Department of Environment, Land, Water & Planning

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Fishermans Bend Climate Readiness Strategy

Organising Framework - Stage 1

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Client: Department of Environment, Land, Water & Planning

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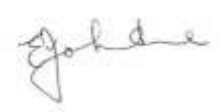
C	06-Feb-2018	Final	Liz Johnstone Associate Director Sustainability	
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Executive Summary

The Fishermans Bend urban renewal area presents a major opportunity to define and demonstrate sustainable and resilient urban renewal, and to positively contribute to Melbourne's reputation as the world's most liveable city.

The redevelopment of Fishermans Bend is in its early stages. While significant planning has been undertaken, the transformation process will take several decades more to be realised.

Decisions made today, and the approach taken to the transformation of Fishermans Bend will have an enduring legacy, and will be pivotal in the future success of this precinct. With rapid population growth and technological change, a changing climate and the urgent need to reduce greenhouse gas emissions Fishermans Bend already faces significant challenges. The observed changes to the climate - hotter, drier, more extreme weather and sea level rise - are projected to continue.

By integrating climate risk considerations into the early planning, design and development of Fishermans Bend, and in particular the drainage infrastructure and public space the impacts of localised flooding and extreme heat can be most cost effectively addressed.

About Fishermans Bend

The Fishermans Bend Urban Renewal Area is located adjacent to the central city, on the Yarra River near where it enters Port Phillip Bay. It abuts some of Melbourne's oldest residential areas in Port Melbourne and South Melbourne, and is already home to many of Melbourne newest neighbourhoods, such as the vertical communities in the precinct and those in the nearby Docklands area. While Fishermans Bend is currently dominated by lower density industrial and warehousing uses, it is planned to transform into a higher density mixed use precinct while consolidating and strengthening its traditional industrial and employment role.

Vision and sustainability goals

The vision for Fishermans Bend is to be "A thriving place that is a leading example for environmental sustainability, liveability, connectivity, diversity and innovation." *(*DELWP 2016)

To drive best-practice sustainability outcomes for the area, eight goals have been identified including:

- Goal 4: A Climate Adept Community – recognises that Fishermans Bend will need to be resilient to extreme weather events; provide a high degree of social cohesion to enhance community resilience and aims for the urban heat island effect to be lower than in other areas of Melbourne.
- Goal 5: A Water Sensitive Community – seeks to design the urban form to accommodate the impact of a changing climate, and establish an integrated water system across Fishermans Bend to provide access to high quality potable and recycled water. (DELWP 2017)"

Climate change risks facing Fishermans Bend

As well as a hotter, drier climate with a greater frequency of extreme weather events, the urban renewal area is low lying, generally under 4m AHD and will be impacted by rising sea levels and storm surges. Intense rainfall events currently result in localised flooding as the ageing drainage system built to support industrial land uses struggles to cope. The siting and design of the development proposed, expected to support 80,000 residents and 80,000 workers, will be critical in ensuring a safe, pleasant and functional urban form, especially in heatwave conditions which are expected to double by the end of the century.

Heatwave condition will impact on health and will be amplified by the urban heat island effect, stress testing future residents, workers and the critical transport and utility infrastructure they rely on. A business as usual approach would result in more congestion, continued power outages and associated economic losses. Where Melbourne residents have traditionally headed to the beach during heatwave conditions, sea level rise and storm surge will erode beaches, leaving less room for people and for nature. The high rise form and intensity proposed for Fishermans Bend demands an innovative response. Easy access to green spaces for cooling and respite will need to rely on both the public and private realms. Buildings will need to be designed to offer thermal comfort, reduce energy demand and also contribute to cooling streets, capturing breezes and providing shade.

Despite its size and proximity to central Melbourne, the site sits within a peninsula, bounded by the river and the Bay. Other than the Westgate Punt, a limited pedestrian and bicycle ferry service, there are no local river crossings restricting access for local traffic, and for foot, bike or public transport which contributes to greater vulnerability and risk during extreme events.

The existing infrastructure was not intended to support high density urban communities, nor function under a changed climate. With most sites privately owned, precinct or sequenced responses to improve the resilience of assets and services will be more difficult to coordinate, fund and deliver.

Key responses

As it is early in the redevelopment process, it is more cost effective to prepare for these changing conditions before they occur, and build new infrastructure with the future in mind. The greatest risks to people relate to a warming climate, with more hot spells; and for the built environment to flooding associated with extreme weather events and, over time, sea level rise and storm surge.

Ensuring that ‘the first layer’ of development is an integrated solution combining landscape, public realm and built form with water management infrastructure designed to support intensive urban development under future climate scenarios will provide certainty and enhance precinct outcomes. Many of the climate adaptation responses, actions and best practice case studies utilise low cost measures and known technologies to deliver multiple benefits at scale, with other more targeted or structural solutions being able to be planned for and realised through the development process over time.

Integrating the ‘green and blue’ infrastructure has potential to add significant value to the area and reduce multiple risks across numerous scenarios. Lower cost examples include building and urban design to accommodate flooding, integrating levees or protection works into public space planning; stormwater harvesting and re-use; communication and warning systems for extreme events; and urban forest strategies. The consideration of solutions can assess water availability, methods of capturing water for irrigation or re-use, or cooling at street level or roof level to benefit a wider area or support green facades.

Such an approach will address both flooding and the urban heat island effect.

Next steps to ensuring climate readiness

To achieve the climate adept and water sensitive communities that the Fishermans Bend Taskforce aspire to, in addition to the many projects and commitments initiated, this report provides a framework for climate readiness (including key objectives, guiding principles and considerations for monitoring, evaluation, reporting and improving).

The commitment to using Green Star – Communities as a tool to monitor the development of Fishermans Bend will be useful for demonstration or catalyst projects, and to communicate and build support for the Vision, priorities and approach.

Key projects underway include integrated water and flood strategies to identify innovative and integrated solutions which mitigate flooding (from sea level rise, storm surge and intense rainfall events) and create value for communities by greening and cooling the area. This report should be reviewed upon completion of the integrated water and flood strategy.

To apply the framework, the guiding principles (Informed and integrated decision making; risk management; complementarity; equity; and community engagement) must be integrated into the Taskforce’s and councils next phases of work. The gap analysis in Section 7 summarised in Table 17 provides a basis for discussion between the taskforce and relevant agencies to address gaps in knowledge, inconsistencies and as a basis for integration, and to guide monitoring and evaluation.

In addition, adaptation responses that are able to be deployed at a precinct scale, or able to deliver a precinct wide benefit (such as for drainage and public space) must be considered early so that they may be progressively funded and delivered as an integrated element of the transformation of Fishermans Bend.

The consideration of precinct-wide approaches raises issues of governance and accountability (who plans, owns, funds, manages?) that must be addressed for effective early action. Similarly, achieving consistently high quality planning and building outcomes precinct-wide will also require a coordinated approach.

A focus on enabling, incentivising and requiring, when appropriate, low-cost, high benefit measures should be prioritised through the integrated water and flood strategies, drainage plans, and precinct planning when integrating heat mitigation and climate risk considerations.

Key terms

Term	Description
Adaptation	Adaptation is defined by the IPCC as the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment.
Adaptation pathway	Adaptive capacity is defined by the IPCC as the ‘ability of systems, institutions, humans, and other organisms to adjust to potential
Annual Exceedance Probability (AEP)	The probability associated with a given event being exceeded in any one year. For example an event with an AEP of 0.1 has a 10% chance of occurring every year.
Artificial reef	Marine resource managers also create artificial reefs in underwater areas that require a structure to enhance the habitat for reef organisms, including soft and stony corals and the fishes and invertebrates that live among them.
Blackwater	Component of the sewage that originates from toilets.
Breakwater	A structure protecting a shore area, harbour, anchorage or basin from waves. The most common breakwaters are in the form of a sloping wall protected by rocks or concrete armour units.
Blue infrastructure	See green infrastructure. Blue landscape elements are linked to water – including pools, ponds and water courses.
Climate projection	A climate projection is the simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases (GHGs) and aerosols, generally derived using climate models.
Climate risk	The potential, when the outcome is uncertain, for adverse consequences on lives, livelihoods, health, ecosystems and species, economic, social and cultural assets, services (including environmental services), and infrastructure"
Detention ponds/basin	Similar to a retarding basin, it is an excavated area installed on or adjacent to tributaries of rivers, streams, lakes or bays to protect against flooding but retaining water permanently.
Dyke	A barrier constructed to prevent sea water from entering low-lying land.
Ecosystem-based adaptation	Sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change.
Green infrastructure	Nature or landscape that provides ecosystem services such as street trees and parks. Green Infrastructure or blue-green infrastructure can also refer to a network providing the “ingredients” for solving urban and climate challenges, such as localised flooding by building with nature
Groyne	A low wall or sturdy timber barrier built out into the sea from a beach to check erosion and sand drift
HVAC	Heating, ventilation and air conditioning (HVAC) equipment for controlling indoor environments.
Impact	Effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a

Term	Description
	specific time period and the vulnerability of an exposed society or system.
Inundation	During a storm, low atmospheric pressure and onshore winds can cause storm surge and extreme wave heights along the coast. When these coincide with high tide, inundation may result. Inundation risk relates to the chance of flooding being experienced in a particular location.
Maladaptation	A maladaptation is defined by the IPCC (2014) as 'an action that may lead to increased risk of adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare, now or in the future'.
Monitoring and evaluation (M&E)	In the context of M&E, monitoring is a continuous or periodic process in which data on specific indicators are systematically collected to provide information about performance of a project. Evaluation is a systematic and objective feedback of a completed or ongoing action, aimed at providing information about design, implementation and performance.
Resilience	The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation.
Retention ponds /basin	Also known as a retarding basin, a retention basin is used to manage stormwater runoff to prevent flooding and downstream erosion, and improve water quality in an adjacent river, stream, lake or bay.
Risk assessment	A systematic process of evaluating the potential risks that may be involved in a projected activity or undertaking.
Sea level rise	An increase in the mean level of the ocean. Eustatic SLR is a change in global average sea level due to an increase in the volume of the ocean. Relative SLR occurs where there is a local increase in the level of the ocean relative to the land, which might be due to ocean rise and/or land level subsidence.
Seawall	A structure separating land and water areas, primarily designed to prevent erosion and other damage due to wave action.
Sustainable Urban Drainage Systems (SUDS)	SUDS are designed to reduce the potential impact of new and existing developments with respect to surface water drainage discharges.
Storm surge	Elevated sea level at the coast caused by the combined influence of low pressure and high winds associated with a severe storm such as a tropical cyclone. Includes wave run up and wave set up.
Transformational adaptation	Adaptation actions resulting in significant change to community expectations and goals, or how they are met, potentially disrupting communities and their values.
Urban Heat Island (UHI) effect	Refers to the event where air temperatures in an urban environment are higher than those in the surrounding hinterland or rural environment as a result of the replacement of natural, vegetated surfaces with asphalt, concrete and rooftops.
Vulnerability	The potential to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.
Water Sensitive Urban Design (WSUD)	A land use planning and engineering design approach which integrates the urban water cycle, including stormwater, groundwater and wastewater management and water supply, into urban planning and design to minimise environmental degradation and improve aesthetic and recreational appeal.

1.0 Introduction

1.1 About this document

The Fishermans Bend Climate Readiness Strategy – Stage 1 (the Strategy) contributes to ensuring that key climate risks are identified and can be considered in the planning process for Fishermans Bend. It will guide the development of a 'climate adept' Fishermans Bend over the coming decades and support the Green Star – Communities Adaptation and Resilience credit requirements. This document covers the following:

1. Summary of the Fishermans Bend urban renewal area and its unique challenges and constraints (Section 2)
2. Overview of the climate change policy context for the project (Section 3)
3. Framework for action to ensure climate readiness, including key objectives for a climate ready Fishermans Bend, guiding principles and consideration of monitoring, evaluation, reporting and improvement (Section 4)
4. High level overview of the key climate risks confronting Fishermans Bend in the short, medium and long term, and a consideration of the severity of impacts of these risks (Section 5)
5. Potential adaptation responses, example actions and case studies (Section 6)
6. Gap analysis to guide further planning considerations (Section 7)
7. Conclusion and next steps (Section 8).

1.2 Background to this Strategy

The redevelopment of Fishermans Bend (the area) is central to the Victorian Government's drive to create a city structure that strengthens Melbourne's competiveness for jobs and investment (DELWP 2017). Along with other major urban renewal projects such as Arden Macaulay, Fishermans Bend is an opportunity for Melbourne to grow over the next 35 years in an integrated and sustainable way.

For Fishermans Bend to be successful at retaining and attracting businesses, workers and residents, it will require high levels of amenity. Such amenities include public transport, walking and cycling paths, open space, high quality buildings and precincts and appropriate and accessible community infrastructure. Fundamental to the success of each of these and the overall success of the area, is how the design and development of Fishermans Bend supports the community's readiness for the shocks and stresses that a changing climate, and rapidly changing society and economy may bring. Climate shocks include more extreme weather resulting in flooding or heatwaves, while stresses may include hotter and drier weather and sea level rise.

Climate readiness requires consideration of Melbourne's current and future climate and the risks that may arise as a result of it. Such risks may directly impact the design, construction and operation of assets, including essential infrastructure, and the community's resilience and ability to cope. This may then have flow on impacts for the economy and the area as a National Employment and Innovation Cluster.

1.3 Who is this Strategy for?

The Strategy has been developed to help guide the future planning and early identification of adaptation opportunities for a climate ready Fishermans Bend. It forms the foundation for further climate planning and action to take place as the planning for the area continues. The Strategy is not intended to be a public-facing document in its entirety but may form part of more targeted communications. This could include specific guidance for developers on climate risks and adaptation responses (building and precinct scale); land owners and tenants to inform them of localised climate risks and adaptation options; and for strategy development. It will also inform the Climate Adaptation Plans prepared under Green Star – Communities and how high and extreme risks may be mitigated.

2.0 Fishermans Bend Urban Renewal Area

2.1 Overview of the area

Fishermans Bend is approximately 485 hectare urban renewal area expected to accommodate 80,000 jobs across a range of industries (DELWP 2017), and accommodate 80,000 residents in a range of higher density housing options over the next 40 years (DELWP 2016). It is Australia's largest urban renewal site, located west of the Melbourne Central Business District, south of the Yarra River, next to the Port of Melbourne and the suburb of Port Melbourne which abuts Port Phillip Bay. It is within both the City of Port Phillip and City of Melbourne. Fishermans Bend includes five proposed precincts; the Employment Precinct, Lorimer, Wirraway, Sandridge and Montague. These precincts, shown in Figure 1 , will each support a mix of employment and residential developments.

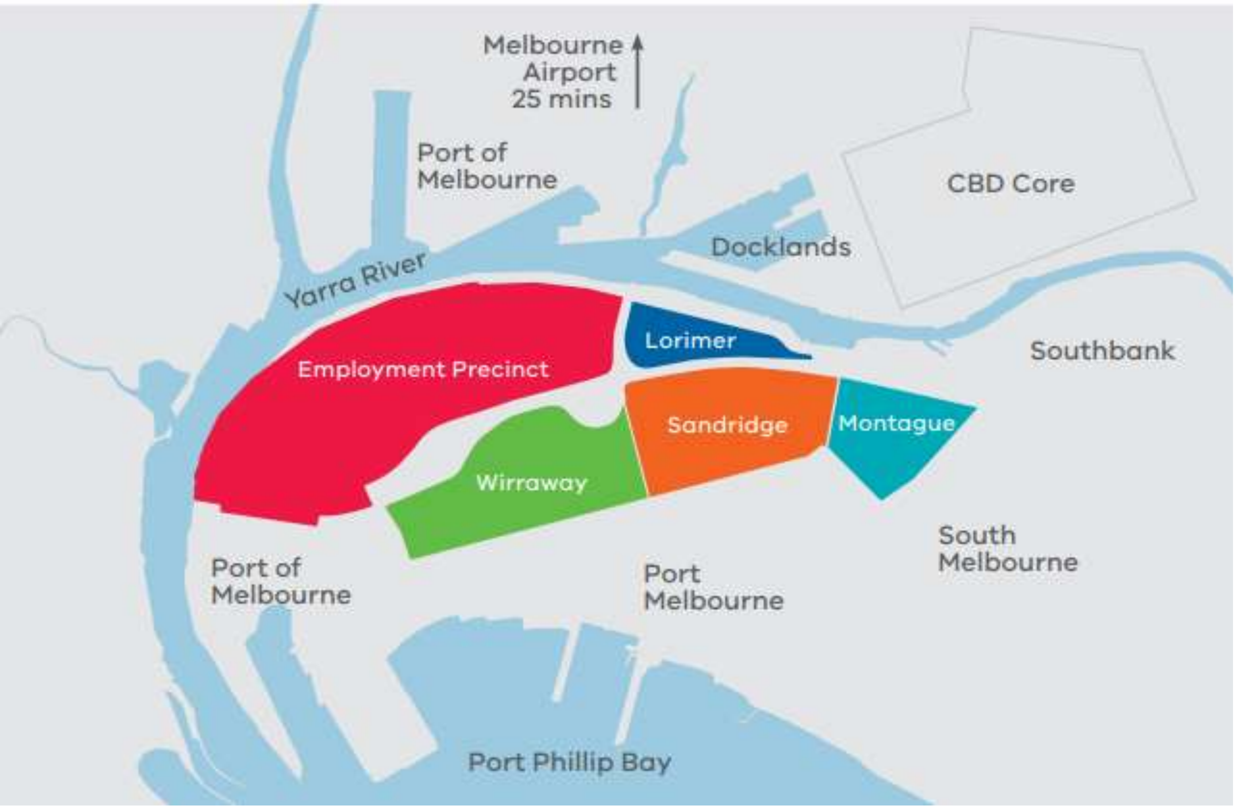


Figure 1 Fishermans Bend Site Overview

2.2 Study area constraints

A unique site, Fishermans Bend is subject to number of physical environmental and policy and planning challenges that are discussed briefly below.

2.2.1 Physical constraints

Physical constraints exist that will directly affect the way that Fishermans Bend is developed and the adaptation responses that are possible. These are due to the location of the area and how it has been used over time. These include:

- **Geology and location:** Lying on Coode Island silt deposited by the Yarra and Maribyrnong Rivers and overlaid with sand ridges from old beach dunes (originally separated by intervening swamps) use of the area for industry has seen reclamation, compaction, fill, and sand mining resulting in environmental and geotechnical challenges.
- **Soil and groundwater contamination:** A long history of industrial activity has impacted soil and groundwater quality in the Fishermans Bend area, with preliminary desktop assessments indicating elements such as heavy metals and solvents may be widespread. As well as elevated

levels of nutrients, salts and metals in groundwater (DELWP 2017). This constrains activities requiring excavation (such as for underground water storage; service trenching; car parks) or groundwater extraction and use for irrigating trees, green spaces and parks.

- **High water table:** The water table is situated close to the surface, compounding the risks associated with groundwater contamination through its potential to come into contact with building foundations, basement structures and subsurface utilities (AECOM 2016).
- **Inundation and sea level rise:** Fishermans Bend is situated on a peninsula within a low lying area adjacent to the Yarra River, near where it discharges into Port Phillip Bay. Ground levels generally vary from 0 metres Annual Height Datum (mAHD) to 4 mAHD. Therefore, significant areas are already subject to inundation, including from sea water in high tide events and by storm surges during extreme weather events, particularly towards the east within the Montague Precinct (GHD 2017; AECOM 2016). This is exacerbated by older infrastructure designed for industrial uses, and the impacts of climate change and run-off associated with urban development. On-going groundwater management may also need to consider salt water intrusion.

