the most significant increase.

As the projections under RCP 8.5 exceed the projections under SRES A2, RCP8.5 represents a scenario leading to more sever impacts. Risk assessments and recommended adaptation actions have therefore taken into consideration of this scenario.

A sensitivity analysis for changing rainfall patterns due to climate change has been performed for both the existing and proposed development cases. The current climate change guidelines in Australia are based on the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC AR5).

The recent draft revision of Australian Rainfall and Runoff (AR&R 2016) provides guidelines for assessing climate change impacts on flood behaviour and is based on IPCC AR5 projections. It recommends a risk-based approach that considers:

- Regional climate change projections
- Service life of asset/planning horizon
- Design standards
- Purpose and nature of the asset
- Consequence of failure of the asset

3.3.2 Rainfall and flooding

The Water, Riparian Land, Flooding and Stormwater Study (Cardno, 2021) undertook flood modelling to consider the effects associated with an increase in rainfall intensity. This increase in rainfall intensity was used as a sensitivity analysis for the drainage system, ensuring it could cope with projected changes. The flood modelling assessment has been undertaken by assessing the 0.5% and 0.2% AEP flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events (approximately 7% and 27% respectively) due to climate change. Interim Climate Change Factors published by Australian Rainfall and Runoff (2018) recommend increasing rainfall intensities of 9.0% and 19.7% for under RCP 8.5 2050 and 2090 respectively. As the increase adopted by Cardno (2021) exceeds the values published by Australian Rainfall and Runoff, the adopted increase is assessed as a ‘worst case scenario’. Risk assessments and recommended adaptation actions have therefore taken into consideration of this worst-case scenario.

4.0 Risk assessment

Of climate related variables, the site's exposure to increasing frequency and intensity of heat events, extreme rainfall and flooding, and storms have been identified as priority focus areas for adaptation. Potential impacts associated with these hazards, relevant for the community, are described in Table 7.

Table 7 Summary of potential impacts for Blackwattle Bay

Climate Hazard	Climate Impact
Changes to mean temperature and the number/severity of hot days	• Extreme heat both increases demand on the energy network because air conditioning units work harder to maintain temperature, and reduces energy network capacity, which can cause brownouts and blackouts when the power grid is at or beyond capacity. • More frequent and more intense instances of extreme heat can cause heat stress and exacerbate any pre-existing health conditions for residents and visitors to the Precinct. In particular, community members such as the elderly, children, and those with pre-existing medical conditions are likely to be more vulnerable to periods of extreme heat. Careful consideration should be made to consider outlining requirements for cooling and areas of respite for all precinct users.
Changes to storm conditions (i.e. extreme wind and east coast low storms)	• Greater intensity of rainfall and runoff has the potential to overwhelm drainage capacity and cause flooding and inundation of roof, ground, and subterranean systems. • Greater intensity of rainfall and runoff has the potential to cause inundation and malfunction of underground utilities such as electricity distribution, fibre cables, pumping stations, other network infrastructure. • East Coast Low storms (ECLs) generate extreme rainfall, wind, and storm surges which can lead to infrastructure and building damage, and pose health and safety risks for residents, workers, and visitors. • Safety concerns for community members with reduced mobility (e.g. in the event of evacuation) such as the elderly, children, those with pre-existing medical conditions, and those of culturally and linguistically diverse (CALD) communities who may be more vulnerable in terms of health, safety, and communication during these events. • Implications for emergency management planning to consider the increase in the frequency and intensity of these extreme events
Changes to mean rainfall and drought conditions	• Drought risk affecting water storage systems on site and increasing dependency on mains water supply for non-potable water use.
Bushfire	• Increased bushfire frequency and intensity impacting air quality leading to health and safety risks for residents, workers, and visitors. • More frequent and more intense instances of bushfires and associated poor air quality can cause heat stress and exacerbate any pre-existing health conditions for residents and visitors to the Precinct. In particular, community members such as the elderly, children, and those with pre-existing medical conditions are likely to be more vulnerable to these events. Careful consideration should be made when outlining requirements for air quality monitoring, air filtration and sealing of buildings.
Sea level rise and coastal flooding	• Sea level rise can exacerbate storm surges which lead to overtopping and inundation of public space and buildings. • Storm surges and coastal inundation has the potential to damage and cause malfunction of underground utilities such as electricity

Climate Hazard	Climate Impact
	distribution, fibre cables, pumping stations, other network infrastructure. • Implications for emergency management planning to consider the increase in the frequency and intensity of these extreme events. • Safety concerns for community members with reduced mobility (e.g. in the event of evacuation) such as the elderly, children, and those with pre-existing medical conditions. Similarly, emergency management planning should ensure communication materials and notices consider CALD community engagement.
Increasing rainfall intensity and flooding	• Greater intensity of rainfall and runoff has the potential to overwhelm drainage capacity and cause flooding and inundation of roof, ground, and subterranean systems. • Greater intensity of rainfall and runoff has the potential to cause inundation and malfunction of underground utilities such as electricity distribution, fibre cables, pumping stations, other network infrastructure. • Implications for emergency management planning to consider the increase in the frequency and intensity of these extreme events. • Safety concerns for community members with reduced mobility (e.g. in the event of evacuation) such as the elderly, children, and those with pre-existing medical conditions. Similarly, emergency management planning should ensure communication materials and notices consider CALD community engagement.