2.2.2 Planning and governance constraints

A number of planning and governance constraints are highlighted in the Victorian Government's (2017) *Fishermans Bend Community Infrastructure Plan:*

- **Proposed high-development densities:** limit the opportunity for community infrastructure to occupy significant land areas. Fishermans Bend is envisaged as a high- to medium-density urban renewal area accommodating 80,000 residents and 80,000 jobs (Victorian Government 2017). Limited undeveloped land areas also limit adaptation responses, such as provision of extensive open space networks for cooling and using landscapes to detain or retard flood water.
- **Land ownership is fragmented**: placing a heavy reliance on the private sector to deliver the development with about 90 per cent of the land in Fishermans Bend privately owned (Victorian Government 2017).
- **Projections for population growth and demographics**. For instance, a future community with a large proportion of young families will have very different needs to a community with a large proportion of residents aged over 60 (Victoria Government 2017). The population would also affect the costs and benefits associated with different adaptation actions.
- **Governance, coordination funding and management:** Fishermans Bend encompasses land in both the Melbourne and Port Phillip council areas, and is adjacent to critical State transport infrastructure. The Victorian Government is directly involved in the Fishermans Bend planning process given its state significance as an urban renewal precinct and because it is part of the Capital City Zone. There is a need for close collaboration between all governing authorities to coordinate the planning, funding and delivery of adaptation actions at all levels and to optimise investment in adaptive built form.

  Governance and coordination challenges can also emerge through the development approvals process and the ongoing management of adaptation infrastructure. For example minimum compliance with building regulations is unlikely to ensure thermal comfort; utilising WSUD to mitigate flood risk can encumber open space and present ongoing management challenges; and planning is inadequate in dealing with future social costs associated with the health impacts of extreme heat or the disruption of extreme weather events that impact at a societal level.

3.0 Policy context

It is important that the Climate Readiness Strategy aligns with broader international and local policy settings, the urban renewal objectives and (draft) framework for Fishermans Bend, and build on existing studies to compare and consolidate identified climate risks, their severity and impacts.

A range of legislation, policy and strategies relate to, or affect, the climate readiness of Fishermans Bend at the international, state and local level. This section provides a brief overview of these instruments.

3.1 Key policy drivers

3.1.1 International and national policies and strategies

At the international level, the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement of November 2016 sets the global policy context for climate change mitigation. Specifically, the Agreement aims to facilitate the ability of countries to mitigate their carbon emissions, adapt to climate change and foster climate resilience. Australia has ratified the Paris Agreement, committing to work towards limiting the increase in global average temperature to well below 2°C above pre-industrial levels. Australia has pledged to reduce greenhouse gas emissions 26-28 per cent by 2020, supported by a renewable energy target.

Focusing on adaptation, Goal 13 of the UN Sustainable Development Goals (SDG) challenges all countries to act to combat climate change and its impacts.

The Australia Government released the National Climate Resilience and Adaptation Strategy in 2015 which includes priorities related to checking and reassessing progress towards building resilience, as well as collaborating to identify emerging risks and interdependences. The National Strategy for Disaster Risk Resilience takes a resilience based approach to build capacity of people and natural and built assets to withstand and recover from natural disasters and emergencies, many of which are climate related.

3.1.2 State policies and strategies

The Victorian Government's Climate Change Framework recognises climate change as a complex and evolving challenge for the Government and the community, and as one of Victoria's most critical issues. The Government has revised the Climate Change Act (2017), established the Climate Change Framework (2017) and released Victoria's Climate Change Adaptation Plan 2017-2020 (Adaptation Plan).

These policies set the direction for reducing Victoria's greenhouse gas emissions (climate mitigation) and to prepare for the unavoidable risks and impacts of climate change (climate adaptation). The Climate Change Act 2017 sets the Victorian emissions reduction targets and stipulates that sectoral Adaptation Actions Plans (AAPs) will be required to be developed every five years, including for the built environment.

3.1.3 Regional and local policies and strategy

While international, national and state level actions enable climate readiness outcomes, local level action remains critical for effective adaptation. Both Port Phillip and Melbourne City Councils have demonstrated leadership and action in implementing local strategies to address climate change, mitigate emissions and build resilience, while a number of strategies have been developed for the metropolitan areas including Plan Melbourne.

The Climate Change Adaptation Plan Refresh 2017 (City of Melbourne) and the Five key actions to make Fishermans Bend Australia's most sustainable urban renewal precinct (City of Port Phillip and City of Melbourne) outline specific goals relating to climate readiness and fostering urban resilience.

Other plans and strategies include the Resilient Melbourne Strategy, TAKE2 pledges, Target 155, City of Melbourne Heatwave Response Plan, EMV Strategic Action Plan, Safer Together and Water for Victoria. The City of Melbourne and the City of Port Phillip have strategies around biodiversity, heat, open space, transport, climate adaptation, urban forests and water. Combined, these strategies contribute to cooling urban environments, responding to flood risk, enhancing biodiversity, increasing open space, enhancing water security and improving community health and wellbeing and building social cohesion. Building and infrastructure owners and utility providers are also increasingly considering future climate scenarios and risks when planning new developments and upgrades.

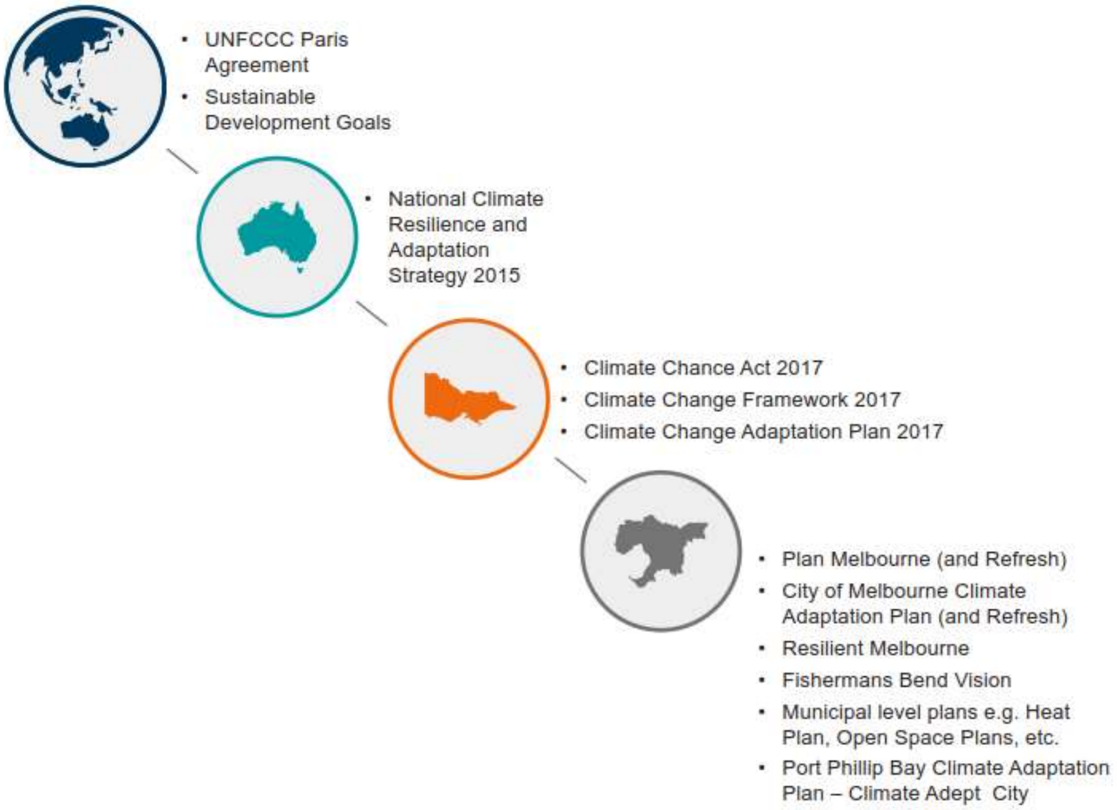


Figure 2 Summary of key strategies and policies influencing a climate ready Fishermans Bend

3.2 Emerging policy challenges

The Fishermans Bend area is directly exposed to many of the challenges facing urban areas globally as a direct consequence of rapid population growth, urbanisation and a changing climate. The scale of the area and development proposed presents a planning and design challenge to provide high amenity and a sustainable, climate ready urban form.

Rapid growth places significant demand on urban systems such as transport, community infrastructure and open space, and for essential goods such as potable water and eco-system services. Urban expansion increases the separation of communities from their food systems. With an ageing community, urban environments must be designed to support active ageing in place.

The changing climate brings more intense, extreme weather events, causing higher social, environmental and economic costs of damage as urban areas grow. This necessitates a policy shift towards building community and disaster resilience, and fostering community cohesion. Urban heat is increasing social and health costs and the demand for energy for cooling can overwhelm supply. As sea level rises, many coastal settlements will become unviable, adding to economic uncertainty and the potential mass movement of people globally.

The nature of work is changing rapidly, supported by technology, which can enables automation of repetitive tasks contributing to the loss of traditional manufacturing jobs. Smart settlements and new technology may see autonomous electric vehicles become commonplace in Fishermans Bend, with many of the industries that support innovative and alternative technologies potentially located there. The development of Fishermans Bend can assist to drive the transition to a low carbon future, with longer-lasting regenerative systems reducing resource inputs, waste and emissions – a circular economy.

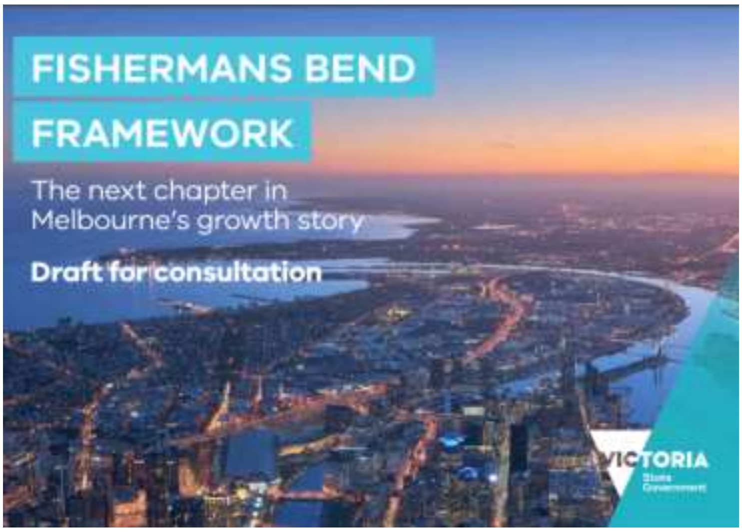
4.0 A framework for action

4.1 Fishermans Bend Framework

The updated Fishermans Bend Framework has been released for public consultation. The framework brings together a range of technical and background reports to propose a long term strategic plan to guide investment and the sustainable development of Fishermans Bend out to 2050.

It builds on the previously released Fishermans Bend Vision and has been prepared with input from the community, industry, key stakeholders and local councils. The draft Framework proposes 10 strategic directions. The 10 strategic directions are:

1. the creation of 21st century jobs
2. the timely provision of infrastructure
3. a place that is easy to get around
4. a vibrant mix of uses and activities
5. distinctive and unique neighbourhoods
6. diverse communities
7. a high quality built environment
8. a sustainable and resilient place
9. manage industrial legacy and ground conditions
10. strong partnerships, effective governance and civic leadership



The draft Framework provides clearer direction for the future development of Fishermans Bend through controls to drive density and mixed use outcomes, as well as to protect open space amenity, guide community infrastructure and transport.

4.2 Vision

The overarching vision for Fishermans Bend is that it is:

> ***"A thriving place that is a leading example for environmental sustainability, liveability, connectivity, diversity and innovation."*** *(DELWP 2016).*

In order to drive best-practice sustainability outcomes for the area, eight sustainability goals have been identified. Among these, Goal 4 aims for a climate adept community. This goal is described as:

> *"**A climate adept community**: Fishermans Bend will need to be resilient to extreme weather events – including flooding, drought, heat waves and storm surges associated with sea level rise. A high degree of social cohesion exists, creating an environment that enhances community resilience. In the future in Fishermans Bend, the urban heat island effect will be lower than in other areas of Melbourne.(DELWP 2017)"*

Achieving this vision and goal requires understanding and managing the climate impacts that are already being experienced in Fishermans Bend and ensuring that the area is prepared for future risks. Fishermans Bend is already experiencing the impacts of climate change. Increasing temperature and reduced, but more intense, rainfall already affect the area. These impacts are likely to become more severe and have the potential to affect the 80,000 jobs and 80,000 residents planned for the area. As it is early in redevelopment process, it is more cost effective to prepare for these changing conditions before they occur.

4.3 Objectives and targets

To support the overarching vision, and the goal to be a climate adept community, specific climate readiness objectives and targets have been identified for Fishermans Bend. These objectives are expressed as long term outcomes and will be an important component of the monitoring and evaluation framework to track adaptation success over time. The objectives are aligned with the key climate risks for Fishermans Bend, described in Section 6.1 , the Fishermans Bend Vision and Sustainability Goals, and State climate change policy and legislation more broadly (DELWP 2016a). The climate readiness objectives are:

- 4.1 - reduce the urban heat island effect in Fishermans Bend
- 4.2 - Embed green infrastructure into the design of public spaces and buildings, to reduce heat, capture storm water and provide for biodiversity
- 4.3 - Develop better community understanding of climate risks

The targets for 2050 are:

- The urban heat island effect is reduced so that Fishermans Bend will be no hotter than Inner Melbourne
- The community is resilient to the shocks and stresses of climate change

In addition, Goal 5, A Water Sensitive Community seeks to reduce the impact of a changing climate, storm surge and flood events, including sea level rise through objectives to:

- 5.1 - Design the urban form to accommodate sea level rise and storm events
- 5.2 - Establish an integrated water system across Fishermans Bend to provide access to high quality potable and recycled water

Integrated urban development and water cycle management will support a more resilient and liveable city, including stormwater detention within buildings and landscapes that incorporate water sensitive urban design principles and improve water quality and manage flooding.

The approach to sustainability is built around Green Star – Communities. This sets out principles and credits in five categories (governance, liveability, economic prosperity, environment and innovation) and is a tool to monitor the development of the precinct over time.

4.4 Principles for a climate adept community

Adaptation is a complex challenge for Governments and communities. The impacts of climate change are unprecedented, and the scale and timing of impacts is constantly evolving. Given this, flexible and robust policies, plans and actions will be required to ensure successful and cost effective adaptation to a range of possible futures. These policies, plans and actions should be informed by the following principles, as informed by the Victorian Climate Change Adaptation Plan 2017-2020, which is based on the principles outlined in the Victorian Climate Change Act 2017 (DELWP 2016b).

- **Informed decision making**. Adaptation responses should:
  - be based on the best available evidence in the context of uncertainty
  - be flexible and iterative, allowing for adjustments as circumstances chance and new information is made available
- **Integrated decision making**. Decision makers should:
  - prioritise responses that are most likely to provide the greatest net social, economic and environmental benefit for Fishermans Bend
  - consider the costs of climate change, including externalities and long-term costs
- **Risk management**. Adaptation responses should:
  - ensure that risks are addressed by those who are best-placed to manage them
  - avoid unintended consequences (maladaptation)
  - not undermine the ability to adapt to climate change over the long term
  - consider trade-offs, and understand and recognise the costs of and limits to adaptation

- **Complementarity.** Adaptation responses should:
  - build on the experience of regions, sectors, communities and industry in adaptation
  - complement existing and planned adaptation work
  - contribute to and be compatible with efforts to reduce greenhouse gas emissions
- **Equity**. Adaptation responses should:
  - be equitable and fair
  - consider both the present and the short, medium and long-term future
  - adhere to principles of intra and intergenerational equity
- **Community engagement**. Adaptation responses should:
  - actively involve the community in setting policy directions and priorities
  - value and respect the knowledge and perspectives of Traditional Owner groups and Aboriginal Victorians.

4.5 Monitoring and review

4.5.1 Foundations of a monitoring and evaluation framework

To track the progress of climate adaptation in Fishermans Bend, it will be important to have a monitoring and evaluation framework based on an underlying logic that links adaptation actions with broader precinct goals and outcomes. A program logic model, as shown in Figure 2, helps to illustrate linkages between the design elements of a program and provides an overview of how a program is intended to work.

This strategy takes steps towards this by articulating long term outcomes for adaptation of Fishermans Bend (outlined in Section 4.3). It is anticipated that subsequent stages of work will determine the specific adaptation actions that will contribute towards these outcomes. These actions would then need to be monitored to determine progress, reviewed at various stages and evaluated to determine their contribution to short, medium and long term outcomes.

The timing of monitoring and evaluation would depend on the actions and alignment with compatible processes such as the Plan Melbourne Monitoring and Reporting Framework, which will report progress every five years and will include a consideration of performance against the United Nations Sustainable Development Goals (SDGs) (DELWP 2017).

Figure 3 Program logic – medium and long term outcomes outlined in this Strategy

4.5.2 Tracking long term outcomes

For the long term outcomes, articulated in this Strategy as objectives in Section 4.3, indicators could be used to track adaptation progress at various points in time. DELWP is currently developing a series of ‘State of Adaptation Indicators’ for integration into the State of Environment reporting in partnership with the Commissioner for Environmental Sustainability. This will ensure government collects relevant data to establish a baseline about how well Victoria is adapting to climate change, and is able to monitor this change over time. This may also form the basis of a themed ‘State of Adaptation’ report, and will be one source of information to inform future climate science reports, and the priorities of the 5-yearly climate change strategies under the Climate Change Act 2017.

It is proposed that data to support measures against the indicators identified would be collated at a state-wide scale, then analysed and synthesised into a narrative at the goal level by a working group and reported every five years. This is also aligned with the five yearly reporting cycle for Plan Melbourne. There is potential to align indicators for long term adaptation outcomes for Fishermans

Bend with these indicators, which are aligned with the broader goal of the Victorian Climate Change Adaptation Plan 2017 – 2020 and the UN Sustainability Goals.

This could align data gathering and reporting on adaptation within the State. The 'State of Adaptation' indicators are currently under development and have not yet been finalised. However, some proposed indicators current under development that may align with the adaptation objectives for Fishermans Bend are outlined in Table 1. These may change as the development of the indicators progresses.

Table 1 Draft State of Adaptation indicators relevant to Fishermans Bend's adaptation objectives

Fishermans Bend Adaptation Objectives	Relevant draft state indicator(s)	Victorian Adaptation Plan Goal	UN SDG[1]
Reduce the urban heat island effect in Fishermans Bend	Impact of heat stress on productivity	Flexible and prosperous economy	Goal 3 - Good Health and Well-being
	Funding for climate adapted construction and refurbishment	Leadership	Goal 11 – Sustainable Cities and Communities
Design the urban form to accommodate sea level rise and storm events	Considering climate risks in land use planning (including in the coastal zone)	Leadership	Goal 11 – Sustainable Cities and Communities
	Households permanently displaced as a result of flood, fire, drought or sea level rise	Connected, safe and resilient communities	Goal 11 – Sustainable Cities and Communities
Embed green infrastructure into the design of public spaces and buildings to reduce heat, capture storm water and provide green links for biodiversity	Landscape vegetation connectivity	A healthy environment	Goal 15 - Life on Land
	Councils (or other organisations) with urban forestry, or other greening or cooling-related strategies	A healthy environment	Goal 11 – Sustainable Cities and Communities
Establish an integrated water system across Fishermans Bend to provide access to high quality potable and recycled water	*No indicator currently proposed* Could include: Sub-catchment based MoUs between planning, responsible and drainage authorities	*No indicator currently proposed* Could include: Capacity of public spaces to store stormwater during times of flood. Number of developments and volume of water from alternative sources	No indicator currently proposed
Develop better community understanding of climate risks	Community preparedness to respond to extreme weather events	Connected, safe and resilient communities	Goal 11 – Sustainable Cities and Communities and Goal 9 – Industry,
	Community awareness of climate risks and associated responsibilities	Collaboration and shared responsibility	

[1] While only one SDG is noted here it is acknowledged that the SDGs are designed to be cross cutting concepts and that more than one SDG may be relevant to each indicator.

Fishermans Bend Adaptation Objectives	Relevant draft state indicator(s)	Victorian Adaptation Plan Goal	UN SDG[1]
	Number of households and businesses affected by natural disasters	Connected, safe and resilient communities	Innovation and Infrastructure
	Weather related disruptions to essential services	Flexible and prosperous economy	Goal 9 - Industry, Innovation and Infrastructure
	Financial losses to business due to extreme weather events	Flexible and prosperous economy	

5.0 Climate change impacts and risks

5.1 Climate variables and projections

The high level screening of existing climate risk assessments undertaken for Fishermans Bend identify three key climate variables: temperature, rainfall and sea level impacting on the area. A summary of the projections for each variable for the City of Melbourne, City of Port Phillip and the Victorian Government is provided in Table 2. Projections relating to key impacts associated with extreme heat (coupled with the Urban Heat Island effect (UHI), intense rainfall, storm surge and sea level rise have also been identified.

The UHI effect is where air temperatures in an urban environment are higher than those in the surrounding hinterland or rural environment as a result of the replacement of natural, vegetated surfaces with urban development.

Table 2 Climate variables and projections (generally RCP4.5 unless stated)

Climate variable	Climate projections		
	City of Melbourne[2]	City of Port Phillip[3]	State Government[4]
Temperature Annual average temperature (annual average number of days over 35°C)	**2030**: +0.4 - 1.1°C (12 - 15 days) **2070**: +1.1 - 3.7°C (20 days) **2090**: +1.1 - 4°C (15 - 32 days)	**2025**: +1.5°C (20 days) **2050**: +2.5 - 3.5°C (30 days) **2100**: +4.5 - 6°C (45 - 50 days)	**2030:** +0.45 - 1.1°C (12 days) **2070**: +1.2 - 1.9°C (14 days) **2070**: RCP8.5 +2.1 - 3.1°C (17 days)
Urban Heat Island effect	+7°C In 2016, 11 days were over 35°C. CBD temperatures can be up to 7°C higher than less urbanised areas		
Rainfall Annual average rainfall	**2030**: -10 to +3% **2070**: -11% **2090**: -27 to +4%	**2025**: -15% **2050**: -20 - 25% **2100**: -25 - 40%	**2030**: -10 to +4.2% **2070**: -16 to +4.6% **2070** RCP8.5: -23 to +4.5%
Heavy rainfall intensity	**2030**: -7.7 to +15% **2070**: -24.8 to +48.9%	**2025**: +10 to 15% **2050**: +35 to 45% **2100**: +80 to 100%	
Storm surge / with SLR		2m surge (80cm rise) 2.3m surge (80cm rise +10% wind-speed increase)	
Sea Level Rise Average sea level rise (SLR)	**2030**: +7 - 19cm **2090**: +27 - 89cm	**2025**: +10 - 20cm **2050**: +40 - 55cm **2100**: +80 - 120cm	**2030**: +7 - 16cm **2070**: +20 - 45cm **2070**: RCP8.5 +25 - 54cm

[2] Extracted from Table 1: Climate change projections for Victoria from City of Melbourne's Climate Change Adaptation Strategy 2009. Based predominantly on projections and emissions scenarios in Climate Change in Port Philip and Westernport 2008. Medium emissions scenario (A1B) for 2030 and a higher emissions scenario (A1FI) for 2070.
[3] Extracted from City of Port Philip Climate Adaptation Plan 2010. Based on NATCLIM (Earth Systems and Planning Research Centre, University of Sydney) 2006 research data as well as CSIRO and Intergovernmental Panel on Climate Change 2001 data.
[4] Climate Ready Victoria Climate Projections Data Sheet https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0021/60753/Greater-Melbourne-Data-sheet.pdf

Each variable has potential to create risks and potential impacts for the area. This section provides an overview of the potential climate risks and impacts before discussing a broad range of adaptation responses that could be considered, with examples of actions that could be undertaken as part of a precinct planning, design and adaptation response. These responses and actions are not intended to serve as an action plan or provide specific recommendations, but provide an overview of potential options and opportunities that can be considered as planning for the area progresses.

5.2 Climate impacts

As noted, the key climate variables identified as significant for Fishermans Bend are temperature, rainfall and sea level rise, with associated extreme weather events. Each of these variables combine to l have a range of impacts on people, buildings (including residential, commercial and industrial), infrastructure (including utility, public realm and community) and precincts as a whole.

5.2.1 Temperature

An increase in average annual temperatures will result in a hotter and drier climate. It is projected that annual temperatures in the Melbourne and Port Philip areas will increase by almost 1°C by 2030 and up to 4°C towards the end of century. Both peak temperatures (and hot spells) are expected to increase as well.. The impacts of the projected temperature increases is amplified by the Urban Heat Island effect, in which dense urban environments can have temperatures up to 7°C hotter than adjacent rural areas.

A summary of the impacts of temperature rises affecting Fishermans Bend is provided in Table 3

Table 3 Impact of temperature changes to Fishermans Bend

Scale		Impact description
People		A warming climate and the transition to a high density urban environment will impact on vulnerable people disproportionately. Poorer, older, younger and those who are homeless are more vulnerable, particularly with the urban heat island effect.. The high concentration of people and workers will place high demand on parks, gardens and streetscapes, which are likely to be impacted by the hotter drier climate. If these areas deteriorate they will provide lower amenity and respite impacting people's health and wellbeing. heat stress. Deaths and illness related to heatwaves would increase. Currently, heatwaves are the leading cause of deaths compared to any other natural disaster in Victoria (Steffen & Perkins 2014). High temperatures also impact on sleep patterns when it is uncomfortable during the night, which increases fatigue. Diseases and pests that are not common in the current climate will present a problem in the future as the overall climate conditions change.
Buildings	**Residential**	Higher temperatures impact upon the performance of the built environment. People spend the majority of their time inside buildings. An increase in peak temperatures (and hot spells) places considerable stress on buildings. It also increases the water and power consumption for buildings and the broader utility network. Building materials and finishes may deteriorate more quickly.
	Commercial	As for residential. Additionally, building services responsible for maintaining comfortable indoor conditions for building occupants are typically designed to operate up to certain temperatures. Reduced comfort impacts on productivity, and will also reduce commercial activity when the public realm is too hot. Capital outlay may be required to retrofit buildings to ensure continued functionality. Changing temperatures will impact upon the physical and chemical processes that cause concrete deterioration. Long term concrete structural performance will be affected.
	Industrial	As for residential and commercial.

Scale		Impact description
Infrastructure	**Utility**	Increased irrigation is required to keep trees and plants healthy, which can also place stress on water infrastructure during a period which typically coincides with less rainfall. Capital expenditure may be required for decentralised energy generation to ensure electricity network capacity can meet peak demand during maximum summer temperatures. Extreme heat may increase network performance and costs, and reduce supply reliability.
Infrastructure	**Public realm**	Higher temperatures impact on the structural integrity of key infrastructure such as roads and bridges. Extreme heat has historically strained public transport infrastructure in Melbourne. Parks and other green infrastructure, which help reduce the urban heat island effect and provide shade to people and buildings, suffer damage due to the reduced evapotranspiration effects. Increased irrigation is required to keep trees and plants healthy.
Infrastructure	**Community**[5]	Increased temperatures may result in decreased engagement with community infrastructures and increased utilisation of others. Certain populations that are vulnerable to extreme heat may be excluded from outdoor activities due to risks emerging from heat exposure. In periods of extreme heat, non-active modes of transport will be prioritised which may result in changing patterns of access to facilities and services. Vulnerable populations may seek greater respite from heat in air-conditioned community or commercial facilities, or in shaded open spaces. Poor housing stock and increasing stress of power prices may result in heat stress and greater demand for health facilities.
Precinct		Higher temperatures coupled with the urban heat island effect can reduce the liveability and attractiveness of an area. The precinct's proximity to the Yarra River and Port Phillip Bay beaches may mitigate this impact slightly relative to some other areas across Melbourne. Precinct planning for shade, greening, using water in the landscape and to catch cooling breezes will assist to limit the impact on precinct amenity

5.2.2 Rainfall

Average annual rainfall is expected decrease due to the effects of climate change. A decrease of approximately 4 to 15% rainfall is expected in the region in the medium term, and 11 to 40% in the long term. This will increase drought risk and severity which in turn increases the risk of fires, and impacts on open space amenity.

A summary of rainfall impacts at different scales is provided in Table 4.

Table 4 Impact of changes in rainfall to Fishermans Bend

Scale	Impact description
People	A drier climate is likely to compound impacts of heat stress, particularly for the most vulnerable. Reduced rainfall places pressure on urban water supplies resulting in water restrictions being placed on the wider community and higher water costs. Drought periods can also lead to less outdoor activities, impacting health and contributing to a loss of social cohesion. A deterioration in the quality of open spaces may make them less attractive and contribute to stress, and reduced health and well-being, should the planned third pipe not enable open spaces to be adequately watered to create a drought free green landscape.

[5] Community infrastructure, as enumerated in the 2014 Community Infrastructure Development Framework, is largely comprised of physical assets (buildings) and public realm infrastructures and the associated services provided. The differentiating aspect is the way in which people engage with these infrastructures. Climate change impacts can be expected be similar to those of buildings and public realm infrastructure, but will be compounded by the ways in which people access, demand and develop dependencies upon these services.

Scale		Impact description
Buildings	**Residential**	Water restrictions may impact on building operations as various key building services require water to function. Increase in dust can impact maintenance requirements for cleaning windows and filters. Reactive soils, such as clay, are susceptible to expansion and contraction as soil moisture content changes. Changes in rainfall frequency, amount and intensity may result in adverse impacts to structures and increased maintenance costs. Water Sensitive Urban Design components such as green roofs, walls and facades may be unable to function under extended drought conditions.
	Commercial	As for residential. Additionally uncertainties associated with rainfall projections may mean that rainfall decline is greater than designed for.
	Industrial	As for residential and commercial
Infrastructure	**Utility**	Decreased stream flows may result in reduced water supply. Increased bushfire risk in catchment areas has the potential to compound this stress. Dry soil conditions are expected to increase the risk of pipe failure and collapse. Changes in precipitation patterns, evapotranspiration and frequency and intensity of droughts may adversely impact hydropower generation. This may be increasingly important as the precinct moves towards carbon neutrality.
	Public realm	Extended drought and water restrictions in the region have severely damaged the health of Melbourne's trees, resulting in a steep increase in tree mortality (Melbourne Council 2011). Low water availability also restricts the ability to maintain green infrastructure. Decreased precipitation has the potential to result in increased ground movement, changes in the water table and associated increases in the salinity of soils. These changes may accelerate the degradation of materials, structures, reinforcements and foundations, reducing the life expectancy of the transport infrastructure and increasing maintenance costs.
	Community	Some community infrastructure, particularly community gardens and outdoor activity spaces require a minimum amount of water to retain functionality. Climate change will increase the likelihood of these thresholds being surpassed.
Precinct		More dust storms are expected which will increase air pollution in the area. This in turn will impact the wider community leading to health issues and additional stress on emergency services. The loss of green infrastructure impacts the natural stormwater management it provides and can result in poor outdoor amenity.

5.2.3 Extreme weather events – storm, flood, heatwave

Despite a drying climate, climate change increases the likelihood of extreme weather events occurring. It is expected that heavy rainfall intensity will increase by up to 15 per cent in the medium term and 50 to 100 per cent in the long term. Intense rainfall events are often accompanied by strong wind, hail, and more recently a thunderstorm asthma event. It is also expected that the number of days over 35°C will double by 2090, increasing the likelihood of hot spells or heatwave conditions. A summary of the impacts of extreme weather events at different scales is provided in Table 5.

Table 5 Impact of extreme weather events to Fishermans bend

Scale	Impact description
People	While flash flooding and storm damage increase the risk of injuries and deaths to the public and result in business closures and job losses, the stress, inconvenience and disruptions add to social and financial strain.. People will be left stranded and access to and from the precinct will be reduced. Emergency response services will be hindered and worsens the health impact of extreme

Scale		Impact description
		weather events. Flood waters can take time to recede, potentially impacting on human health. Vulnerable people, in particular disadvantaged, homeless, the elderly or young are disproportionately affected by heat stress. Deaths and illness related to heatwaves would increase. Currently, heatwaves are the leading cause of deaths compared to any other natural disaster in Victoria (Steffen & Perkins 2014). High temperatures also impact on sleep patterns when it is uncomfortable during the night, which increases fatigue. Diseases and pests that are not common in the current climate will present a problem in the future as the overall climate conditions change.
Buildings	**Residential**	Storm damage, including wind, hail and flooding typically cause substantial damage to buildings and increase maintenance and repair costs. Insurance costs are anticipated to increase as financial companies re-assess the risk associated with these events to mitigate their own exposure to such risks. Heatwaves increase the demand for power for cooling, and demand can often overwhelm supply, increasing demand for back-up power when available.
	Commercial	As for residential. Extreme weather often prevents staff and customers from accessing commercial premises, In addition business continuity can be impacted by interruptions to supply and distribution channels, power interruption, and also through direct damage to stock, assets and business records
	Industrial	As for residential and commercial.
Infrastructure	**Utility**	Extreme weather events increase risk of damage to stormwater infrastructure and facilities due to higher peak flows. The incidence of sewer overflows may increase. Rapid changes in cloud cover or wind speed may affect the stability of grids with high renewable energy generation. This will be increasingly important as the renewal project moves towards carbon neutrality.
	Public realm	Access to and through the precinct (via major arterial roads including the West Gate and Princes Freeways), public transport systems and local access will be severely impacted due to flooding or storm damage, or power outages associated with hot spells or storm damage. Access to alternative pedestrian and cycling routes, and to sheltered and shaded routes will assist to manage impacts of disruptions. Impacts on local infrastructure and utilities such as electricity supply and telecommunications are likely to be substantial as well. Water quality is likely to be reduced from higher stormwater contamination.
	Community	Volunteer emergency services may be more frequently required. Access to community infrastructure may be compromised in the event of extreme weather events, leaving vulnerable populations in unstable situations.
Precinct		The impact of flooding, both in severity and frequency, will impact investment decisions in the precinct. Potential liability and reputational damage relating to the construction of buildings and infrastructure not being designed to take into account future climate change risks would be significant. Impacts on urban greening and other cooling strategies can also impact on employer and investor decisions in the precinct.

5.2.4 Sea level rise

Considering the location of the precinct, there is a significant risk posed by sea level rise. It is estimated that average sea level rise will be up to 15 centimetres in the medium term and 59 to 120 centimetres in the long term. Riverine and coincident flooding will also increase in frequency. Storm surge will amplify this flood risk.

A summary of the impacts of sea level rise at different scales is provided in Table 6.

Table 6 Impact of sea level rise on Fishermans Bend

Scale		Impact description
People		Localised coincident flooding will increase damage and disruption in the area and cause residents to be stranded, disruption to businesses and damage to assets. The stress associated with such events will cause a strain on the mental health of the residents and regular visitors to the precinct. Access to local beaches will reduce as the coastal area is eroded or inundated causing greater stress and health impacts particularly in hot weather.
Buildings	**Residential**	Buildings will be extremely susceptible to damage from rising sea levels in particular from inundation in low lying areas. Coastal properties and assets will be impacted in various ways and may result in the loss of the property altogether for highly erodible areas. Structural damage from sea water intrusion is an important consideration for the design on the buildings.
	Commercial	Higher water costs and restrictions also impact on building operations as various key building services require water to function. Increased incidence of debris can impact maintenance requirements for cleaning windows and filters. Loss of beaches will have a direct impact on access to coastal buildings and commercial uses will become less attractive destination impacting their viability.
	Industrial	As for residential and commercial.
Infrastructure	**Utility**	Flooding and the gradual sea level rise will cause damages to infrastructure in low lying areas. Increase salinity levels in recycled water may infiltrate the sewage network and wastewater treatment facilities.
	Public realm	Increases in soil salinity may accelerate the degradation of materials, structures, reinforcements and foundations, reducing the life expectancy of the transport infrastructure and increasing maintenance costs. Vegetated open space areas will require a different type of plant/grass.
	Community	Community infrastructure may be susceptible to damage from rising sea levels in particular from inundation in low lying areas. Accessibility to services provided by the infrastructure may also be impacted. Reduced beach areas may make some coastal dependent uses unviable
Precinct		Flooding and beach erosion will result in the loss of beaches and other low-lying areas impacting biodiversity and increasing competition for space. Recreational spaces, trails and paths which drive tourism and residential investment and the protection provided to private assets beyond the coastal strip will be lost. Across the precinct SLR may impact vegetation as areas either temporarily inundated and the impacts now will intensify as the return frequency increases.

5.3 Climate risk assessment

Using climate impact and projection information from the most recent City of Melbourne and City of Port Phillip Adaptation Strategies, a high level risk assessment was undertaken to identify key risks for Fishermans Bend now, and in the future (2030 and 2070). The risk assessment considered risks arising from the climate variables discussed above, categorising these risks as:

- Temperature and heatwave
- Drought and reduced rainfall
- Intense rainfall and wind event
- Sea level rise

A full risk register is provided in Appendix A. Risks were assessed in relation to their likelihood and consequence using consequence ratings from the City of Melbourne's 2009 Adaptation Strategy, provided in Appendix B, which was carried forward into the 2017 Refresh. This assessment used information provided in previous studies only; no new risk information was added.

A summary of the most significant (high, extreme) risks identified across the four categories is shown in Tables 7, 8, 9 and 10. The majority of these significant risks arise from extreme rainfall and wind events and extreme heat and heatwave. These risks centre on impacts to human health, mobility and the economy. Many of the risks associated with intense rainfall and wind events are being experienced now, and will continue to be relevant in the future. The risks from sea level rise do not manifest until 2070, representing significant opportunities for mitigation as part of the planning and development process.

Table 7 Extreme heat and heatwave

Risk	Now	2030	2070
Increased heat stress related death / illness among at risk population groups			
Passengers become stranded as trains and trams are delayed / cancelled in hot weather			
Blackout			
Increased maintenance costs of assets and infrastructure			
Disruption to any outdoor event due to hot weather			
Reduced public and social use of space during heat waves			
Future liability and reputation damage relating to construction of dwellings or infrastructure unsuited to projected climatic conditions			

Table 8 Drought and reduced rainfall

Risk	Now	2030	2070
Insufficient urban water supply			
Impacts to biodiversity in upstream waterways due to insufficient environmental flows resulting from reduction in water availability			

Table 9 Extreme rainfall and wind event

Risk	Now	2030	2070
Mass stranding of people due to public transport stoppages, as a result of flooding or storm damage.			
Adverse health outcomes due to emergency services being hindered by storm and flood impacts, such as flooded roads, traffic delays, and other blockages.			
Increased potential for injuries or deaths occurring as a result of flash flooding.			
Increased reparation costs following intense rainfall and wind events, including damaged buildings, damaged or collapsed roads, damage to river banks and associated infrastructure, general clean up.			
Business closure and job loss due to business interruption from storm damage and flooding.			
Increased potential for injury, death, damage or delays resulting from damage to or falling of trees.			
Lost tourism following storms or intense rainfall events.			

Table 10 Sea level rise

Risk	Now	2030	2070
Residential property damage from increased flood return to habitable areas			
Costly infrastructure adaptations as a result of increased flood return to habitable, marine and waterfront recreation areas			
Injury and death due to increased frequency of flooding to waterfront leisure and recreation areas			
Stranding of residents due to increased flood return to habitable areas			
Decreased waterfront property / precinct values due to increased flood return to habitable, marine and waterfront recreation area			
Mental stress resulting from the consequences of increased flood return to habitable areas			
Potential liability due to approved residential and business construction that did not account for increased flood return to habitable areas			
Damages to waterfront businesses due increased frequency of flooding to leisure/ recreation areas[6]			

[6] Note Montague experiences flooding impacted by SLR now

6.0 Climate adaptation responses, actions and best practice case studies

6.1 Overview

A number of adaptation responses have been identified which can mitigate the identified significant climate risks. As the future urban form of Fishermans Bend is uncertain, this Section provides an overview of 'Adaptation Responses' and associated examples of 'Adaptation Actions'. These Adaptation Responses and Actions are general and should be further considered and developed as appropriate to Fishermans Bend as the planning process progresses. The appropriateness of the Adaptation Response will vary depending on a range of factors and site constraints, such as those highlighted in Section 2.2.