In order to adequately and appropriately detail how Blackwattle Bay will address the social, environmental and economic effects of climate change including potential impacts on vulnerable groups, it is necessary to understand the risks. The following section details the risks that were identified for the Precinct by the project team and through stakeholder engagement activities (refer Section 2.4). Table 9 outlines priority risks identified by stakeholders and Table 10 details existing and proposed adaption options and mitigation strategies to help reduce these risks. Appendix A contains definitions of each of the consequence and likelihood criteria used to determine risk ratings and the overall matrix to determine the risk rating for each risk. Figure 12 outlines how risks to the assets have been developed from an assessment of climate variables and projected climate change.

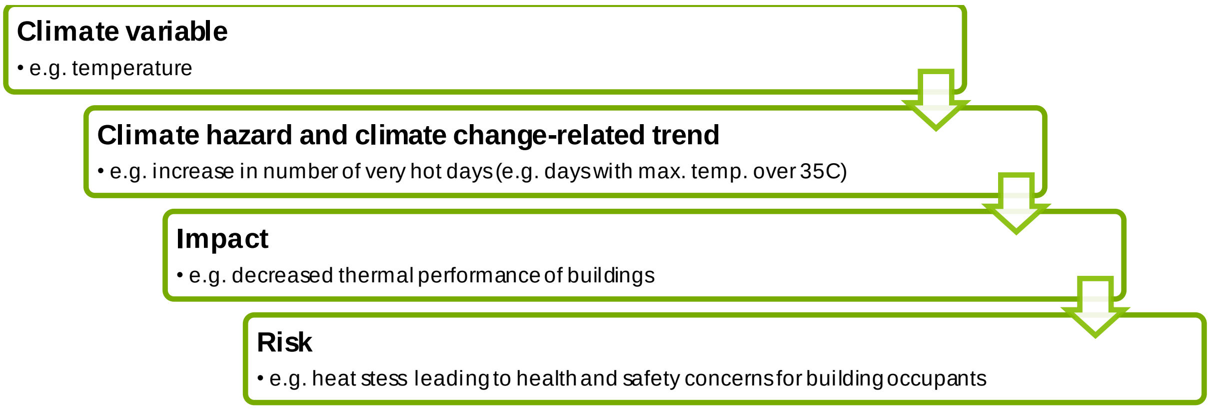

Figure 12 Climate Change Risk Assessment Process

Based on the location and local modelling it was determined that extreme heat, extreme rainfall and flooding, storm events, and sea level rise are the key climate hazards relevant for the project.

In total, 45 risks were identified for the Precinct. Of these 17 were rated ‘low’ in the 2030 time period, 24 rated ‘medium’ and 4 rated ‘high’. It is worth noting that no extreme risks were identified for the time periods of 2030 nor 2090 (Table 8).

Table 8 Summary of risk assessment

Risk rating	2030	2090
Low	17	5
Medium	24	24
High	4	16
Extreme	0	0
Total risks	**45**	**45**

Given these key climate hazards and the undesirable nature of high risks, all four 'high' risks were extracted from the risk register to understand current and future methods for managing such impacts. Table 9 provides a summary of the assessment for the near future (2030). In addition, priority risks rated 'medium' are also included (identified by the project stakeholders outlined in Section 2.4). The full risk assessment matrix for the Precinct is provided in Appendix B, and also includes an assessment of risk ratings for the far future (2090) time period.

Table 9 Summary of priority risks for the Precinct

Climate hazard	Risk statement	2030
Changes to mean temperature and the number/severity of hot days.	H1 – Extreme heat resulting in heat stress outcomes for residents, workers and visitors, particularly for vulnerable members of the community	High
	H2 – Extreme heat events increasing energy demand and reducing energy network capacity resulting in an increased number of black outs causing electrical and communications failure	High
	H3 - Increased energy and water demand for all building types, especially for commercial office buildings when air conditioning units work harder and impact energy network capacity	High
	H5 – In an extreme event where power is lost, the interdependencies between resident's healthcare systems and electrical and communications could fail and cause loss of life and injury	Medium
Changes to storm conditions (i.e. extreme wind and east coast lows)	S2b – Debris from high winds causing more significant and more frequent damage to external surfaces (e.g. loss of building materials) and exposed plant / equipment (e.g. HVAC units)	Medium
Changes to mean rainfall and drought conditions	W4 – Reduced rainfall resulting in drought conditions and impacting regional water supply	Medium
Bushfire	B2 – Smoke from bushfires causing increase in respiratory and human health impact to workers, visitors, and residents and causing damage from penetration into buildings through unsealed areas and reduced efficiency of equipment (e.g. HVAC units)	Medium
Sea level rise and coastal flooding	S1 – Sea level rise exacerbating the impact of flooding from storm surge during an extreme storm causing building damage, damage to landscape and ecosystems, erosion and safety issues	Medium
Increasing rainfall intensity and flooding	F2 – Increase in safety issues to personnel, residents, and visitors around hazardous and unpredictable stormwater runoff and flood waters	Medium