The following Section provides a summary of Responses and Actions for each risk category, with extreme events separated into two components: extreme rainfall events (flooding) and extreme wind and hail events, due to the substantial number or potential responses and actions in each. Case studies of international best practice are also provided for each category to illustrate how Responses and Actions have been implemented locally and across the globe. Further information on Adaptation Responses is provided in a Catalogue of Adaptation Responses in Appendix C. A more detailed collection of the case studies is provided in **Appendix D.**

Table 11 Factors to be considered in relation to each adaptation response

Factors		Icon
Scale to be applied The applicability of responses across various urban scales	Building	
	Sub-precinct	
	Wider Urban Catchment	
Relative cost to implement First costs to implement	Low	
	Medium	
	High	
Potential for co-benefits Potential for response to have benefits in other environmental, economic, and social spheres	Increased energy efficiency or reduced energy use	
	Benefits for urban greenery and ecosystems	
	Increased water efficiency or reduced water use	
	Decreased intensity of carbon emissions	
	Community education, cohesion, and resilience	
Avoided Cost/Potential Savings	High	

Factors		Icon
Likelihood response will provide cost savings through avoidance of impacts	Medium	
	Low	
Relative ease of implementation (effort) Complexity of aligning resources, organisations and stakeholders to implement.	Easy	
	Medium	
	Hard	
Within existing policy/strategy Response has been considered or addressed in existing policy, strategy, or requirement	Yes	
	No/Not Known	

6.1.1 How to use this section

For each risk category, a high-level analysis of potential responses and associated actions has been compiled. It was not within the Project scope to provide more granular detail for individual actions. Instead the Actions can be used as a checklist to inform developers, residents and agencies of potential activity they should consider. More detail on each Action and the applicability of individual Actions to buildings, sub precincts and the area would require more detailed investigation, and modelling in some instances. For instance, indicative costings for identified Actions could not be compiled.

It was also unfortunately not possible to prioritise actions above others that have a greater potential to deliver multiple benefits. However, it is safe to assume that many of the actions will deliver multiple co-benefits and community benefits. Actions have been ordered with those which could potentially be lower cost or relatively easier to implement or more beneficial listed first. The ease of implementation is also largely governed by whether policies and plans to encourage this Action are already in place for Fishermans Bend. The presence or absence of supportive plans and policies is also indicated in the Gap Analysis in Section 7.

The ordering would need to be verified through further work and assessment. Further information on Adaptation Responses is provided in a Catalogue of Adaptation Responses in Appendix C – this also includes for each Action high level guidance on which Actions need to be planned for at precinct scale and which need to be pushed through building and development processes or which will need to progress funded by service providers.

These responses and actions are gathered from international best practice and act as a checklist to prompt consideration of additional actions that could form part of the comprehensive policy framework currently being developed for Fishermans Bend.

6.1.2 Co-benefits and community benefits

As stated on the Fisherman's Bend Urban Design Strategy, the urban form in the area should and will provide for multiple benefits or co-benefits:

> *"The urban form of Fishermans Bend should support the broader sustainability objectives for the area, including responsible water, energy and waste management as well as enhancing biodiversity. The built form controls need to support the delivery of sustainable buildings by promoting good solar and daylight access and cross-ventilation".*

While co-benefits have been highlighted for each Response it is recognised that there are also significant community co-benefits generated for inhabitants and workers in the area from pursuing sustainable and climate resilient urban design and the Actions in this document. Many Actions are likely to deliver multiple co-benefits and community benefits. Community benefits include increased cooling and thermal comfort in buildings and public spaces, increased community wellbeing, improved health outcomes, greater social and community cohesion and improved productivity etc. Developments that provide a range of opportunities for socialising, relaxing, sharing and community participation in comfort and safety can support social interaction amongst residents and the broader community. This can help to build community networks which are critical in enhancing a community's resilience to long-term stresses (such as social inequality and climate change) as well as acute shocks (such as heatwaves or floods). These are outlined in detail in the Resilient Melbourne Strategy, 2016).

6.2 Temperature risk and responses

6.2.1 Extreme heat and heatwave

Along with extreme rainfall, the impact of extreme heat and heatwave contribute to a significant number of risks being experienced now. Heat can be considered as both an acute shock (heatwaves leading to morbidity and mortality) and as a chronic stress (heat in built up areas impacting people's homes and preventing people from using recreational areas, walking or cycling and ongoing psychological stress). While current risk centres on potential for morbidity and mortality from extreme heat and heatwave, in the future, increasing temperatures may lead to more impacts on the use of outdoor and recreational areas, walking or cycling.

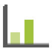
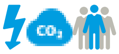
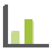
Adaptation responses to extreme heat and heatwave includes a range of cooling methods, while building level cooling, behavioural approaches and community education and resilient critical infrastructure may reduce risks associated with heat as an acute shock, cooling with urban greenery, shading, cool and planning measures and urban layout may help adapt to heat as a chronic stress. There are precinct specific issues and opportunities to tackle urban heat. Mapping of the micro climate under current and future climate conditions taking account of future options for urban form, density, use characteristics and topography will inform developers and agencies of any special challenges or opportunities for cooling at the individual building and sub precinct level. The current building energy standards cater for some but not all future climate challenges, for instance through identified climate maximum NatHERS annual building cooling loads and through the 2017 Victorian Apartment Design Guidelines. The later refer to microclimate considerations – where rain gardens, grassed areas, green walls, green roofs, permeable pavements and water features are encouraged as they contribute to cooling the microclimate. These Guidelines aim to promote climate responsive landscape design and water management in developments that support thermal comfort and reduce the urban heat island effect. They also promote apartments that are energy efficient through passive design which provides good thermal comfort and daylight access and reduced energy costs.

With the ongoing effects of climate change it is recognised that ensuring the thermal performance of apartments over summer will become increasingly important. Urban greenery is particularly important in high density areas with little or no access to public spaces. The co-benefits and community benefits created from urban greenery by increased cooling and thermal comfort in buildings and public spaces include: increased community wellbeing, improved health outcomes, greater social and community cohesion and improved productivity etc. The overall layout and massing of a development is linked to the opportunity for buildings to be sustainable, including allowing sunlight and daylight to reach internal spaces, opportunities for natural ventilation and providing open space for landscape opportunities to support biodiversity and cool buildings. Opportunities for green open space and passive building design such as natural ventilation and good daylight and sunlight access are particularly important for Fishermans Bend. Building and precinct designs need to contribute to the creation of a positive cool and safe public realm.

These responses span a range of costs, and can be applied at varies scales as summarised in Table 12 .

Table 12 Extreme heat and heatwave responses and example actions

Response			Actions
Cooling with urban greenery	Scale		• Green spaces (i.e. parks and trees) and shade corridors in urban areas • Green facades (i.e. green walls/roofs) • Tree planting and urban vegetation • Creation of wetlands and vegetated ponds • Assess vegetation impacts on UHI • Natural turf and grass cover
	Cost	$	
	Avoided Cost		
	Co-benefits		
	Effort		
	Existing strategy		
Shading	Scale		• Conduct shade audit of existing facilities and new facility designs • Provide shade (natural, facades, overhangs, buildings) • Shade structures for play equipment and outdoor recreational areas • External solar shading for buildings (artificial and vegetated) • Double skin façades
	Cost	$	
	Avoided Cost		
	Co-benefits		
	Effort		
	Existing strategy		
Cooling with water	Scale		• Cooling with water elements (e.g. misting, fountains and ponds) • Geothermal heating/cooling using seawater
	Cost	$ $ $	
	Avoided Cost		
	Co-benefits		
	Effort		
	Existing strategy		
Planning measures and urban layout	Scale		• Develop heat mitigation strategies for all public spaces • Mandate site composition to reduce UHI • Implement best practise design guidelines (e.g. Victorian Apartments Design Guidelines 2017) • Adopt integrated (risk sensitive) land use planning • Orientate for prevailing winds and ventilation corridors • Revise building standards and codes • Microclimate and urban heat island modelling and mapping
	Cost	$ $	
	Avoided Cost		
	Co-benefits		
	Effort		
	Existing strategy		
Building-level cooling strategies	Scale		• Upgrade the efficiency of HVAC systems or decentralised power • Passive/natural ventilation to increase
	Cost	$ $	

Response			Actions
	Avoided Cost		thermal comfort • Improve use of thermal properties of building materials • Light coloured (reflective) materials and vegetation for cool roofs and pavements • Reduce solar heating using recessed windows, roof overhangs and shades • Active (mechanical) cooling, including chilled beams and conventional air conditioning systems • Automatic mid-pane blinds • Chilled beams or under floor supply • Double glazing • Building sealing • Solar control film • Geothermal heat pumps for reserve cycle air conditioning/ water heating • Building Management Control • Equipment resilience to temperature • Development of cooling towers • Building envelope insulation
	Co-benefits		
	Effort		
	Existing strategy		
Behavioural approaches and community education	Scale		• Heatwave response plan, toolkits, checklists and guidelines • Identify and develop heat refuges • Community education to increase awareness of heat stress/sun exposure • Heatwave warning system including transport option information • Flexible working hours to avoid heat exposure • Event protocol in heatwaves • Anti-violence outreach programs for heat
	Cost		
	Avoided Cost		
	Co-benefits		
	Effort		
	Existing strategy		
Resilient Critical Infrastructure	Scale		• Conduct detailed review of the design capacity of critical infrastructure • Encourage decentralised renewable energy production and locally based energy systems to lessen vulnerability to grid failure • Backup power supply • Centralised power controls • Real time data and analytics for emergency scenario modelling
	Cost		
	Avoided Cost		
	Co-benefits		
	Effort		
	Existing strategy		

In practice – City of Chicago
Extreme heat preparedness

The City of Chicago has taken systematic steps to help prepare its communities for the impacts of extreme heat and heatwave. Chicago's approach focuses on community preparedness, particularly identified vulnerable populations. Chicago developed a community outreach program that targeted neighbourhoods particularly vulnerable to extreme heat events. This was done through a partnership with the Field Museum, a leader in science education and engagement. The aim of the program was to educate residents on climate vulnerability in their neighbourhood and work with them to identify actions to reduce the impacts of heat events. This was informed by identifying urban heat island areas in Chicago which could be exacerbated by climate change (EPA 2017). Other key actions undertaken included expanding Chicago's text and email notification system, establishing 'cooling centres' and conducting well-being checks on vulnerable individuals.

In practice – Cooperative Research Centre for Low Carbon Living
Guide to Urban Cooling Strategies

The CRC for Low Carbon Living (2017) Guide to Urban Cooling Strategies provides practical guidance for built environment professionals and regulatory agencies seeking to optimise development projects to moderate urban microclimates and mitigate urban heat island effects in major urban centres across a range of climates in Australia. It details a range of urban heat mitigation strategies for streetscapes, plazas, squares, buildings and malls, which are categorised by Australian climate zones (including Melbourne) and for a range of urban typologies. Urban surface properties, vegetation cover, shading and orientation are key variables.

6.3 Rainfall risk and responses

6.3.1 Drought and reduced rainfall

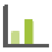
Risks associated with drought and reduced rainfall for Fishermans Bend primarily relate to water supply, both for urban use and to support environmental flows and biodiversity. Adaptation responses therefore include storage and retention, water efficiency measures, and treatment of sources of water for re-use. Additionally, contingency planning or changing maintenance routines may be worth some consideration. In response to impacts on reactive soils, such as clay, which are susceptible to expansion and contraction as soil moisture content changes, enhancement of building and structural integrity may be considered.

The aim is to use diverse water sources, including recycled water and stormwater, to secure water supplies and protect public spaces, getting the best use for alternative water sources. These actions require putting integrated water management into practice, working with local water corporations and building upon a water efficiency culture by reinvigorating water efficiency programs, and working with residents, schools, business and industry to improve water efficiency. They build on South East Water's integrated water planning for the community at Fishermans Bend through storm water storage, rainwater capture, smart tanks and centralised sewer mining.

Responses and actions in Tables below relating to retention landscapes and infiltration may only be appropriate in modified ways as the Urban Renewal Area contains areas of contaminated soils and a high-water table.

These responses span a range of costs, and can be applied at varies scales as summarised in Table 13 .

Table 13 Drought and reduced rainfall adaptation responses and example actions

Adaptation response			Example actions
Storage and Retention	Scale		• Water sensitive urban and building design (WSUD) • Stormwater capture, harvesting, treatment and recycling • Rainwater harvesting and decentralised collection and storage • Infiltration and transport-sewers • Retention landscapes and bio-retention ponds (where possible)
	Cost		
	Avoided Cost		
	Co-benefits		
	Effort		
	Existing strategy		
Water efficiency	Scale		• Mandatory minimum standards for water efficiency fixtures • Develop policy for water efficiency and WSUD • Policies to ensure that water resource implications of new developments are assessed • Reducing public space irrigation mains water use • Retrofit water efficiency controls • Technologies for digital real-time metering • Leakage control in water distribution system • Metering linked to central management system • More efficient HVAC water cooling systems • Water restrictions • Reduced freshwater for cooling • Community potable water use education • Drought tolerant plants
	Cost		
	Avoided Cost		
	Co-benefits		
	Effort		
	Existing strategy		
Treatment and alternate sources	Scale		• Collect and treat grey / black water for non-potable use • Identification and use of alternate sources • Water recycling • Recover condensation from HVAC • Use of ground water (where applicable) • Small scale, on site desalination
	Cost		
	Avoided Cost		
	Co-benefits		
	Effort		
	Existing strategy		
Contingency planning and changing maintenance routines	Scale		• Distributed storage networks (such as rainwater tanks) for stormwater storage • WSUD principles embedded into plans • Maintain groundwater flow volumes • Technologies for real-time metering Recycled water from sewer mining • Intelligent water networks • Pressure sewer systems
	Cost		
	Avoided Cost		
	Co-benefits		
	Effort		
	Existing strategy		

Adaptation response		Example actions
Enhancement of building and structural integrity	Scale Cost Avoided Cost Co-benefits Effort Existing strategy	• Amend design standards and build above standards where needed • Soil and land structure monitoring structural review • Use of different building materials • Strengthen building foundations • Infrastructure strengthening

In practice - City of Port Phillip
Towards a water sensitive city - Open Space Water Management Plan

In response to the impact of increasing temperatures on the health of trees and open spaces in the City of Port Phillip, the Open Space Water Management Plan was developed to help council better manage existing water sources, find alternative water sources and adapt open spaces to drier, hotter climates. The plan outlines actions for improving and upgrading irrigation systems for better efficiency and to reduce the use of potable water for irrigation. It also outlines alternative water sources, the use of water sensitive urban design and other management practices (City of Port Phillip 2017).

In practice – South East Water
Integrated Water Servicing Strategy for Fishermans Bend

Fishermans Bend is recognised as an opportunity to showcase sustainable, leading-edge solutions to transition the area into a water sensitive city/precinct. Integrated water management is a central part of achieving these sustainability and liveability objectives. In conjunction with City of Melbourne, City of Port Philip, DELWP, the Environment Protection Agency and Fishermans Bend Hub, South East Water has developed an Integrated Water Servicing Strategy which is designed to reduce the water footprint by 45 per cent. The Strategy includes use of recycled water from a sewing mining plant in the precinct, distributed stormwater storage through rainwater tanks, water sensitive urban design principles and digital metering, pressure sewer systems and intelligent networks.

6.3.2 Extreme rainfall events (flooding)

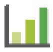
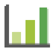
Impacts from extreme rainfall contribute to a large number of significant risks which have impacts for assets, human health, mobility and the economy. A wide variety of adaptation Responses are available for extreme rainfall. These include protective infrastructure at a building, precinct and catchment scale, temporary protection, storage and retention, planning measures and layout, building design and infrastructure standards, resilient critical infrastructure, changes to maintenance operations and routines, business continuity and emergency management responses and ecosystem based adaptation. Again, as for 6.3.1 reduced precipitation and drought, the responses and actions in the Table below relating to retention landscapes and infiltration may only be appropriate in modified ways and with enhanced sensitivity as the Urban Renewal Area contains areas of contaminated soils and a high water table.

The recently commissioned work on innovative and integrated water management for Fishermans Bend will foster a systems approach to combine landscape and public realm solutions with the required water management infrastructure and urban development to increase resilience and apply best practice/new thinking. Opportunities are sought for high quality development, greening of the urban environment, a celebration of water within the public domain, connection to the waterfront where possible and exceptional public realm outcomes. Many of the Responses and Actions below will be considered in this work.

These responses span a range of costs, and can be applied at varies scales as summarised in Table 14.

Table 14 Extreme rainfall event (flooding) adaptation responses and example actions

Adaptation response			Example actions
Storage and retention	Scale Cost Avoided Cost Co-benefits Effort Existing strategy		• Rainwater harvesting • Green roofs • Permeable surfaces • Swales • Channels and rills • Creation of buffer strips • Soakaways / infiltration trenches and basins • Rain gardens • Small scale detention basins, ponds and landscapes (where applicable)
Planning measures and urban layout	Scale Cost Avoided Cost Co-benefits Effort Existing strategy		• High resolution flood mapping, incorporating SLR and storm surge that is linked to and updated in line with climate projections • Adopt Integrated Land Use Planning to site sensitive uses out of harms way • Sustainable Urban Drainage (SUDS) • Incorporate WSUD in design phase. • Incorporate climate change projections in drainage and stormwater planning • Constrain development to avoid, or regulate development in vulnerable locations • Retreat from high-risk areas (including relocation of community critical infrastructure)
Building design and infrastructure standards	Scale Cost Avoided Cost Co-benefits Effort Existing strategy		• Conduct detailed review of the design capacity of critical infrastructure • Assess structure stability and vulnerability especially of critical infrastructure, • Water sensitive urban and building design • Dry-proof facilities (Sealable buildings) • Wet-proof facilities • Increase capacity of roof drainage for heavy rain events • Check valve/non-return valves • Design buildings and infrastructure for flood/inundation risk (e.g. floodable ground floors, alternative access, raised floor heights, utilities and machinery above flood levels, etc.) • Raise land • Floating and amphibious buildings

Adaptation response			Example actions
Building scale protection	Scale		• Assess structural stability and vulnerability • Dry-proof facilities (sealable buildings) • Wet-proof facilities (allow entry of water without causing damage, back-up generators for pumps) • Flood proof utility buildings and infrastructure (e.g. boilers, HVAC, transformers, etc.) • Ensure redundancy available in form of uninterrupted power supplies (UPS) and backup generation (particularly for flood infrastructure and kit such as pumps, etc.) • Check valve/non-return valves • Reinforce stability • Floating and amphibious buildings
	Cost		
	Avoided Cost		
	Co-benefits		
	Effort		
	Existing strategy		
Precinct-scale protection	Scale		• Check adequacy of drainage capacity • Increase capacity of sewer and stormwater systems • Permeable paving (remove/minimise impervious surfaces) • Drainage corridors • Smart-drain (groundwater) • Disconnect paved surfaces from sewer system • Increase height difference between street level and ground floor level (raised curbs/hollow roads) • Disconnect combined sewer/stormwater systems • Construction of seawalls, barrages or dykes (also consider mounds and evacuation hills) • Storm surge gates / flood barriers
	Cost		
	Avoided Cost		
	Co-benefits		
	Effort		
	Existing strategy		
Catchment-scale protection	Scale		• Develop floodplain risk management plan • Investigate sustainable urban drainage systems (SUDS)Increase water discharge capacity of rivers and floodplains • Flow-through dam for flood-control • Construct/improve of upstream dams • Dredge waterways to enhance flow • Manage aquifer recharge
	Cost		
	Avoided Cost		
	Co-benefits		
	Effort		
	Existing strategy		
Emergency management protocols	Scale		• Plan for emergency passage and access • Install Early Warning System • Public education and flood communication strategy • Reduce reliance on one form of transport • Establish safe locations & refuges
	Cost		
	Avoided Cost		
	Co-benefits		

Adaptation response			Example actions
	Effort Existing strategy		• Ensure website (and related emergency notices) operate from a back-up server. • Precinct scale evacuation procedures, modelling and optimisation • Video service screenings on emergency preparedness • Emergency pumps either located in, or rapidly deployed to, high risk areas • Rapid response cordoning-off areas; alternative transport provision • Backup power supply • Plan and establish alternative or on-site power supply
Temporary protection	Scale Cost Avoided Cost Co-benefits Effort Existing strategy		• Increase fixed pump capacity • Emergency pumps • Mobile/temporary flood protection structures
Resilient critical infrastructure	Scale Cost Avoided Cost Co-benefits Effort Existing strategy	- 	• Detailed review of the design capacity of critical infrastructure, particularly drainage • Locally based energy systems • Install remote and automated monitoring and control systems for vital equipment and infrastructure • Construct overhead service lines were feasible • Diverse or redundant supply and transmission options for energy supply • Elevate or flood proof flood-prone structures • Elevate flood wall/ring dyke for vital infrastructure • Floating or elevated roads
Changing maintenance / operational routines	Scale Cost Avoided Cost Co-benefits Effort Existing strategy		• Investigate roof structure integrity to minimise leakage and water damage. • Review and improve stormwater maintenance schedule to minimise debris build-up in drainage system. • Pre-plan clean up response • Check flood insurance and preparation measures • Revise asset management plans to consider climate projections • Maintain vegetation to prevent wind damage/debris • Identify flood vulnerability points in transport network

Adaptation response		Example actions
		• Ongoing review of sewerage operations to mitigate overflow risks • Continue tree replacement programs • Instigate debris control measures • Install infrastructure to improve storm water quality • Minimise pollution to waterways in flood • Restrict use times • Multiple mode and route options for transport needs
Ecosystem based adaptation	Scale Cost Avoided Cost Co-benefits Effort Existing strategy	• Constructed small scale wetlands (as appropriate on available land) • Create small scale natural buffer zones • Enhance all public space • Rehabilitate and restore river and streams and natural flows (including riparian buffers) • Increase tree planting and native vegetation areas

In practice – City of Copenhagen
Copenhagen Cloudburst Management Plan, Denmark

The City of Copenhagen is investing heavily in protecting the city from extreme weather. It has developed an overarching Copenhagen Climate Adaptation Plan (2014) and initiated a combined project with urban district renewal and flood protection management under the Copenhagen Cloudburst Management Program. The program emphasises the use of ‘blue’ and ‘green’ infrastructure, such as parks and gardens, with ‘grey’ water retention infrastructure for stormwater management, with co-benefits of higher recreational values, more urban quality and increased biodiversity.

In practice – Vicinity Centres
Business Continuity Plan for Flood Prone Shopping Centres
The Gympie region is prone to riverine flooding from the Mary River and also local runoff from Deep Creek. Both Gympie Central and Goldfields Plaza are part of Vicinity Centres portfolio and have been impacted from such flooding events. There had been multiple occasions in the past decade where water had entered the surrounding buildings. This presents a problem from an ongoing operation standpoint as not only does this limit access to the centres for customers but also staff and retailers and sales. In order to minimise the risk in the future of such flooding events, Vicinity Centres have developed a Flood Management Plan to inform all stakeholders of appropriate procedures and potential actions to ensure the continued operation of the facilities and to reduce the likelihood of damage during flooding and extreme weather.

6.4 Extreme weather events risk and responses

Extreme wind and hail events can cause damage and disruption, which have significant impacts on the community, assets, mobility and the economy. Adaptation responses identified for extreme wind and hail events are broadly applicable to extreme events in general, including strengthening infrastructure, changing maintenance / operational routines, business continuity and emergency management protocols.

These responses span a range of costs, and can be applied at varies scales as summarised in .

Table 15 Extreme wind and hail events adaptation responses and example actions

Adaptation response		Example actions
Emergency management protocols	Scale Cost Avoided Cost Co-benefits Effort Existing strategy	• Develop storm evacuation/early warning systems or plans • Public education of extreme weather risks • Safe locations & refuges • Assess electrical storms • Emergency evacuation procedures • Storm-protection plan • Ensure website (and related emergency notices) operate from a back-up server. • Backup power supply • Flood risks and safe behaviour
Strengthen infrastructure	Scale Cost Avoided Cost Co-benefits Effort Existing strategy	• Assess resilience of power lines etc. • Underground cabling • Upgrade overhead electricity transmission infrastructure • Diverse or redundant supply and transmission options for energy supply • Standards for passenger comfort that take climate change into account • Protective measures from debris hazard • Roof structure operation and maintenance to provide resilience to wind • Server room - resilience to wind • Structure hail proofed • Building strength standards • Assess wind loading
Changing maintenance / operational routines	Scale Cost Avoided Cost Co-benefits Effort Existing strategy	• Consider increased frequency and intensity of extreme weather in asset management • Tree replacement policy to reduce storm damage • Vegetation maintenance to prevent wind damage/debris • Reduce risks from tree debris

In practice – Barangaroo Development Authority and Lend Lease
Change Adaptation and Community Resilience – Barangaroo South, New South Wales

An adaptation and community resilience plan was developed for Barangaroo South, a 22 hectare, $8 billion urban renewal site between Sydney's Central Business District and the harbour. Climate risks identified included changing temperature, changing rainfall, sea level rise, severe weather and changing humidity. Adaptation measures for the precinct comprised of stormwater infrastructure upgrades and improved management, basement waterproofing and tanking and an electrical network within the precinct which provides redundancy if part of the network is damaged with onsite backup should the whole network be disrupted (Lendlease n.d.).

6.5 Sea Level Rise risk and responses

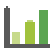
The impacts of sea level rise are likely to become more acute in the future, highlighting the importance of considering these impacts now. Adaptation responses to sea level rise include on-shore and off-shore protection, responses to saline intrusion and material resistance, planning measures and urban layout, community education and awareness and building-scale adaptation. In the context of Fishermans Bend some of these responses and actions may be severely constrained due to the scarcity of land for public use, contaminated land, high water table and other constraints. This may necessitate innovative and new measures being developed specifically for the area to manage this risk. These measures may include insurance. While some 90+ per cent of new home insurance covers flood, policies do not consider actions of the sea, including damage from sea level rise, coastal erosion and flooding due to king tides.. Should that be priced into affected properties, insurance may be cost prohibitive.

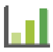
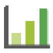
The Responses and Actions listed are consistent with Melbourne Water's *Planning for Sea Level Rise Guidelines (2017)* and *Guidelines for Development in Flood-prone Areas (2007)* which set out the specific requirements that apply to development proposals in areas that will be affected by tidal inundation (including storm surge and wave action) as a result of predicted sea level rise. The aim of these guidelines is to ensure that proposed development is compatible with any flood risk. The responsible authority must consider, as appropriate the degree of flood, associated with the location of the land and the use, development or management of the land so as to minimise any such hazard through the use of benchmarks.

As stated above the recently commissioned work on innovative and integrated water management for Fishermans Bend aims to highlight integrated and innovative solutions which mitigate flooding from SLR and storm surge. It is hoped that the solutions will foster a systems approach to combine landscape and public realm solutions with required water management infrastructure and urban development. The opportunities for high quality development, greening of the urban environment, a celebration of water within the public domain, connection to the waterfront where possible and exceptional public realm outcomes will be unlocked.

These responses span a range of costs, and can be applied at varies scales as summarised in Table 16 .

Table 16 Sea level rise adaptation responses and actions

Response			Actions
Planning measures and urban layout	Scale		• High resolution flood mapping, incorporating SLR and storm surge and rainfall that is linked to and updated in line with climate projections • Incorporate SLR in long term coastal planning • Assess coastal access and infrastructure standards • Worst case scenario planning (coincidence flooding events) • Develop vision and planning/zoning guidelines/laws for coastal areas • Develop SLR adaptation strategy and action plan for planning developments • Multiple mode and route options for transport in urban areas • Building structures above flood levels • Constrain development - avoid or regulate development in vulnerable locations • Raise vulnerable land • Land buy-back or relocation of assets
	Cost		
	Avoided Cost		
	Co-benefits		
	Effort		
	Existing strategy		

Response			Actions
Community education and awareness	Scale		• Emergency preparedness training • Clear communication materials on the findings and safety precautions of coastal inundation modelling and SLR • Mentoring programs • Innovative business resilience networks • Community events and programs, Neighbourhood resilience projects • Information packages, guidebooks and toolkits (residents, businesses)
	Cost		
	Avoided Cost		
	Co-benefits		
	Effort		
	Existing strategy		
Building scale adaptation	Scale		• Review asset management plan to incorporate SLR • Identify and prioritise assets and asset components at risk to SLR and storm surge • Incorporate projected SLR into building/engineering standards • Building design elements for facades, basements, access and egress points
	Cost		
	Avoided Cost		
	Co-benefits		
	Effort		
	Existing strategy		
Off-shore protection	Scale		• Investigate innovation in coastal protection with built structures (Groynes, breakwaters, artificial reefs) • Floating barriers • Land reclamation and re-creating a foreshore are where possible • Whole-of-bay protection measures
	Cost		
	Avoided Cost		
	Co-benefits		
	Effort		
	Existing strategy		
On-shore protection	Scale		• Coastal drainage systems • Improve pumps for backflow prevention • Investigate construct/improve dykes (also mounds and evacuation hills) (where possible) • Innovate in coastal protection with built structures (Groynes, revetments, seawalls) • Investigate storm surge gates / flood barriers • Small scale constructed wetlands • Protect coastal buffer vegetation • Restore and manage any remaining coastal wetlands areas • Retreat from high-risk areas (including relocation of community critical infrastructure) (as a last resort)
	Cost		
	Avoided Cost		
	Co-benefits		
	Effort		
	Addressed by existing strategy		
Saline intrusion and material	Scale		• Design beyond current minimum compliance and building standards
	Cost		

Response		Actions
resistance	Avoided Cost Co-benefits Effort Existing strategy	• Saltwater intrusion barriers • Maintain higher water table to prevent saltwater intrusion • Extraction of saline and brackish groundwater • Reduce groundwater withdrawal rates • Increase of (artificial) recharge in upland areas • Resistant building façades • Install low-head dam for saltwater wedge and freshwater pool separation • Create physical barriers, such as sheet piles, clay trenches and injection of chemicals • Cathodic protection within the basement envelopes

In practice – City of New York
Dryline (The Big U)

The Dryline project (a section of the Big U) was developed to address the vulnerability of the Manhattan coast to storm surges and flooding. The project proposes a protective 'ribbon' of infrastructure along 9km of coast in Southern Manhattan, which would act as a high-water barrier, protecting the city from inundation. A key element of the project is ensuring the barrier provides multiple benefits to the community, based on particular needs identified in community consultation (LargargeHolcim Foundation 2017).

In practice – City of Rotterdam
Integrated approach to resilient urban design

While protected by levees, dams, embankments and water defences (including 787-foot-long floodgates that can swing open to protect the city against storm surge), high groundwater levels and increasingly extreme weather conditions mean Rotterdam is still vulnerable to flooding. In conjunction with an integrated and holistic approach to resilience and urban design, Rotterdam is investing in a suite of smart, innovative and sustainable solutions. The goal is to make the city climate-proof by the year 2025 through a variety of different measures, including water storage and detention in underground parking garages, and 'water plazas' and the development of a park that is subject to the ebb and flow of the river.

7.0 Gap analysis

7.1 Overview

To help guide further stages of work towards a more climate resilient Fishermans Bend, a qualitative gap analysis was undertaken which reviewed relevant policies, regulatory documents, masterplans, and design standards relevant to the Fishermans Bend urban renewal precinct against the climate risks and responses identified in Section 6. The analysis considered the three scales of appropriate response – building, sub precinct level and the wider urban renewal area. A full summary of this analysis is provided in Appendix E.

The gap analysis is a repository of current policies and attempts to make a high-level assessment of the workings of the various policies and standards going beyond the policy objectives that aspire to climate readiness.

While the analysis considered the broad range of adaptation responses identified in Section 6, not all will be pursued for Fishermans Bend. Some may not be relevant, or may be cost prohibitive or inappropriate. Further identification of adaptation responses is anticipated in the next stage of work. This gap analysis is intended to guide the next phases of work by discussing some of the potential gaps within current policy and regulatory frameworks.

To develop appropriate incentives and provide the requisite flexibility for diverse and innovative outcomes, the Fishermans Bend Framework (FBF) has endeavoured to move beyond prescriptive regulations and standards and provide high level guidance, with varying degrees of prescriptiveness and scale. Additional guidance and requirements are found in the Melbourne Planning Scheme (pertaining to the Employment and Lorimer precincts) and the Port Phillip Planning Scheme (relevant to the Montague, Sandridge and Wirraway) as well as the local, metropolitan and state strategies and guidance listed in Appendix E.

The non-prescriptive guidance in the FBF provides flexibility and space for innovation, which may allow the development to achieve its stated environmental goals, but this also carriers the risk of a piecemeal approach to climate change adaptation and preparedness.

In the detailed assessment in Appendix E, new or untested policies are shown as "in development", indicating that there is some way to go to ensuring robust adoption and that further enabling strategies and programs may be required. In some cases, policies and strategies are in place at some scale but not at all scales pointing to a gap in the policy coverage which could be strengthened.

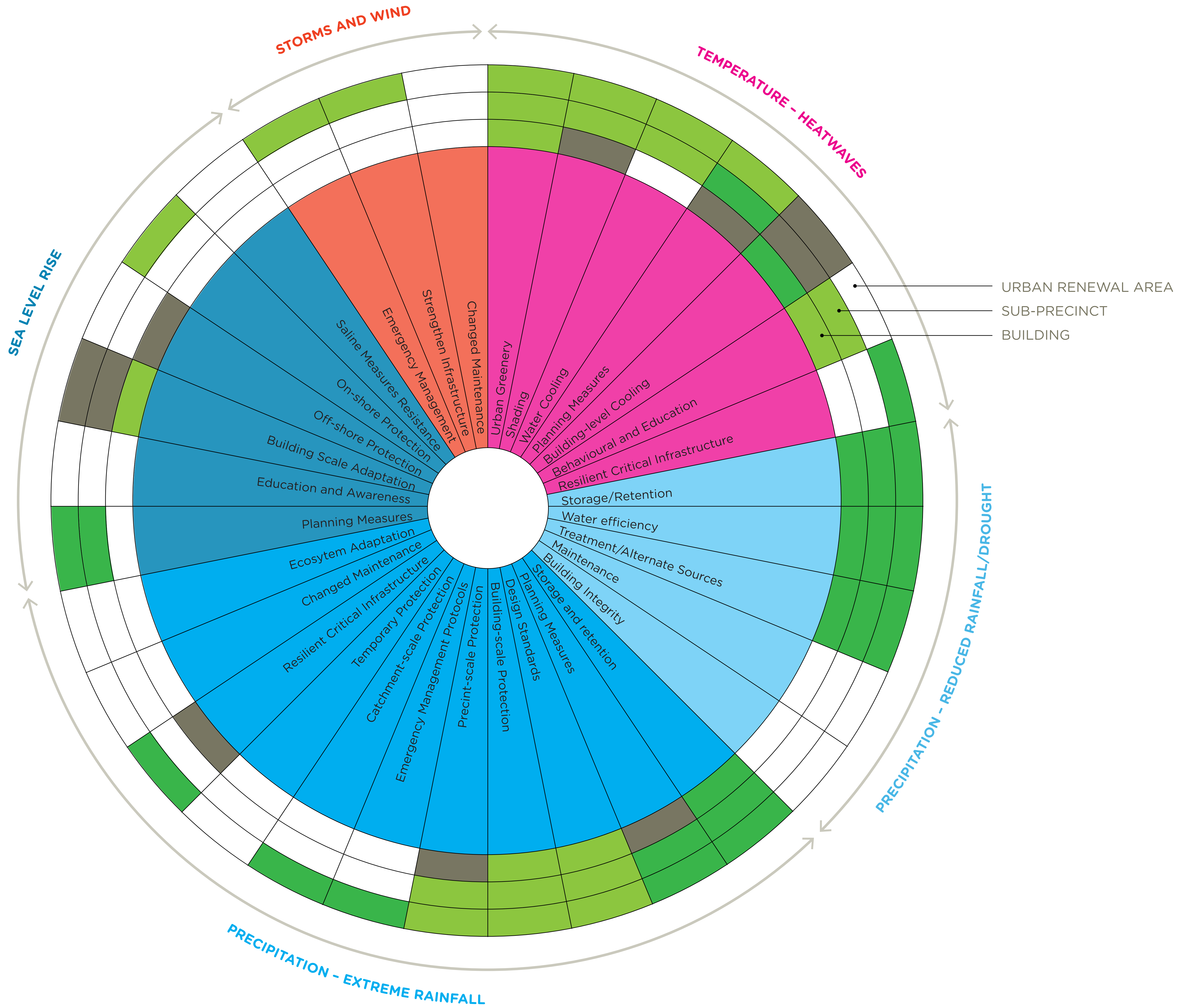
A colour coded summary of the gap analysis follows in a diagram and table. The gap analysis should be read in conjunction with the Response Tables in Section 6. In the diagram:

- areas of 'white' and 'light green' point to Response areas where there is a potential gap
- areas of 'white' (in Figure 4 and Table 17) indicate that based on the information available, the Project Team were not able to ascertain whether responses were in place
- areas of 'light green' point to response areas where policy is in development or it may be non-mandatory or only partially cover the risk

In many of these cases the Project Team was not able to cite appropriate plans or strategies in the public arena. These were predominantly relating to sea level rise and extreme rainfall as well as for extreme storms. Gaps in actions relate to emergency management, maintenance regimes, critical infrastructure, catchment scale protection and ecosystems approaches, as well as off-shore, on-shore and temporary protection against sea level rise. There was also a gap in the provision of education and awareness raising programs and material on sea level rise. These are all therefore areas requiring further investigation.

It is worth noting that the City of Port Phillip and the City of Melbourne have recently commissioned work investigating innovative and integrated solutions to mitigate flooding and drive the future identify of Fishermans Bend. It is hoped that the solutions will take a systems approach to better integrate landscape and public realm solutions with the required water management infrastructure and urban development to increase resilience and apply best practice/new thinking. The outcomes of this piece of work will fill many of the gaps identified.