5.0 Climate adaptation plan

Overall, changes to mean temperature and the number/severity of hot days, changes to storm conditions (i.e. extreme wind and east coast lows), changes to mean rainfall and drought conditions, and sea level rise and coastal flooding have been identified as hazards considered to have the most potential impact on the development and its community.

Extreme heat can cause heat stress to residents and increase the incidence of illness, increase the cost of keeping buildings cool because more energy is needed, and increase the risk of critical energy infrastructure failing. In particular, there are significant health impacts associated with heatwaves and extreme heat days, particularly for vulnerable members of the community (e.g. children, the elderly, and those experiencing illness). Adaptation actions regarding the management of heat and its impacts primarily relate to reducing outdoor ambient temperatures, improving the thermal performance of indoor areas, ensuring the health of safety of community members, and understanding the implications for infrastructure continuity for building performance.

Extreme rainfall can damage properties through flooding, increase costs associated with flood protection and insurance, limit safe access and egress from a site, and cause structural damage to buildings. Adaptation actions related to flood mitigation are primarily targeted to reducing safety hazards to residents and the community, minimising damage, reducing runoff, managing water on site, providing shelter for the wider community, and educating residents on flood safety.

Similarly, the primary risks associated with storms include hazards related to wind and hail damage to buildings and outdoor areas, as well as damage and interruption to supporting critical infrastructure such as power and water supplies.

A key consideration when developing adaptation actions is the consideration of vulnerable community members such as the elderly, children, those with pre-existing medical conditions, and culturally and linguistically diverse communities. During extreme climate events these social groups are generally more likely to experience health concerns, social isolation, and difficulties in terms of evacuation or emergency management planning.

Drawing on the findings of the climate resilience assessment for the Blackwattle Bay community, Table 10 presents recommended adaptation actions identified which are integrated in to the Draft Precinct Plan or could be incorporated as the design and operation phases develop. Actions have been identified for all extreme and high risks identified in the climate change risk assessment. Given the uncertainty of the NSW Government's ongoing role in the community, operational practices have not been included in the adaptation actions. Instead, actions have been prioritised based on their cross-cutting benefits, where gains in resilience also lead to gains in resource efficiency, human health, and community cohesion.

Table 10 Adaptation actions

Climate hazard	Risk statement	Adaptation Actions	Phase
Changes to mean temperature and the number/ severity of hot days	H1 – Extreme heat resulting in heat stress outcomes for residents, workers and visitors, particularly for vulnerable members of the community	The Urban Forest Strategy indicates that streets and promenades will have a minimum tree canopy cover of 60%, with a mix of small/medium/large trees (up to 20m high). The open space areas (Bank St Park and Promenade Open Space) will have a minimum tree canopy cover of 30% and will be a mix of tree sizes including those over 20m in height. This will be facilitated by maximising the retention of deep soil areas. These targets represent an increase in the existing canopy coverage. Canopy coverage over paved surfaces serves as a cost-effective means of mitigating urban heat island effects and additional projected increases in mean temperature and extreme heat events. The tree retention and replacement targets will help to reduce the urban heat for pedestrians and residents (including those most vulnerable; elderly, youth, and those with pre-existing medical conditions). An increase in vegetation surrounding an urban site also helps to improve air quality which benefits those with respiratory issues.	Precinct Planning
		The Precinct Plan features several water sensitive urban design measures which provide a means for cooling the microclimate and reducing urban heat island effects. For example, the integration of water into landscapes assists in cooling urban areas via evaporation, provides activities for children, and provides amenity for the community. If designed appropriately, there are also significant co-benefits for flood mitigation.	Precinct Planning
		Given that the Plan supports these areas of public open space as well as tree lined streets, there are opportunities for visitors to seek respite from heat during hot weather events. Shading and seating arrangements to consider climate change projections, particularly those related to extreme heat and the number of hot days. These areas offer respite for residents and visitors and provide protection from heat for people in transit, particularly those vulnerable to heat stress.	Precinct Planning
		Facades are planned to have depth and will incorporate shading to reduce heat gain, particularly for ground floor premises.	Precinct Planning
		Coordinate adaptation responses with initiatives outlined by the draft Pyrmont Peninsula Place Strategy[34] to encourage green building facades and rooftop gardens.	Detailed design

[34] NSW Department of Planning, Industry and Environment, 2020. Pyrmont Peninsula Place Strategy. Available online: https://www.planningportal.nsw.gov.au/Pyrmont