GAP ANALYSIS ADAPTATION RESPONSES & PLANNING



VARIABLES

- TEMPERATURE – INCREASED MEAN TEMPERATURE AND HEATWAVES
- PRECIPITATION – REDUCED MEAN PRECIPITATION AND DROUGHT
- PRECIPITATION – EXTREME RAINFALL EVENTS (FLOODING)
- SEA LEVEL RISE
- STORMS AND WIND – EXTREME WIND AND HAIL EVENTS

STATUS

- POLICY/STRATEGY/REQUIREMENT IN PLACE
- IN DEVELOPMENT/PARTIAL COVERAGE/NON-MANDATORY
- NOT KNOWN
- ADAPTATION NOT APPLICABLE AT SCALE

Table 17: Gap analysis

Key		
Bldg - Building	Policy/Strategy/Requirement in Place	
SP – Sub Precinct	In Development/Partial Coverage/Non-Mandatory	
URA – Urban Renewal Area	Not Known	
	Adaptation not applicable at scale	

Significant Climate Variables	Adaptation Response	Scale			Sample Relevant Key Existing Policy(s)
		Bldg	SP	URA	
Temperature Increased mean temperature and heatwaves (extreme weather events)	**Cooling with Urban Greenery** Utilising vegetation to provide shade and cooling through evapotranspiration				Fishermans Bend Precinct Plan 2015-2025 (2017) City of Melbourne Urban Forest Strategy 2012-2023 (2011) Resilient Melbourne Metropolitan Urban Forest Strategy (2016) Fishermans Bend (FB) Public Space Strategy (Draft) (2017)
	Shading Provision of increased structural shading for public spaces	NA			Fishermans Bend Public Space Strategy (Draft) (2017)
	Cooling with Water Utilising blue solutions for urban cooling	NK			FB Vision (Fishermans Bend Taskforce) (2016) FB Public Space Strategy (Draft) (2017)
	Planning Measures and Urban Layout Implementing controls at the planning stage to enable uptake of climate resilient practice, and avoid mal-adaption	NA			Planning Scheme: 22.12 Stormwater Management (WSUD) - City of Port Phillip: 22.12-2, 22.13-3, 22.12-4 FB Strategic Framework, Objective 7.1, Standards 4 (2016) Fishermans Bend Framework, Objective 5.1 (2017) FB Public Space Strategy (Draft) (2017)
	Building-level Cooling Strategies		NA	NA	Planning Scheme: 22.13 Environmentally Sustainable Development - City of Port Phillip Apartment Design Guidelines for Victoria (2017) Action 2.5 in Climate Change Adaptation Strategy Refresh - design standards for all climate hazards
	Behavioural Approaches and Community Education - Building community resilience to heatwaves			NK	City of Port Phillip - Being Safe During Storms, Floods and Heatwaves (2016)
	Resilient Critical Infrastructure Ensure the reliability and functionality of critical systems in times of extreme heat events	NK	NK		EMV Critical Infrastructure Resilience Strategy (2015)
Rainfall - Reduced mean precipitation and drought	**Storage and Retention** **Preserving and enhancing water resources**				Fishermans Bend: A Water Sensitive Community (Fact Sheet) (2016) Planning scheme: 21.03 Ecologically Sustainable Development - City of Port Phillip Apartment Design Guidelines for Victoria, (2017)
	Water efficiency Reducing the demand for water resources				Planning Scheme: 21.03 Ecologically Sustainable Development - City of Port Phillip Water for Victoria Action 5.3 (2016) Apartment Design Guidelines for Victoria, (2017)
	Treatment and Alternate Sources Identification of additional water supply sources				Fishermans Bend: A Water Sensitive Community (Fact Sheet) (2016) Planning Scheme: 22.12 Stormwater Management (WSUD) - City of Port Phillip: 22.12-2, 22.13-3, 22.12-4 Planning Scheme: 22.13 Environmentally Sustainable Development - City of Port Phillip
	Contingency Planning and Changing Maintenance Routines Updating maintenance regimes to account for climate change effects	NK	NK	NK	
	Enhancement of Building and Structural Integrity	NK	NK	NK	

	Considering the implications for changing soil moisture and stability				
Rainfall - Extreme weather (flooding events)	**Storage and Retention** Moderating flows, and preserving and enhancing water resources				Planning Scheme: 22.13 Environmentally Sustainable Development - City of Port Phillip Fishermans Bend Strategic Framework Obj 7.2 std 1, 2, (2016) Fishermans Bend Framework Obj 5.2 (2017)
	Planning Measures and Urban Layout Taking a master-planned approach to increasing resilience to extreme storms	NA			Planning Scheme: 13 Environmental Risks - City of Melbourne FB Strategic Framework Obj 7.1 std 1, 4 (2016) Fishermans Bend Framework Obj 5.1 (2017) Municipal Integrated Water Management Plan 2017 - City of Melbourne (2017) Planning for Sea Level Rise Guidelines (Port Phillip and Westernport Region) - Melbourne Water (2017) Victorian Coastal Strategy (2014) Fishermans Bend Public Space Strategy (Draft) (2017)
	Building Design and Infrastructure Standards Updating design and construction codes and standards to be in suitable alignment with needs under future climate conditions				City of Port Phillip Climate Adaptation Plan (2010) Fishermans Bend Strategic Framework Obj 7.1 std 1, 4 (2016) Fishermans Bend Framework Obj 5.1 (2017) Apartment Design Guidelines for Victoria, (2017)
	Building-Scale Protection Structural measures to allow passage of flood waters without causing major structural damage, or preventing flood waters from entering facilities				Planning Scheme: 13 Environmental Risks - City of Melbourne Municipal Integrated Water Management Plan - City of Melbourne (2017) Apartment Design Guidelines for Victoria (2017)
	Precinct-scale Protection Wide scale engineering for the protection of precincts	NA			Planning Scheme: 13 Environmental Risks - City of Melbourne Municipal Integrated Water Management Plan - City of Melbourne (2017)
	Emergency Management Protocols Better prepare emergency response procedures to account for increased frequency of extreme events	NK	NK		City of Melbourne Flood Emergency Plan (2012) City of Port Phillip Climate Adaptation Plan (2010) Port Phillip City Council Municipal Emergency Management Plan (2011)
	Catchment-scale Protection Upstream and systemic management of water in extreme events	NK	NK		Catchment Management Authority Regional Floodplain Management Strategies (2017) Victorian Floodplain Management Strategy (2016)
	Temporary protection Temporary (and often mobile) solutions which can be built up and used when needed	NK	NK	NK	
	Resilient Critical Infrastructure Ensure the reliability and functionality of critical systems in times of flooding and extreme storm	NA	NK	NK	Fishermans Bend Road Raising Investigation (GHD) (2017) EMV Critical Infrastructure Resilience Strategy (2015)
	Changing Maintenance/Operational Routines Ensuring all systems and infrastructure are structurally sound and ready for extreme events	NK	NK	NK	City of Melbourne Total Watermark - City as a Catchment update (2014)
	Ecosystem-based Adaption	NK	NK	NK	
Sea Level Rise	**Planning Measures and Urban Layout**	NK			Planning Scheme: 13 Environmental Risks - City of Melbourne Planning for Sea Level Rise Guidelines (Port Phillip & Westernport Region) - Melbourne Water (2017) Victorian Coastal Strategy (2014)
	Education and Awareness	NK	NK	NK	
	Building Scale Adaptation		NA	NA	Planning for Sea Level Rise Guidelines (Port Phillip and Westernport Region) - Melbourne Water (2017)
	Off-shore Protection Coastal management techniques and structures to protect land from weather and longshore drift	NA	NK	NK	
	On-shore Protection Both hard and soft engineering approaches to coastal defence	NK	NK		Planning for Sea Level Rise Guidelines (Port Phillip and Westernport Region)- Melbourne Water (2017)

	Saline Intrusion and Material Resistance	NK	NK	NK	
	Emergency Management Protocols	NK	NK		City of Port Phillip Climate Adaptation Plan (2010) Port Phillip City Council Municipal Emergency Management Plan (2011) EMV Critical Infrastructure Resilience Strategy (2015)
Extreme weather - Storms & extreme wind and hail events	**Strengthen Infrastructure** Ensuring the reliability and functionality of critical systems in times of extreme events	NK	NK		EMV Critical Infrastructure Resilience Strategy (2015)
	Changing Maintenance/Operational Routines	NK	NK	NK	Fishermans Bend Strategic Framework Obj 4.1 Std 1, Obj 5.2 Stds 3, 4, 5, Obj 5.3 Std 1 (2016) Fishermans Bend Framework Obj 1.5, 6.1, 6.2 (2017)

References to the Fishermans Bend Strategic Framework (2016) have been updated in the above table to also reference the draft FBF as appropriate. The following section provides discussion of the gap analysis, as well as raising issues in addressing the gaps or opportunities to align with current activities. It includes discussion on both the FBF and previous Fishermans Bend Strategic Framework.

7.2 Increased temperature and heatwaves

Cooling with urban greenery

There are sufficient policies and guidance at the building, precinct and city level to engender urban cooling through greening in the form of blue/green infrastructure and urban vegetation. However this can take decades to become established and therefore must be prioritised.

Structural shading

There are no policies for structural shading relating to Fishermans Bend. While consideration should be given to the option of structural solutions, if the urban forest canopy targets set out in the 2015-2025 Precinct Plan of public realm canopy at 40% by 2040, and entire precinct canopy at 12% by 2040 are met, significant reductions in mean and maximum temperatures will be achieved. However many buildings will be medium to high density and not benefit from natural shading. Individual building Green Star – Design & As Built ratings within the Green Star Communities precinct may assist.

Cooling with Water

The Fishermans Bend Vision contains incorporation of water sensitive design principles into public realm infrastructure. This aspiration is considered insufficient to promote embedding of water elements into public and private spaces. Specific policies and guidelines could be developed if blue solutions are to be utilised to adapt to increased temperatures. Clarity about who pays, owns, and manages these assets is required.

Planning measures and urban layout

Planning requirements to encourage adaptive urban layout exist in section 22 of the Port Phillip and Melbourne Planning Schemes, and guidance in the Fishermans Bend Framework provide appropriate coverage of planning measures and urban layout. Plan Melbourne contains provisions for urban layout and density to reduce pressures of heat on urban areas. The precinct planning should be consistent with the objectives set out in Plan Melbourne to ensure amenity and liveability.

The aim to have Fishermans Bend no warmer than other areas in Metropolitan Melbourne may be achieved through the existing policies, however investigations into street alignments, ventilation corridors and the development of ongoing heat mitigation strategies for all public spaces should be considered. Potential further actions could include wind modelling and to investigate the relationship between street alignment, ventilation corridors and urban heat and the development of a public spaces heat mitigation strategy.

Building-level cooling strategies

There is sufficient policy and guidance to engender appropriate building-level cooling strategies found in section 22.13 of the City of Port Phillip Planning scheme and the Apartment Design Guidelines for

Victoria. However this standard should be regarded as minimum compliance to achieve the FBF vision.

Behavioural approaches and community education

There is appropriate coverage of behavioural approaches and community education to reduce impacts of extreme heat on wellbeing and safety. City of Port Phillip provides guidance on safety during storms, floods and heatwaves, while the City of Melbourne provides tips to keep cool in the heat and maps of places to keep cool during periods of higher temperature. These policies and coping strategies could be made more accessible and visible to Fishermans Bend residents and enhanced by the creation of a central hub for heat related information. The development of a cool spaces map for Fishermans Bend is encouraged to facilitate desirable community responses.

Resilient Critical Infrastructure

A significant gap exists in terms of guidance for developing and enhancing the resilience of critical infrastructure to heat. The Emergency Management Victoria Critical Infrastructure Resilience Strategy presents a high level strategy, but no translation from strategic to actionable in the form of specific guidance or requirements exist for Fishermans Bend. Potential further actions could include the development of a Fishermans Bend Resilient Critical Infrastructure Strategy to account for interdependencies between infrastructure and adaptation responses.

7.3 Drought and reduced rainfall

Storage and Retention

There is sufficient policy and guidance to preserve and enhance water resources through mandating water sensitive urban design. This is largely derived from the City of Port Phillip and City of Melbourne planning schemes and the Sustainability and Infrastructure objectives of the Fishermans Bend Framework. However with high density residential development tanks will be shared and larger, and for smart tanks, potentially easier to coordinate.

Contingency planning and changing maintenance routines

There is a gap in policy and guidance pertaining to contingency planning and maintenance routines. While other measures such as treatment of alternative sources, water sensitive urban design and water efficiency measures increase redundancy in the system, additional guidance could be considered to ensure the development of adaptive maintenance routines and contingency planning at the building, precinct and city scale.

Water Efficiency

There are sufficient measures in place to ensure water efficiency measures are utilised in Fishermans Bend, however options could be explored to incentivise specific and diverse actions beyond WSUD to include retrofitting extant buildings and infrastructure, and managing leakage control in the distribution system. The development has the sustainability goal of each resident in Fishermans Bend using no more than 100 litres of potable water per day, which is significantly below the state average. In addition, the City of Port Phillip Guiding Principles and Strategic Directions mandate best practice water and energy efficiency, and potable water substitution.

Enhancement of Building and Structural Integrity

No policy or guidance was found that addresses the changing soil stability and conditions resulting from the geology, historical uses and climate change at Fishermans Bend. Due to the legacy contamination at the site, specific guidelines may be considered to ensure adaptation responses are suitable. This will require further geotechnical modelling to inform appropriate design requirements.

Treatment and Alternative Sources

The Fishermans Bend Framework contains suitable objectives to ensure treatment of and use of alternative sources. Grey water collection and reuse is expected for all developments with 300 or more dwellings, and Objective 7.2 standard 1 calls for development to maximise the use of alternative water sources whilst await connection to the future precinct wide recycled water supply. Stormwater captured on site must also be re-used in toilet flushing and irrigation.

7.4 Extreme weather events - rainfall

Temporary protection

Significant gaps exist in temporary protection adaptation responses, which is to be expected in the early planning stages. This specific adaptation response requires preparations that are generally related to other structures and urban forms. A coordinated response is essential to ensure protections in one area do not exacerbate flooding in other areas, or restrict emergency access or egress. As planning progresses the development of a coordinated flood response strategy with clear lines of responsibilities and accountability for temporary protections may be useful within the broader emergency planning context.

Storage and retention

Storage and retention responses are addressed at all relevant scales due to Fishermans Bends focus on water sensitive urban design (expressed in Objective 7.3 and accompanying standards), as well as planning scheme requirements, and broader alignment with liveability and amenity goals. The efficacy of WSUD features may be enhanced through coordination of developer contributions, including for open space, to allow channels, detention basins and retention ponds and landscapes to better function as a larger system rather than discrete components, and to be well integrated into the public realm.

Planning measures and urban layout

Planning measures and urban layout are addressed in part through planning schemes specifying land affected by 1 in 100 year flood events to be identified, and for avoidance of intensifying impacts of flooding through inappropriately located uses and developments, as well as specific objectives and standards in the FBF.

While planning to reduce the impact of the future increased rainfall intensities on assets and infrastructure is generally addressed by guidance provided by Melbourne Water, the approach is generally an allowance on free board level which does not deliver comprehensive, integrated approaches consistently across the precinct,

There is a gap regarding a precinct-wide approach that the current study may address.

Resilient critical infrastructure

In addition to the guidance provided by Melbourne Water, the Fishermans Bend FBF Design Guidance addresses the location of essential services in Standard 4: The location of essential services, such as power connections, switchboards and other critical services should anticipate and address potential flooding events. There are also investigations underway to consider road raising for a more resilient road network at Fishermans Bend. Broader consideration of the resilience of critical infrastructure would be beneficial, particularly for community critical infrastructure and to ensure transport alternatives under a range of scenarios.

7.5 Extreme events - wind and hail

Strengthen infrastructure

A significant gap exists between possible adaptation responses and any guidance, standards, or policies that would incentivise these responses. There are no policies or guidance relating to resilience of power infrastructure such as underground cabling (which may be prohibited by soil contamination), or redundancy and diversity in supply, nor wind modelling to inform building wind loading requirements. Further investigation into these areas may be beneficial.

Changing maintenance/operational routines

Maintenance and operational routines must account for extreme wind and hail events. Present objectives considering the impact of extreme wind on building and precinct scale vegetation is considered to be sufficient. Objective 5.2 Standard 5 and Objective 5.3 standard 1 require tree planting to align with local council strategies. The Metropolitan Urban Forest Strategy and City of Melbourne and City of Port Phillip strategies contain criteria to ensure climate resilience of tree species. There is a need for additional exploration in incorporating extreme weather risk into asset management. While a significant portion of asset management will occur privately, policies should be explored to ensure consideration of climate change impacts in business continuity planning and asset management. There is potential to investigate policies and incentives to ensure developments have site specific asset management plans and for businesses to plan for increased frequency and intensity of extreme weather events.

Emergency management protocols

Both City of Melbourne and City of Port Phillip have emergency management plans in place to respond to extreme weather events. Variations exist between the emergency management plans given the different location and risk profiles of the two councils. To ensure clarity of response, a common Fishermans Bend component for the municipal emergency management plans could be considered and discussed as councils prepare their Municipal Emergency management Plans.

7.6 Sea Level Rise

Section 6 presents a series of sea level rise adaption responses. Responses include on-shore protection, off-shore protection, limiting salinity intrusion, amending urban layout through planning responses, community education and awareness and building scale adaptation. These responses collectively address a common risk and adapt to sea level rise impacts to various extents.

Planning and urban form

There is robust guidance concerning urban layout and land use derived from obligations under the Melbourne and Port Phillip Planning Schemes as well as guidance provided in the Victorian Coastal Strategy, and the Planning for Sea Level Rise Guidelines for the Port Phillip and Westernport Region, amongst other documents. As planning progresses for Fishermans Bend it will be important to ensure the planning requirements benchmark of planning for possible sea level rise of 0.8 metres by 2100 is met. Similarly to flood risk a precinct wide response should be developed to guide development.

On-shore protection, off-shore protection, building scale adaptation, community education and awareness.

Policy gaps have been identified concerning on-shore protection, off-shore protection, building-scale adaptation, and education and awareness however these gaps are of lesser concern due to robust planning guidelines mentioned above, and the need for a broader response for Hobsons Bay. Building scale adaptation is rendered superfluous by appropriate land use planning for the area as a whole. This gap could also

While community education and awareness is important for individuals to build an understanding of climate impacts, and may contribute to strengthening community resilience in times of stress, the temporal nature of sea level rise impacts (occurring over the long term) is beyond most individuals' decision making and planning timeframe.

Saline Intrusion and Material Resistance

Measures to limit saline intrusion and increase material resistance would potentially complement existing requirements concerning sea level rise land use planning, but a policy gap remains. There may be potential to develop a city-scale groundwater management strategy in partnership with local governments, utility providers and catchment management authorities and relevant government bodies.

8.0 Recommendations for further investigation and next steps

As the first stage in the development if a Climate Adaptation Plan for Fishermans Bend, this project scanned existing risk assessments and adaptation plans to identify key climate risks, impacts and gaps. With a large area to be transformed over many decades, these gaps are summarised below under the themes of: Governance; Knowledge; and Temporality.

8.1.1 Governance

Fishermans Bend extends over two municipalities and abuts key commercial and recreational areas of significance to Melbourne (the Port of Melbourne; Westgate Bridge; Yarra River, and Port Phillip Bay). Governance arrangements are dispersed. The gaps in governance impacting on Fishermans Bend relate to:

- Potential inconsistencies between City of Melbourne and City of Port Phillip planning, building, local law and policy guidance and requirements, including for climate projections, zoning and drainage standards (such as between the Capital City Zone and an Industrial Zone)
- Identification and delivery of precinct-wide initiatives and cumulative consequences, including
  - Scaling results from building to precinct and from precinct to building; and
  - Funding, ownership and management of decentralised systems and their interaction with centralised systems
- Consistent incentives and developer contributions for precinct wide outcomes. This may result in system wide fragility, lack of redundancy and homogeneity.
- Diversity of stakeholders undertaking action within a larger framework
- Coordination of critical infrastructure and adaptation responses under stressed conditions

City of Melbourne and City of Port Phillip intersections

Meeting the Fishermans Bend objectives will require active, vigilant and adaptive management over time, directed at multiple objectives, and over varied and overlapping scales. While the overarching objectives of the councils are largely aligned, specific mechanisms, targets and processes differ which may remain appropriate at a precinct scale given the flexibility of the non-prescriptive nature of the guidance in the FBF. To address the risk of a piecemeal approach to climate change adaptation and preparedness being undertaken, coordination of key Fishermans Bend wide adaptation responses will be necessary, with drainage and green infrastructure clear priorities.

Precinct wide initiatives, cumulative consequences and incentives for developer action

The need to manage the interactions between decentralised decision making and centralised organisation systems in the precinct is an emerging challenge. In particular, it will be important to consider the cumulative consequences of unilateral actions by developers. Private ownership and large number of lots makes the delivery of precinct-wide adaptation responses challenging and risks sub-optimality, for example, strategies to reduce flood risk at the building level may increase the exposure of other buildings to flooding.

Developers in the precinct face similar incentives and guidelines. Similar price signals, guidelines and objectives will lead to relatively standardised responses. Lack of diversity in developments may result in system-wide fragility and lack of redundancy and homogeneity within the precinct. Active engagement between legislators, landowners, financiers, communities, non-for-profit organisations and government agencies would work to limit confusion and avoid lack of adaptation or maladaptation from uncertainties emerging in gaps between jurisdictions and should be aligned towards meeting the objectives of the Fishermans Bend vision.

Critical infrastructure

The funding, ownership and management of infrastructure is a challenge. Disruptions to critical infrastructure can inhibit existing emergency response strategies, disable building-level cooling strategies, and undermine adaptive actions undertaken by individuals, communities and organisations. To mitigate this risk, and allow other adaptation responses to take place, a Fishermans Bend-specific critical infrastructure resilience strategy could be considered. The focus of this strategy may include exploration of the interdependencies between current response and adaptation processes to extreme heat events, stresses presented by increasing mean temperatures, future climate change impacts and associated uncertainties, and precinct and city-scale critical infrastructures necessary for the continuing functioning of the Fishermans Bend precinct.

Increasing the resilience of critical infrastructure requires planning and integration with urban form, necessitating robust governance structures (as described above) and substantially upfront capital investments. To ensure provision of resilient and climate adept infrastructure, innovative investment mechanisms such as tax increment financing, betterment tax and joint development projects could be explored.

8.1.2 Temporality

Fishermans Bend will take many decades to develop and therefore short, mid and long term opportunities (and how these will change with developments in policy, technology and community attitudes/values over that time) will be important considerations.

While related to governance, there are also gaps relating to how development can be staged to ensure no regrets solutions:

- Realising transformative benefits and allowing for innovation (Fishermans Bend is a large scale, high density urban renewal area and most guidance assumes extant urban form; single ownership or management; or greenfield context)
- Remain cognisant of option foreclosure (and opening new suites of options and incentives)
- Examine how incentives are likely to change over time (re macro trends (population pressures, economic structure; energy emissions intensity)

Transformative benefits

The built form in Australia is largely extant. Guidelines, standards and strategies focus on incremental change within the constraints presented by established buildings, forms, communities and institutions. Fishermans Bend presents a novel opportunity for enacting best-practice and visionary sustainability practices. This is recognised in existing planning (such precinct wide recycled water supply), however the intent to rely upon existing guidelines and standards to not restrict innovation may undermine the ability to realise some opportunities.

For Urban Heat there are a number of adaptations that address multiple risks and deliver broad benefits. For urban greening, and integrated water management and WSUD, all high value adaptation measures, will be transformative when fully implemented and will reduce multiple risks across numerous scenarios. It is important to plan for these to ensure that the space, funding, coordination and management is in place as it can take many decades to realise the benefits.

Option foreclosure

Once established, the built environment is largely static, with amendments to structures and form requiring significant costs. There is a significant risk in applying existing technologies and approaches that may foreclose other options, lock-in inferior outcomes or complicate adaptation responses. This may be addressed by staging developments and infrastructure provision to account for rapidly emerging technologies, evolving community attitudes and findings in climate projections.

Changing incentives over time

The Fishermans Bend project must consider short, mid and long term opportunities and how these will change with developments in policy, technology and community attitudes and values. The incentives appropriate for the present will not necessarily be suitable moving forward as technology develops. What is politically feasible will continue to change, and what communities' value and desire is in constant flux as a result of demographic change, population pressures, housing market and resource economics, industry composition, and the shift to renewables.

8.1.3 Knowledge

Gaps in knowledge can impact policy settings, funding decisions and actions taken by various stakeholders. The major gaps in knowledge impacting on Fishermans Bend relate to:

- Co-incident flood risk (extent, depth and duration of sea level rise combined with localised catchment and riverine flooding)
- Cumulative benefit (scaling of benefits from buildings to precinct)
- Managing concessions (e.g. forgo public open space for WSUD)

Co-incident flood risk

The development and provision of more accurate, granular and timely modelling and information relating to flood, wind, and heat incidents would support planning for future impacts, assist with resilient critical infrastructure provision, and clarify the systemic consequences of multiple developments. There is a need to investigate the co-incident flood risk (the extent, depth and duration of sea level rise combined with localised catchment and riverine flooding). The precinct's proximity to the Yarra River and Port Phillip Bay underscores the necessity for investigation of co-incident flood risk.

Cumulative benefits

A better understanding of the cumulative benefits (and potential risks) of stakeholder actions, at the building to precinct scale will inform the development of better design guidelines, emergency management responses and maintenance regimes. How cooling mechanisms and effects are dispersed, how WSUD features mitigate flood impacts, and how individual building flood protection systems interact requires a detailed understanding of the interactions between developments occurring at different and overlapping scales.

Managing concessions

Concessions, such as forgoing public open space for water sensitive urban design, must be appropriately managed to ensure the integrity of adaptation responses and alignment with the broader objectives for Fishermans Bend. An overwhelming weighting of concessions from one area to another could undermine efficacy of adaptation responses but could also enable broader benefits .across Fishermans Bend and beyond to be realised.

9.0 References

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Appendix A

Risk assessment

Appendix A Risk assessment

1. Drought and reduced rainfall

Risk no.	Risk title and rating	Now	2030	2070
1	Insufficient urban water supply	8	7	7
2	Impacts to biodiversity in upstream waterways due to insufficient environmental flows resulting from reduction in water availability	7	8	8
3	Increase in health problems related to declining water quality	6	6	6
4	Increased issues of social inequity and public conflict resulting from prolonged water restrictions, causing incidents of water theft and restrictions infringement	5	6	6
5	Loss of public amenity due to decreasing quality of public gardens, damage to assets	5	5	5
6	Increased liability costs due to declining quality of water leading to public health issues	5	5	5
7	Future liability and reputation damage relating to the construction of dwellings unsuited to projected climatic conditions, specifically resilience to low urban water supplies	3	6	6

2. Intense rainfall and wind event

Risk no.	Risk title and rating	Now	2030	2070
1	Mass stranding of people due to public transport stoppages, as a result of flooding or storm damage.	8	9	9
2	Adverse health outcomes due to emergency services being hindered by storm and flood impacts, such as flooded roads, traffic delays, and other blockages.	8	8	8
3	Increased potential for injuries or deaths as a result of flash flooding.	7	9	10
4	Increased reparation costs following intense rainfall and wind events, including damaged buildings, damaged or collapsed roads, damage to river banks and associated infrastructure, general clean up.	7	8	9
5	Business closure and job loss due to business interruption from storm damage and flooding.	7	8	8
6	Increased potential for injury, death, damage or delays resulting from damage to or falling of trees.	7	6	6
7	Lost tourism following storms or intense rainfall events.	6	7	7
8	Burst water supply pipes.	6	5	5
9	Increased potential human health risk as a result of sewer inundation.	5	6	6
10	Cleanup costs and disruptions from cars damaged/stranded by flash flooding.	5	6	6
11	Increased frequency and severity of public health risk from waterways. This is due to increased toxin concentrations entering waterways following intense rainfall events and reduced access for amenity purposes.	5	5	4
12	Public discontent due to reduced access to rivers and river banks for amenity and bike/pedestrian commuting purposes following intense rainfall events.	4	4	4

3. Extreme heatwaves and bushfire

Risk no.	Risk title and rating	Now	2030	2070
1	Increased heat stress related death / illness among at risk population groups	8	8	9
2	Passengers become stranded as trains and trams are delayed / cancelled in hot weather	8	8	9
3	Blackout	7	6	6
4	Increased violence / anti-social behaviour causing increased public nuisance and hospital admissions	7	7	7
5	Increased prevalence of food borne disease	6	6	6
6	Increased maintenance costs of assets and infrastructure	7	7	6
7	Disruption to any outdoor event due to hot weather	6	6	7
8	Reduced public and social use of space during heat waves	6	6	7
9	Business interruption due to electricity blackout	6	5	5
10	Heat stress related illness among outdoor council workers. This caused by an increased number of hot days, and becomes especially exacerbated during hot spells.	6	6	6
11	Train and tram derailments / accidents result in injuries and major disruptions	5	5	6
12	Future liability and reputation damage relating to construction of dwellings or infrastructure unsuited to projected climatic conditions	3	6	8

4. Sea level rise

Risk no.	Risk title and rating	Now	2030	2070
1	Residential property damage from increased flood return to habitable areas	4	6	7
2	Costly infrastructure adaptations as a result of increased flood return to habitable, marine and waterfront recreation areas	4	6	8
3	Environmental damage due to flooding of industrial areas in expanded flood zone.	4	6	6
4	Injury and death due to increased flood return period to waterfront leisure and recreation areas	4	6	7
5	Stranding of residents due to increased flood return to habitable areas	3	6	7
6	Decreased waterfront property / precinct values due to increased flood return to habitable, marine and waterfront recreation area	3	6	7
7	Mental stress resulting from the consequences of increased flood return to habitable areas	3	5	7
8	Potential liability due to approved residential and business construction that did not account for increased flood return to habitable areas	3	5	7
9	Damage to businesses due to flooding caused by expansion of flood zone (Fishermans Bend)	3	6	6
10	Damage to road and rail infrastructure due to flooding resulting from expansion of flood zone (Fishermans Bend)	3	6	6
11	Interruption of freight movement due to expansion of flood zone (Fishermans Bend)	3	6	6
12	Mass stranding of workers as a result of flooding in Fishermans Bend	3	6	6
13	Decreased waterway activity and loss of major events due to reduced bridge clearances	2	5	6
14	Increased maintenance, cleaning refurbishment and replacement of marine structures and bridges due to higher water levels and increased flood return	2	5	6
15	Damages to waterfront businesses due to increasing flood return period of waterfront leisure/ recreation areas	2	6	7
16	Decreased use of public realm due to increased flood return period to leisure and recreation area	2	5	6

*Combined rating out of 10 reflects likelihood of occurrence.

Appendix B

Consequence ratings - City of Melbourne Climate Change Adaptation Plan 2009

Appendix B Consequence ratings - City of Melbourne Climate Change Adaptation Plan

The following consequence ratings were used for the risk assessment. These ratings are from the City of Melbourne (2009) Climate Change Adaptation Plan, Appendix D – Likelihood, Consequence and Risk Rating (pp 127 – 128).

Likelihood	Number	Description
Almost Certain	5	The event is expected to occur in most circumstances
Likely	4	The event will probably occur in most circumstances
Possible	3	The event should occur at some time
Unlikely	2	The event could occur at some time
Rare	1	The event may occur only in exceptional circumstances

Table 19: City of Melbourne risk likelihood ratings

Consequence	Category	Business Continuity	Environmental	Financial and Economic	People and OHS
Catastrophic	5	The continuing failure of the City of Melbourne or major service providers to deliver essential services. The removal of key revenue generation.	Catastrophic and irreversible environmental damage attributed by the courts to the negligent or incompetent actions of the City of Melbourne.	Above $20,000,000 (calculated as approximately 10% of the City of Melbourne's annual revenue before tax)	Multiple fatalities (more than five persons) and significant irreversible disabilities.
Major	4	Widespread failure to deliver several major strategic objectives and service plans. Long-term failure of major service provider causing lengthy service interruption.	Long-term and widespread environmental damage taking greater than 5 years to recover and requiring significant restorative work.	$2,000,000 to $20,000,000	Single or multiple fatalities and multiple irreversible disabilities.
Moderate	3	Failure to deliver minor strategic objectives and service plans. Temporary and recoverable failure of service provider causing intermittent service interruption for a week.	Significant environmental damage taking several years to recover and requiring moderate restoration work.	$200,000 to $2,000,000	Multiple irreversible disabilities and/or critical long-term injuries.
Minor	2	Temporary and recoverable failure of service provider causing intermittent service interruption for several days.	Minor environmental damage such as remote temporary pollution.	$20,000 to $200,000	Single or multiple disabilities requiring short to mid term hospitalisation/ medical aid.
Negligible	1	Negligible impact on business processes, brief service interruption for several hours to a day.	Brief, non hazardous, transient pollution or damage.	Up to $20,000	Injuries requiring minimal temporary first aid.

Consequence	Category	Reputation	Infrastructure and Assets	Political	Liability
Catastrophic	5	Loss of support of the State Government with scathing criticism and removal of the Council. International media exposure.	Long-term loss of Town Hall, CH1, CH2 or CBB, including damage to the City of Melbourne assets such as IT infrastructure etc.	Loss of power and influence restricting decision making and capabilities. Dismissal of the Council by State Government.	Regulatory or contract breaches causing very serious litigation, including major class action. Significant prosecution / fines for the City of Melbourne and individuals.
Major	4	Public and National media concern / exposure with adverse attention and long-term loss of support from the City of Melbourne residents.	Short to mid term loss of Town Hall, CH1, CH2, or CBB. Damage to the City of Melbourne assets.	Major adverse impact and intervention by Common-wealth and State Government.	Major regulatory or contract breaches and litigation. Liability implications and fines for Directors/ Managers.
Moderate	3	Significant statewide concern / exposure and short to mid term loss of support from the City of Melbourne residents.	Damage to one part of a major facility or many parts / all of a small facility.	Moderate adverse impact and intervention by State Government.	Regulatory or contract breaches causing investigation / report to authority and prosecution and moderate fines.
Minor	2	Minor local community concern manageable through good public relations.	Damage to internal assets, system etc. Isolated to a part of a facility.	Minor adverse impact and intervention by Local Government Authorities and Municipal Association of Victoria.	Minor regulatory or contract breaches causing likely prosecution and minor fines.
Negligible	1	Transient matter, such as customer complaint, resolved in day-to-day management.	Minor property damage such as storm, criminal, accidental, no internal asset damage.	Negligible impact from one Local Government Authority.	Negligible regulatory breaches that are detected early and rectified. Insignificant legal issues and non compliance.

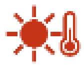
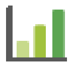
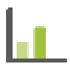
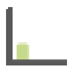
Appendix C

Catalogue of adaptation responses and actions

Appendix C Catalogue of adaptation responses and actions

Contents:

Icons

Factors		Icon
Variable Climate hazard	Reduced rainfall and drought	
	Extreme rainfall (flooding)	
	Extreme wind and hail	
	Extreme temperature and heatwave	
	Sea level rise	
Scale to be applied The applicability of responses across various urban scales	Building	
	Precinct	
	City	
Cost to implement First costs to implement	Low	
	Medium	
	High	
Potential for co-benefits Potential for response to have benefits in other environmental, economic, and social spheres	Increased energy efficiency or reduced energy use	
	Benefits for urban greenery and ecosystems	
	Increased water efficiency or reduced water use	
	Decreased intensity of carbon emissions	
Avoided Cost/Potential Savings Likelihood response will provide cost savings through avoidance of impacts	High	
	Medium	
	Low	
Ease of implementation (effort) Complexity of aligning resources, organisations and	Easy	
	Medium	

Factors		Icon
stakeholders to implement.	Hard	
Within existing policy/strategy	Yes	
Response considered or addressed in existing policy, strategy, or requirement	No/Not Known	

How to use this Catalogue

This catalogue identifies a number of adaptation responses which could mitigate the significant climate risks identified for Fishermans Bend. It provides an overview of 'Adaptation Responses' and associated examples of 'Adaptation Actions'. As the future urban form and timing of the urban renewal of Fishermans Bend is uncertain, the adaptation responses and actions provided are general and require further considered as the planning process and redevelopment progresses.

The appropriateness of the adaptation response will vary depending on a range of factors, such as land contamination, land availability and the overall strategy taken to deal with major risks such as flooding.

The catalogue provides a summary of responses and actions for each risk category (with extreme events separated into two components: extreme rainfall events (flooding) and extreme wind and hail events) due to the substantial number of potential responses and actions for each. The risk categories are:

- Extreme heat and heatwave
- Drought and reduced rainfall
- Extreme rainfall event flooding
- Sea level rise

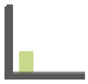
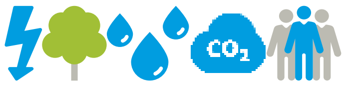
For each risk category, a high-level analysis of potential responses and associated actions has been compiled. It was not within the scope of this project to provide more granular detail for individual actions or indicative costings. Instead the actions provide a checklist to inform stakeholders and decision makers about potential activity they should consider. More detailed investigation, and modelling in some instances, is required to assess the applicability of individual actions at a building, sub precinct and broader urban renewal area scale. it was also not possible to identify specific actions above others with greater potential to deliver multiple benefits or provide best value. However, it is safe to assume that many of the actions address a number of risks and will deliver co-benefits. Actions have been ordered with those which could potentially be lower cost or relatively easier to implement being listed first. The ease of implementation is largely governed by whether policies and plans to encourage this action are already in place for Fishermans Bend. The prioritisation of actions needs to be verified through further work and assessment.

The listing for each Action also includes high level guidance on which actions need to be pursued using building and development processes (B); those that need to be planned for at a precinct scale (PR) or those which will need to be progressed and funded by service providers or public utilities and agencies (PU).

It is worth noting many of the actions will deliver multiple benefits and may respond to a number of climate risks. For example, increased greening and shade for cooling and thermal comfort in buildings and public spaces can increase community wellbeing, improve health outcomes, support social and community cohesion and improve productivity as well as address the risks from extreme heat and a drier climate. Developments that provide a range of safe and comfortable opportunities for socialising, relaxing, sharing and community participation can support social interaction amongst residents and the broader community. This can help to build community networks which are critical in enhancing a community's resilience to long-term stresses (such as social inequality and climate change) as well as acute shocks (such as heatwaves or floods), as outlined in the Resilient Melbourne Strategy 2016.

Extreme heat and heatwave

Cooling with Urban Greenery

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits
					

Description

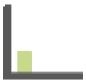
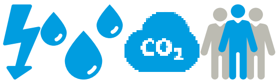
Green spaces in cities can also provide cooling through shading and enhanced evapotranspiration, thus reducing the heat island effect that occurs in many urban areas. Green areas are often threatened by expanding city development, which have fragmented natural areas, creating small patches of green spaces in amongst buildings and roads. For example, patches of urban forest are generally separated from each other, which affects the ability of many species to disperse, or move among different locations with similar habitats. Ecological corridors or connections between urban forest, gardens or other green spaces are recognised as a way to limit the negative effects of fragmentation. The creation of connected green areas and corridors can be applicable in most urban areas. The wide array of available techniques allows application in areas with very different characteristics and even where space is limited. The aim is to optimise development projects to moderate urban microclimates and mitigate urban heat island effects. Techniques include, for example, green roofs and walls, which use vegetation on the roofs and facades of buildings to provide cooling in summer and thermal insulation in winter. The evaporation from a single tree can produce the cooling effect of ten room-size, residential air conditioners operating 20 hours a day. Also removing concrete and hard surfaces can reduce urban heat substantially. Urban cooling through green space provision can be applied to streetscapes, plazas, squares, buildings and malls. Passive systems include: street trees, green roofs/walls and wetlands/water bodies. The effectiveness of each technique varies according to the location, urban context (density, scale) and climate zone.

Example actions

- Green spaces (i.e. augment available parks and trees) and corridors in urban areas **(PR) (PU)**
- Green facades (i.e. green walls/roofs) **(B) (PR)**
- Tree planting and plantings **(B) (PR) (PU)**
- Creation of wetlands and vegetated ponds **(B) (PR) (PU)**
- Assess vegetation impacts on heat island effect **(PR) (PU)**
- Green wedges **(PR) (PU)**
- Urban vegetation **(B) (PR) (PU)**
- Natural turfs and grass cover **(B) (PR)**

Photos

Shading

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits
					

Description

Shade plays an important role in design improved microclimates better able to cope with extreme heat events. The aim is to design and provide for thermally comfortable pedestrian-friendly cities and urban areas. While the adaptation response T1:Cooling with urban greenery described above aims to mitigate the effects of extreme heat and urban heat island through natural means, this response deals with what can be achieved through artificial means of shading such as: building facades, awnings, standalone shading structures, and portable solutions, like outdoor umbrellas. Again there are a range of artificial urban heat mitigation strategies for streetscapes, plazas, squares, buildings and malls. The effectiveness of each technique varies according to the location, urban context (density, scale) and climate zone.