Climate hazard	Risk statement	Adaptation Actions	Phase
		Prioritise the provision of shade to active transport routes (i.e. walkways and bicycle paths) and public transport connections (i.e. bus stops and light rail station) to facilitate greater uptake of these transport modes during hotter months.	Detailed design
		During the building design phase, prioritise design measures such as delivering dual aspect dwellings where possible to maximise opportunities to provide natural ventilation, avoiding overheating and excessive reliance on mechanical air conditioning systems above and beyond minimum standards outlined by the Apartment Design Guide SEPP where possible.	Detailed design
		During the building design phase structures should incorporate climate responsive facades, and flexibility provided for shading structure design. Encourage public space and buildings to integrate green roofs and vertical planting. Similarly, further consideration or specification of building materials within detailed design stages (light coloured roofing materials, selection of concrete / asphalt colour, high reflectivity materials for build facades).	Detailed design
		Provision of mechanically cooled community facilities (such as play areas, libraries etc) and commercial areas provides a place of refuge during extreme heat days.	Detailed design
		Given the Ecologically Sustainable Development Report's (AECOM, 2020) recommendation to achieve a 5 Star Green Star – Communities rating, the recommendation would be strengthened by achieving the Urban Heat Island Credit to guide the minimisation of urban heat island impacts.	Detailed design
		The Ecologically Sustainable Development Report's (AECOM, 2020) recommendation to achieve a 5 Star Green Star – Buildings rating for buildings would facilitate the development of more liveable, resilient buildings for the precinct. In particular, targeting the achievement of the *Heat Resilience* credit (at least 75% of the whole site area comprises of one or a combination of strategies that reduce the heat island effect) and the *Design for Inclusion* credit (which has an outcome to ensure buildings are designed and constructed to be inclusive to a diverse range of people with different needs) is recommended.	Detailed design
		Develop a list of potential design response strategies to be considered in final design (development application stage) within the design guidelines.	Detailed design

Climate hazard	Risk statement	Adaptation Actions	Phase
	H2 – Extreme heat events increasing energy demand and reducing energy network capacity resulting in an increased number of black outs causing electrical and communications failure	Consider opportunities to incorporate additional capacity for solar PV (or other renewable energy) and storage across the precinct. Noting limited land take, seek opportunities to incorporate PV into public realm structures such as shading.	Detailed design
		Explore options for allocating onsite battery storage to support decentralised energy solutions. The underpass area has been set aside for shared utilities and infrastructure related to the public realm and may be an area such battery technology could reside. Similar to solar PV there may also be opportunities to incorporate these into public realm structure as part of their detailed design.	Detailed design
		Consider incentivising compliance beyond baseline targets for NABERS and BASIX to maximise energy efficiency opportunities and reduce the overall energy demand of the Precinct.	Detailed design
		Ensure that selection of building equipment and materials (e.g. HVAC, cables) caters to higher operating temperatures and extreme heat events (e.g. design to 2070 temperatures) to reduce local occurrence of interruptions.	Detailed design
		Explore opportunities to provide uninterruptable power supplies, generators, or solar PV and batteries to maintain functionality of critical systems during blackouts or network instability.	Detailed design
		Clarify ownership and maintenance arrangements with key stakeholders (e.g. City of Sydney, Ausgrid, Sydney Water) plant, equipment, and public domain such as lighting, water services, management of coastal inundation of public domain spaces.	Detailed design
		Energy demand modelling should include future temperature projections (2030 at a minimum) to allow adequate planning for power infrastructure upgrades associated with the precinct's redevelopment.	Detailed design
	H3 - Increased energy and water demand for all building types, especially for commercial office buildings when air conditioning units work harder and impact energy network capacity	Review design guidelines with a lens to include climate change considerations. This may include aspects such as planning principles, material selection, and service provision.	
		Energy demand modelling and the selection of building equipment and materials (e.g. HVAC, cables) should be specified to higher operating temperatures and extreme heat events to ensure efficiency of systems are maintained into the future.	Detailed design
		The Ecologically Sustainable Development Report's (AECOM, 2020) recommendation to achieve a 5 Star Green Star – Buildings rating for buildings would facilitate the	Detailed design

Climate hazard	Risk statement	Adaptation Actions	Phase
		development of more liveable, resilient buildings for the precinct that are less resource (i.e. energy and water) intensive.	
		Insulation design, glazing of facades, building design and materials selection must each go through a detailed cost benefit analysis. Develop design criteria for future detailed design (material selection, reflectivity), and incorporate this into design guidelines.	Detailed design
		Natural (passive) ventilation is a key principle of the design of buildings in addition to maximising the orientation of the building to help reduce heat gain and the burden of the HVAC systems.	Detailed design
		Consider incentivising compliance beyond baseline targets for NABERS and/or BASIX to maximise thermal performance of buildings. For example, during detailed design phases additional weighting could be granted for the achievement of stretch targets.	Detailed design
		Explore opportunities for landscaping to capture and use water (increase cooling effects) and opportunities to reuse water on site for irrigation through water sensitive urban design measures.	Detailed design
		Consider a microgrid operator to manage energy efficiency and renewable energy operations.	Detailed design
	H5 – In an extreme event where power is lost, the interdependencies between resident's healthcare systems and electrical and communications could fail and cause loss of life and injury	Explore opportunities to provide uninterruptable power supplies, generators, or solar PV and batteries to maintain functionality of critical systems during blackouts or network instability. This may require exploring options to allocate additional space for onsite battery storage to support decentralised energy solutions.	Detailed design
		Engage with Local Emergency Management Committee and Local Area Health District to undertake scenario planning exercises to prepare the community and emergency service providers.	Operation
Changes to storm conditions (i.e. extreme wind and	S2-B – Debris from high winds causing more significant and more frequent damage to external surfaces (e.g. loss of building materials) and	Colonnade along foreshore promenade to provide shelter to retail and commercial spaces and visitors.	Detailed design
		Building placement should be optimised to consider wind mitigation and reduce the impact of high winds resulting from extreme storms. Design guides should seek to strengthen facades and areas likely to experience high wind affects (e.g. reduce glass facades, external fixtures, unfixed outdoor seating and shading).	Detailed design

Climate hazard	Risk statement	Adaptation Actions	Phase
east coast lows)	exposed plant / equipment (e.g. HVAC units)	When selecting tree species for planting, prioritise species that are both resilient to high winds, and have a strong tolerance to future rainfall/drought conditions. Tree placement can also seek opportunities to provide wind mitigation effects.	Detailed design
		Connections with emergency services, and incorporation of emergency responses such as public nodes, where vulnerable members can access information and instructions, and ensuring the public domain accessible and easy to use by vulnerable community members.	Operation
Changes to mean rainfall and drought conditions	W4 – Reduced rainfall resulting in drought conditions and impacting regional water supply	Seek opportunities to incentivise water efficiency measures above the minimum standards associated with BASIX. For example, provision of high efficiency water fixtures (6-star WELS), inclusion of high-water efficiency appliances as part of apartment package or offering financial incentives for residents to purchase high efficiency appliances.	Detailed design
		Prioritise the selection of drought tolerant tree species during landscaping activities.	Detailed design
		Consider on-site water capture and reuse (e.g. spatial provision for rainwater harvesting tanks and pumps and/or onsite water treatment facilities), minimise paved areas and maximise stormwater infiltration – maximise opportunities to reuse water in the landscape through water sensitive urban design.	Detailed design
		Consider water recycling technologies as part of building design, and advocate for network-wide recycled water infrastructure.	Detailed design
Bushfire	B2 - Smoke from bushfires causing increase in respiratory and human health impact to workers, visitors, and residents and causing damage from penetration into buildings through unsealed areas and reduced efficiency of equipment (e.g. HVAC units)	Seek opportunities to allow for filtration devices in centralised HVAC systems to shut off outdoor air intake and improve air quality during smoke haze events. This action may be incorporated into design guidelines for implementation within buildings.	Detailed design
		Incorporate requirements within the design guidelines to provide emergency medical equipment such as defibrillators in building common areas such as the lobbies of commercial and residential buildings.	Detailed design
Sea level rise and coastal flooding	S1 – Sea level rise exacerbating the impact of flooding from storm surge during an extreme storm	Cardno (2021) notes that future sea levels of 1.78m AHD and 2.28m AHD for 2050 and 2100 should be planned for respectively. Specification of podiums / site levels at 3.0m AHD elevation, with non-critical areas (e.g. Promenade) designed at 2.5m AHD.	Masterplanning

Climate hazard	Risk statement	Adaptation Actions	Phase
	causing building damage, damage to landscape and ecosystems, erosion and safety issues	The Draft Precinct Plan identifies a stepped embankment between promenade and water level to ensure access to water is maintained regardless of sea level.	
Increasing rainfall intensity and flooding	F2 – Increase in safety issues to personnel, residents, and visitors around hazardous and unpredictable stormwater runoff and flood waters	Considering the short duration of flooding for the study site and limited ability to provide safe evacuation offsite, Cardno (2021) recommends a shelter-in-place approach is recommended for the Blackwattle Bay SSP. As such, during detailed design phases, buildings will incorporate flood mitigation controls to manage these risks where required. In addition, upgrades to the stormwater network are recommended during future design phases.	Detailed design

6.0 Next steps

This report presents a Climate Change Adaptation Report for the Blackwattle Bay SSP and is a snapshot of the community at a single point in time, reflecting the information available at the time of assessment. It is recommended this report is reviewed and revised as needed to align with future development of the design and the staged completion of precincts within the community.

The Plan is intended to be shared with residents, businesses, and other key community stakeholders (e.g. proponents of the individual commercial, residential and community infrastructure projects within development) for consideration in their individual resilience and emergency management planning. The Emergency Response Checklist, provided in Appendix B is intended to be disseminated to residents, businesses and other key stakeholders to support community preparedness.

Next steps for Infrastructure NSW to address the climate adaptation and community resilience challenges identified in this report include:

- Review the Climate Change Adaptation Report and identify the relevant development stage and responsibility for implementation of each action
- Undertake a workshop to prioritise actions identified in the above task for implementation based on INSW's sphere of influence and control and develop the roles and responsibilities for implementation.
- Liaise with relevant stakeholders to consider a collaborative and coordinated response to improving community resilience.
- Nominate a review date to track progress of the implementation of adaptation and community resilience actions.

Appendix A

Risk Assessment Criteria

Appendix A Risk Assessment Criteria

The risk assessment methodology within this report adopts the Commonwealth Government's guidelines, *Climate Change Impacts & Risk Management - A Guide for Business and Government*. This guideline is cited in the *Australian Standard 5334-2013 - Climate change adaptation for settlements and infrastructure - A risk-based approach* as well as industry standard guidelines such as the Green Building Council of Australia's Green Star rating system credits relating to climate resilience.

Table 11 Consequence criteria (adapted from Department of the Environment and Heritage, 2006)

Conse-quence Rating	Consequence Category and Criteria				
	Public safety	**Local economy & growth**	**Community & lifestyle**	**Environment & sustainability**	**Service delivery**
Cata-strophic	Large numbers of serious injuries or loss of lives	Regional decline leading to widespread business failure, loss of employment and hardship	The region would be seen as very unattractive, moribund and unable to support its community	Major widespread loss of environmental amenity and progressive irrecoverable environmental damage	Services would be incorrectly targeted, delivered late or not at all in a large number of cases
Major	Isolated instances of serious injuries or loss of lives	Regional stagnation such that businesses are unable to thrive and employment does not keep pace with population growth	Severe and widespread decline in services and quality of life within the community	Severe loss of environmental amenity and a danger of continuing environmental damage	There would be isolated instances of services being incorrectly targeted, delivered late or not delivered at all
Moderate	Small numbers of injuries	Significant general reduction in economic performance relative to current forecasts	General appreciable decline in services	Isolated but significant instances of environmental damage that might be reversed with intensive efforts	There would be isolated but important instances of services being poorly targeted or delivered late
Minor	Serious near misses or minor injuries	Individually significant but isolated areas of reduction in economic performance relative to current forecasts	Isolated but noticeable examples of decline in services	Minor instances of environmental damage that could be reversed	There would be isolated instances of service delivery failing to meet acceptable standards to a limited extent
Insig-nificant	Appearance of a threat but no actual harm	Minor shortfall relative to current forecasts	There would be minor areas in which the region was unable to maintain its current services	No environmental damage	Minor technical shortcomings in service delivery would attract no attention

Table 12 Likelihood criteria (adapted from Department of the Environment and Heritage, 2006)

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

Table 13 Risk matrix (adapted from Department of the Environment and Heritage, 2006)

Risk Matrix-Assigned Risk Rating		Consequence Criteria (C)				
		C5 - Insignificant	C4 – Minor	C3 - Moderate	C2 – Major	C1 - Catastrophic
Likelihood Criteria (L)	L1 - Almost Certain	Medium (M)	Medium (M)	High (H)	Extreme (E)	Extreme (E)
	L2 - Likely	Low (L)	Medium	High	High	Extreme
	L3 - Possible	Low	Medium	Medium	High	High
	L4 - Unlikely	Low	Low	Medium	Medium	Medium
	L5 - Rare	Low	Low	Low	Low	Medium

Appendix B

Risk Register

Appendix B Risk Register

Table 14 Key for Risk Register

Likelihood Criteria(L)
L1 - Almost Certain
L2 - Likely
L3 - Possible
L4 - Unlikely
L5 - Rare

Consequence Criteria (C)
C1 - Catastrophic
C2 – Major
C3 – Moderate
C4 – Minor
C5 - Insignificant

Risk Rating
E - Extreme
H - High
M - Medium
L - Low

Table 15 Blackwattle Bay SSP Risk register

Risk ID	Variable & Associated Risk	Climate variable	2030			2090			Priority (Y = Yes)
			C	L	Risk Rating	C	L	Risk Rating	
W-1	Changes in overall climate impacting ecological systems/biodiversity and potentially increasing mosquito populations and ensuing health risks	Change in Mean Temperature	C4	L4	L	C4	L4	L	
W-2	Increased temperature and extreme heat events resulting in higher living costs associated with utility and health costs	Extreme Heat	C4	L2	M	C4	L2	M	
W-3	Increased occurrence of dust storms as a result of drought causing damage and air quality issues	Drought	C4	L4	L	C4	L4	L	
W-4	Reduced rainfall resulting in drought conditions and impacting regional water supply	Drought	C3	L3	M	C3	L2	H	Y
W-5	Impacts of extreme heat on commercial activities on the site leading to reduced visitor counts, issues of food storage and food supply during blackouts and brownouts	Extreme Heat	C4	L2	M	C4	L3	M	
W-6	Storm surge and extreme rainfall disturbing contaminated soils/coastal materials and causing	Extreme Storms (e.g. East Coast	C3	L3	M	C3	L3	M	

Risk ID	Variable & Associated Risk	Climate variable	2030			2090			Priority (Y = Yes)
			C	L	Risk Rating	C	L	Risk Rating	
	ecological and human health impacts if water is contaminated as a result of flooding	Low) and High Winds							
W-7	Extreme heat causing people and businesses to use more air conditioning and fans therefore increasing energy demand. It also leads people to drink more water and use more water to maintain landscaping	Extreme Heat and Mean Temperature Change	**C4**	**L2**	M	**C4**	**L1**	M	
S-1	Sea level rise exacerbating the impact of flooding from storm surge during an extreme storm causing building damage, damage to landscape and ecosystems, erosion and safety issues	Sea Level Rise, Extreme Storms (e.g. East Coast Low) and High Winds	**C2**	**L4**	M	**C2**	**L4**	M	**Y**
S-2A	Increased hail damage causing more significant and more frequent damage to external surfaces (e.g. loss of building materials) and exposed plant / equipment (e.g. HVAC units) as well as flooding if drains become clogged with hail	Extreme Storms (e.g. East Coast Low) and High Winds	**C3**	**L3**	M	**C3**	**L2**	H	
S-2B	Debris from high winds causing more significant and more frequent damage to external surfaces (e.g. loss of building materials) and exposed plant / equipment (e.g. HVAC units)	Extreme Storms (e.g. East Coast Low) and High Winds	**C2**	**L3**	H	**C3**	**L2**	H	**Y**
S-3	Increased intensity and frequency of extreme events resulting in rain and moisture penetration (e.g. damaged roofing)	Extreme Storms (e.g. East Coast Low) and High Winds	**C3**	**L3**	M	**C3**	**L3**	M	
S-4	Increased frequency of evacuations caused by flooding or extreme storms where vulnerable popoulations have challenges evacuating	Extreme Storms (e.g. East Coast Low) and High Winds	**C3**	**L3**	M	**C3**	**L1**	H	

Risk ID	Variable & Associated Risk	Climate variable	2030			2090			Priority (Y = Yes)
			C	L	Risk Rating	C	L	Risk Rating	
H-1	Extreme heat resulting in heat stress outcomes for residents, workers and visitors, particularly for vulnerable members of the community	Extreme Heat and Mean Temperature Change	**C3**	**L2**	H	**C3**	**L1**	H	**Y**
H-2	Extreme heat resulting in heat stress causing loss of worker productivity and risks to worker health & safety	Extreme Heat and Mean Temperature Change	**C3**	**L3**	M	**C3**	**L2**	H	**Y**
H-3	Extreme heat events increasing energy demand and reducing energy network capacity resulting in an increased number of black outs causing electrical and communication system failure	Extreme Heat and Mean Temperature Change	**C2**	**L2**	H	**C3**	**L1**	H	**Y**
H-4A	Increased energy and water demand for all building types, but especially for commercial office buildings when air conditioning units work harder and impact energy network capacity	Extreme Heat and Mean Temperature Change	**C3**	**L3**	M	**C2**	**L2**	H	
H-4B	Increased energy and water demand for all building types, but especially for commercial office buildings when air conditioning units work harder and impact energy network capacity	Extreme Heat and Mean Temperature Change	**C3**	**L3**	M	**C2**	**L2**	H	
H-5	In an extreme event where power is lost, the interdependencies between resident's healthcare systems and electrical and communications could fail and cause loss of life and injury	All hazards	**C2**	**L3**	H	**C2**	**L2**	H	**Y**
H-6	Extreme heat events and increased ambient temperatures limiting walkability harming, health and wellbeing due to reduced physical activity & reduced activation affecting safety	Extreme Heat and Mean Temperature Change	**C3**	**L3**	M	**C3**	**L3**	M	
H-7	Increased requirements for cooling and areas of respite, including greater demand on existing shared spaces that are cooled	Extreme Heat and Mean Temperature Change	**C3**	**L3**	M	**C3**	**L1**	H	

Risk ID	Variable & Associated Risk	Climate variable	2030			2090			Priority (Y = Yes)
			C	L	Risk Rating	C	L	Risk Rating	
H-8	Extreme heat impacting health of residents including children under the age of 4 years, especially at night	Extreme Heat and Mean Temperature Change	C3	L3	M	C3	L1	H	
H-9	Increased extreme heat incidences causing increase in operational and maintenance costs (HVAC performance, failure of infrastructure, repair / replacement)	Extreme Heat and Mean Temperature Change	C4	L2	M	C4	L2	M	
H-10	Higher ambient temperatures causing buildings to overheat or affecting thermal performance or comfort	Extreme Heat and Mean Temperature Change	C4	L4	L	C4	L3	M	
H-11	Reduction in the use of outdoor public recreational space	Extreme Heat and Mean Temperature Change	C4	L2	M	C4	L1	M	
H-12A	Accelerated degradation of external surfaces/cladding	Extreme Heat and Mean Temperature Change	C4	L4	L	C4	L3	M	
H-12B	Accelerated degradation of external surfaces/cladding	Extreme Heat and Mean Temperature Change	C4	L4	L	C4	L3	M	
H-13	Accelerated degradation of concrete structures / reduced building life	Extreme Heat and Mean Temperature Change	C4	L4	L	C4	L3	M	
H-14	Heat wave temperatures leading to increased softening pavements causing road disruptions and higher maintenance costs	Extreme Heat and Mean Temperature Change	C4	L4	L	C4	L3	M	

Risk ID	Variable & Associated Risk	Climate variable	2030 C	2030 L	2030 Risk Rating	2090 C	2090 L	2090 Risk Rating	Priority (Y = Yes)
H-15	Risk to visitors not prepared for elements or unable to understand English emergency announcements	Extreme Heat and Mean Temperature Change	**C5**	**L3**	L	**C4**	**L3**	M	
H-16	Extreme heat causes stress on wholesale and industrial activity on the site, especially those using cold storage and transferring perishables to and from the Fish Market	Extreme Heat and Mean Temperature Change	**C4**	**L4**	L	**C4**	**L3**	M	
H-17	Increased number of 'shelter in place' occasions during extreme events leading to increased behavioural stresses	Extreme Heat and Mean Temperature Change	**C4**	**L4**	L	**C4**	**L2**	M	
H-18A	Impacts of increased incidence of violent crime and antisocial behaviour during heatwave events on community	Extreme Heat and Mean Temperature Change	**C4**	**L4**	L	**C4**	**L3**	M	
H-18B	Impacts of increased incidence of violent crime and antisocial behaviour during heatwave events on community	Extreme Heat and Mean Temperature Change	**C4**	**L4**	L	**C4**	**L3**	M	
B-1	Increased frequency of bushfires causes impacts to power supply continuity	Bushfire	**C4**	**L5**	L	**C3**	**L5**	L	
B-2	Smoke from bushfires causing increase in respiratory and human health impact to workers, visitors, and residents and causing damage from penetration into buildings through unsealed areas and reduced efficiency of equipment (e.g. HVAC units)	Bushfire	**C3**	**L3**	M	**C3**	**L1**	H	**Y**
B-3	Smoke from bushfires causing damage from penetration into buildings through unsealed areas and reduced efficiency of equipment (e.g. HVAC units)	Bushfire	**C4**	**L2**	M	**C3**	**L1**	H	

Risk ID	Variable & Associated Risk	Climate variable	2030			2090			Priority (Y = Yes)
			C	L	Risk Rating	C	L	Risk Rating	
D-1	Increased maintenance and irrigation of landscaping of parks, open space and street trees	Drought	**C5**	**L3**	L	**C5**	**L2**	L	
D-2	Soil subsidence, movement and cracking as a result of increased variability of periods of wetting and drying causing reduced integrity of building and car parking foundations and potential structural failure	Drought	**C4**	**L4**	L	**C4**	**L3**	M	
F-1	Inundation of buildings, roads, footpaths and other site infrastructure by water limiting access and egress and potentially leading to isolation	Extreme Rainfall and Flooding	**C3**	**L3**	M	**C3**	**L2**	H	
F-2	Increase in safety issues to personnel, residents, and visitors around hazardous and unpredictable stormwater runoff and flood waters	Extreme Rainfall and Flooding	**C3**	**L3**	M	**C3**	**L3**	M	**Y**
F-3	Greater intensity of rainfall and runoff overwhelming drainage capacity and causing flooding and inundation of roof, ground and subterranean systems	Extreme Rainfall and Flooding	**C4**	**L2**	M	**C4**	**L1**	M	
F-4	Greater intensity of rainfall and runoff causing inundation of underground utility issues (electricity distribution, fibre cables, pumping stations, other network infrastructure malfunctions)	Extreme Rainfall and Flooding	**C3**	**L3**	M	**C3**	**L2**	H	
SL-1	Sea level rise causing increased insurance costs and/or possible loss of insurability of certain sites within the Bays Market District	Sea Level Rise	**C4**	**L3**	M	**C4**	**L3**	M	
SL-2	Sea level rise changing groundwater levels causing subsidence that impacts utility lines	Sea Level Rise	**C4**	**L5**	L	**C4**	**L4**	L	
SL-3	Groundwater level changes causing subsidence in wider area (especially underground car parking, heritage items and existing buildings)	Sea Level Rise	**C2**	**L5**	L	**C2**	**L4**	M	