Example actions

- Conduct shade audit of existing facilities and new facility designs **(PR) (PU)**
- Provision of shade (natural, facades, overhangs, buildings) **(B) (PR)**
- Awnings (considering maximum length) **(B) (PR)**
- Double skin façades **(B) (PR)**
- Shade structures for play equipment and outdoor recreational areas**(B) (PR) (PU)**
- External solar shading for buildings (artificial along with vegetation) **(B) (PR)**

Photos


Cooling with Water

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Description

Water is an important way of dealing with heat in the urban landscape. Including water elements, like fountains or ponds within an urban area, leads to a decrease the temperature within the city. Evaporation of the water of the pond or fountain leads to an actual temperature decrease. However during longer periods of drought this solution could conflict with water saving measures.

Example actions

- Cooling with water elements (e.g. fountains and ponds) **(B) (PR) (PU)**
- Provision of drinking water and misting **(B) (PR) (PU)**
- Geothermal heating/cooling using seawater in coastal areas **(PR) (PU)**

Photos

Planning measures and urban layout

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Description

Integrated land use planning is a strategy to prevent or reduce climate impacts (drought, water scarcity, heat stress and flooding). Land use can positively affect the regional water balance, which in turn influences the evapotranspiration process through infiltration and soil water redistribution. Surface roughness, which controls overland flow velocity and floodplain flow rates is also an important factor that can be actively managed through land use controls. Introducing controls to encourage or require the planting of trees and vegetation, sustaining wetlands, avoiding bare soil (especially during precipitation seasons), maximising vegetation cover, and the introduction drought/flood-tolerant crops can all reduce flood and drought risk.

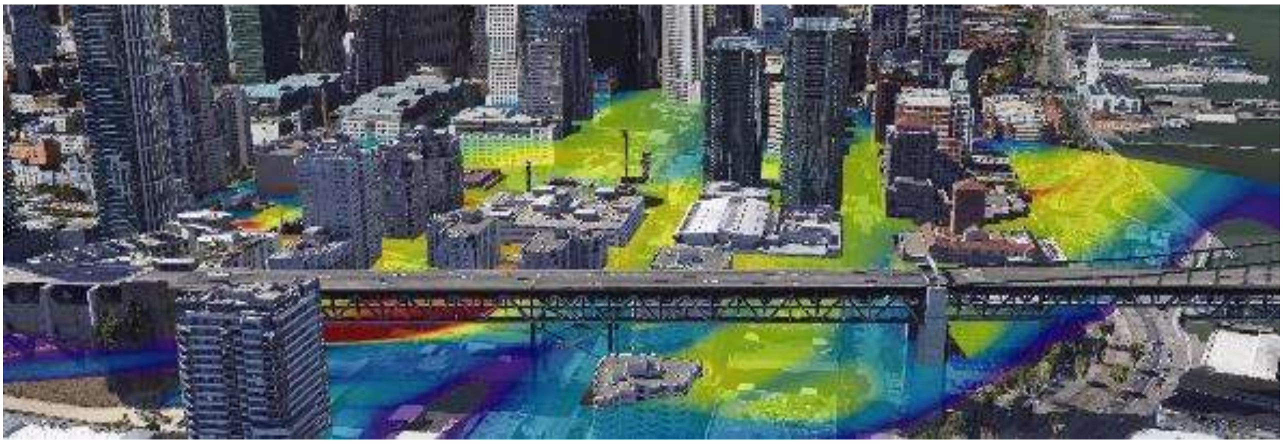
Measures to avoid or reduce exposure of valuable urban assets generally involve zoning, building codes, such as minimum floor heights and water proofing, as well as land use permits. For example, land use zones can be established to include areas where building is strictly prohibited or limited, areas where building is possible but designs have to include climate adaptation responses, and other areas with no restrictions. The use of maps and plans provide information regarding hazard and these restrictions. Therefore, planning principles should include:

- Avoidance of construction in highly flood prone areas ;
- Concentration of development in low hazard areas;
- Restricted developments in highest flood risk areas (especially economically valuable and sensitive buildings)
- Careful stormwater services planning.

Example actions

- Adoption of integrated land use planning **(PR) (PU)**
- Heat mitigation strategies for all public spaces **(PR) (PU)**
- Orientation to prevailing winds **(B) (PR) (PU)**
- Revised building standards and codes **(PR) (PU)**
- Ventilation corridors **(PR) (PU)**
- Mandated site composition to reduce UHI **(PR) (PU)**
- Design guidelines **(PR) (PU)**

Photos



Building level cooling strategies

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Description

Building-level cooling strategies aim to optimise the design of buildings and their cooling systems to provide the best energy efficiency under higher temperature operating loads and increase occupant wellbeing. Good building design decreases power consumption, saves money and reduces the effects of climate change. On the other hand, poor building design is uneconomical and contributes to greenhouse gas emissions. The internal temperature of a building is a product of three factors: the outside conditions; how a building is designed and constructed; and how a building is used. Buildings that are poorly designed, constructed or maintained may exacerbate the effects of heat-waves on occupants, particularly those that are more vulnerable. Interventions cover both active (e.g. misting systems and operable awnings) and passive systems (street trees, green roofs/walls, water bodies, cool roofs and façades). Techniques both internal and external to the buildings include: cool surfaces, cool paving, high albedo paving, high emissivity paving, permeable paving, cool building envelopes, high albedo roof surfaces, green roofs, green walls, evaporative cooling, surface /running water, misting fans, shading structures (temporary and permanent). Within the context of Fishermans Bend misting fans for temporary cooling, surface water and other evaporative cooling strategies are recommended. Relatively low rainfall during summer makes water sensitive urban design principles essential to ensure evaporative cooling. High solar radiation intensity and UV level mean increased tree canopy and shading are ideal strategies, especially in higher density urban settings where the tree canopy cover is relatively low. Similarly, high emittance paving is the best practice to radiate away the urban heat. With reduced annual rainfall, permeable paving is an effective strategy for urban cooling while also addressing stormwater management.

Example actions

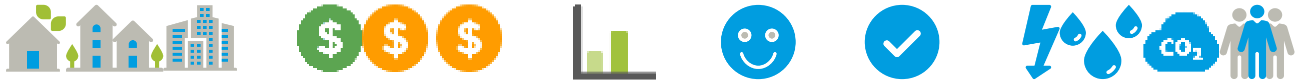
- Upgrade the efficiency of HVAC systems **(B) (PR)**
- Passive ventilation to increase thermal comfort **(B)**
- Improved use of thermal properties of building materials **(B)**
- reduce solar heating using recessed windows, roof overhangs and shades**(B) (PR)**
- Active (mechanical) cooling, including chilled beams and conventional air conditioning systems **(B) (PR)**
- Automatic blinds**(B)**
- Heat reflective coatings**(B)**
- Double glazing **(B)**
- Building sealing **(B)**
- Solar control film **(B)**
- Geothermal heat pumps for reverse cycle air conditioning/ water heating **(B) (PR)**
- Light coloured materials and finishes **(B) (PR)**
- Vegetation on roofs and pavements **(B) (PR))**
- Cool roofs **(B) (PR)**
- Building Management Control **(B)**
- Equipment resilience to temperature **(B)**
- Development of cooling towers **(B) (PR)**
- Building envelope insulation **(B) (PR)**
- Mid pane blinds **(B)**

Photos


KØGE SUPER HOSPITAL

Behavioural Approaches and Community Education

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits



Description

It is acknowledged that development and implementation of policies and actions dealing with heatwaves and other weather extremes requires co-operation with stakeholders. In many cases it is impeded due to a lack of stakeholders' capacity. Capacity development takes the form of engagement between civil society (stakeholder groups), and local and national government. Representative stakeholders should come from all sections of society likely to be affected by weather extremes. Underpinning stakeholders' capacity building is that people are more likely to support adaptation strategies when they feel their views have been taken into account.

Governments and institutions at the national or regional level undertake planned and reactive adaptation. Adaptation is ultimately a localised phenomenon driven by the need for people to adapt to the local manifestations and impacts of climate change. People pursue adaptation strategies appropriate to their individual circumstances, which might result in unpredictability of adaptation.

At the local level adaptation is a complex process formed as social systems reorganize, in a largely unplanned fashion, through a series of responses to external stresses. Adaptive capacity can be weakened by a refusal to accept the risks associated with climate change, or by a refusal of key actors to accept responsibility for adaptation. These positions may be ideological, or a consequence of vested interests denying the existence of risks associated with climate change. Thus large-scale structural economic factors and prevailing ideologies can play a vital role in determining which adaptations are feasible.

Example actions

- Community education to increase awareness of heat stress/sun exposure **(PR) (PU)**
- Innovative business resilience networks **(PR) (PU)**
- Community events and programs**(PR) (PU)**
- Event protocols for extreme events **(PR) (PU)**
- Heatwave Response Plan **(PR) (PU)**
- Hot conditions safety campaign **(PR) (PU)**
- Information packages (residents, businesses) **(PR) (PU)**
- Neighbourhood resilience projects **(PR) (PU)**
- Emergency preparedness training **(PR) (PU)**
- Heatwave / flood warning system including transportation and cooling centres info **(PR) (PU**
- Flexible working hours to avoid heat exposure **(PR) (PU)**

Photos

Resilient Critical Infrastructure

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Description

Critical infrastructure supports services that are essential for everyday life such as energy, water, transport, communications, food, health and banking and finance. Disruptions to critical infrastructure can have a range of serious implications for business, governments and the community. More resilient critical infrastructure will support the continued provision of essential services despite increasing frequency and intensity of extreme events. Climate proofing critical infrastructure against extreme heat can include: installation of back- up power generation, augmented cooling, higher performing HVAC systems, centralised control over key precinct infrastructure to 'hoteling' of assets to conserve power in times of crisis and real time data and analytics to enable emergency scenario modelling to support emergency response planning etc.

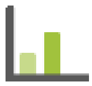
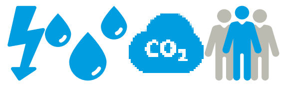
Example actions

- Locally Based Energy Systems & decentralised renewable energy production to lessen vulnerability to grid failure **(PR) (PU)**
- Detailed review of the design capacity of critical infrastructure **(PR) (PU)**
- Backup power supply **(B) (PR) (PU)**
- Centralised power controls **(PR) (PU)**
- Real time data and analytics for emergency scenario modelling **(PR) (PU)**

Photos

Drought and reduced rainfall

Storage and retention

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits
					

Description

This response aims to catch water where it falls for efficient local re-use, and/or storage for later use. It is implemented through natural and artificial means. Artificial means include: structures for water infiltration and retardation, reduced impermeable areas, pervious pavements, roads and parking areas, local storages (ponds, building storages, groundwater cisterns) and roof planting etc. It also includes increased storage in the river system itself which can be achieved by the development of flood plains and wetlands. Permeability taxation can encourage reconstruction of green areas in cities. By promoting infiltration, storage and trapping water in the precincts, flood peaks can be lowered. Improvement of drainage systems can also enhance water storage.

Natural water retention measures are those that aim to safeguard and enhance the water storage potential of landscapes, soils and aquifers by restoring ecosystems, natural features and characteristics of watercourses using natural processes. They can be supported and integrated with specially designed infrastructure (blue green or green). These measures all contribute to integrated goals such as: biodiversity conservation and landscape restoration. Water retention landscapes are permanent artificial lakes that serve to manage storm water runoff, prevent flooding, tackle erosion, improve water quality and support the restoration of the water cycle. Again this is all done by retaining rain in the area where it falls. These measures improve the environment and allow for groundwater recharge. Water retention basins are sometimes also referred to as wet ponds. A water retention landscape consists of a series of interconnected retention spaces, from pond-sized to lake-sized, in which the rainwater can collect behind a dam constructed from natural materials. The retention spaces are not sealed with concrete or any artificial layer, so water can slowly diffuse into the earth. The retention landscapes and infiltration responses and actions in the following Tables may need to be modified to be appropriate for Fishermans Bend due to the contaminated soils and high-water table.

Example actions

- Retention landscapes **(PR) (PU)**
- Stormwater capture, harvesting, treatment and recycling **(PR) (PU)**
- Rainwater harvesting / decentralised collection and storage **(PR) (PU)**
- Water sensitive urban and building design **(PR) (PU)**
- Freshwater injection and aquifer recharge **(PR) (PU)**
- Infiltration and Transport-sewers **(PR) (PU)**
- Bio-retention Ponds **(PR) (PU)**

Photos - Integrated stormwater system – Greening the Pipeline (Melbourne Water)

Water efficiency

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

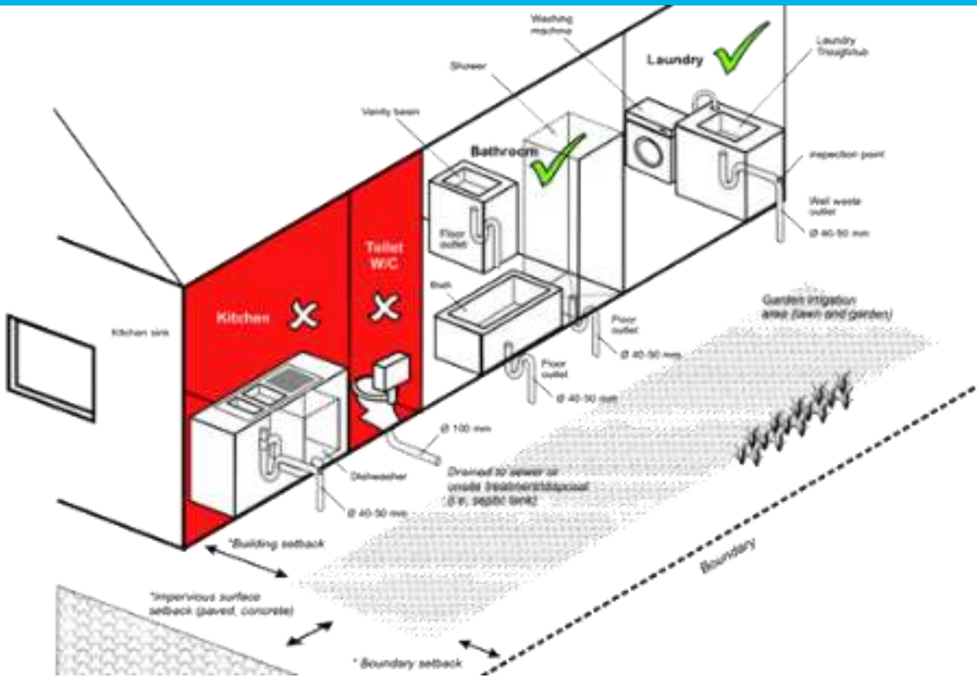
Description

Actions to decrease demand for water is the first step in managing water when it is in short supply. Managing urban water demand through the right mix of measures is essential for ensuring safe and reliable water supplies, especially in times of acute scarcity and drought. Demand management can be promoted through a mix of pricing, efficiency and policy instruments, including restrictions. Efficiency programs include Water Efficiency Labelling Scheme (WELS) and the Smart Approved Water Mark (SAWM) accreditation program for products and services that save water outdoors. Improved demand management must consider social implications as the economic costs related to water restrictions are often borne disproportionately by certain industries and sections of the community.

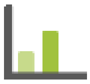
Example actions

- Reduce freshwater demand for cooling **(B) (PR) (PU)**
- Water real-time metering **(B) (PR) (PU)**
- Water metering linked to central management system **(PR) (PU)**
- Switch to more efficient water cooling systems in HVAC **(B) (PR) (PU)**
- Mandatory minimum standards for water efficient fixtures **(PR) (PU)**
- Develop policy for water efficiency and WSUD **(PR) (PU)**
- Retrofit water efficiency controls **(B) (PR) (PU)**
- Water restrictions **(PR) (PU)**
- Leakage control in water distribution system **(PR) (PU)**
- Incorporate policies which ensure that the water resource implications of new developments are assessed **(PR) (PU)**
- Reducing irrigation for public spaces etc. mains water use **(PR) (PU)**
- Community education on potable water use **(PR) (PU)**
- Drought tolerant plants **(B) (PR) (PU)**

Photos



Treatment of Alternate Water Sources

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits
					

Description

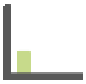
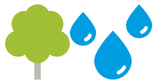
Increasing demand, particularly for urban uses, in combination with decreasing water availability may put pressure on water supplies. Reducing demand and utilising existing water resources in efficient ways is likely the first step in adapting. There may ultimately be a need to also identify alternate sources of water supply. A range of alternative sources can be investigated and utilised (such as recycled water, ground water, etc.).There are a number of water recycling approaches and technologies, including grey and black water reuse and reclamation technologies for sewage-treated water.

Example actions

- Identify and use alternative source options - ground water, site bores, recycled water, small scale desalinisation **(B) (PR) (PU)**
- Recover condensate from HVAC**(B) (PR) (PU)**
- Collect and treat grey/black water for non-potable use **(B) (PR) (PU)**
- Water recycling (including technologies to reclaim sewage-treated water) **(B) (PR) (PU)**

Photos

Contingency planning and changing maintenance routines

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits
					

Description

Contingency planning and changing maintenance routines can be used to avoid, mitigate and manage drought conditions. More efficient use of existing water supplies can delay the need for new supplies, minimising the costs and environmental impacts associated with developing new supplies. This can be done through the development of water conservation and drought contingency guidelines and requirements delivered through water suppliers/utilities and other stakeholders. A drought strategy with to reduce drought risk and therefore the associated economic, social, and environmental impacts of drought can be developed. Understanding the water cycle needs in a local context and customising solutions around this, as well as holistic thinking about local liveability, recreational, amenity and social outcomes are required in the planning process.

Objectives would be to: reduce water consumption from the levels that would prevail without conservation efforts; reduce the loss and waste of water; improve efficiency in the use of water; increase the level of recycling and reuse; and extend the life of current water supplies by reducing the rate of growth in demand. Maintenance regimes and asset management plans for other stakeholders and asset owners/operators in a drought affected area are also important. Drought will have significant direct and indirect implications for aspects such as landscaping and increased air borne particles/dust (which in turn can impact building HVAC systems).

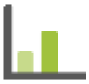
Integrated water management is a central part of achieving this response which can be done through an Integrated Water Servicing Strategy. Facilitating integrated water management planning requires strong stakeholder partnerships with a commitment to working collaboratively, openly sharing information and ensuring clear allocation of responsibility and risk. Options include: increase use of recycled water from a sewer mining plant; stormwater storage; distributed storage through the use of rainwater tanks (e.g. Smart Tanks), a distributed storage networks for non-potable uses, water sensitive urban design, technologies for digital metering, pressure sewer systems; intelligent networks.

Example actions

- Water sensitive urban design principles embedded into plans **(B) (PR) (PU)**
- Recycled water from sewer mining **(PR) (PU)**
- Stormwater storage **(B) (PR) (PU)**
- Distributed storage through the use of rainwater tanks (e.g. Smart Tanks) **(B) (PR) (PU)**
- Maintain groundwater flow volumes **(PR) (PU)**
- Distributed storage networks **(PR) (PU)**
- Technologies for digital metering **(B) (PR) (PU)**
- Pressure sewer systems **(PR) (PU)**
- Intelligent water networks **(B) (PR) (PU)**

Photos - Rain garden and recycled water for irrigation (Melbourne Water)


Enhancement of building and structural Integrity

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits
					

Description

Building and structural adaptation responses are needed to deal with changing soil moisture and land stability as a result of reduced precipitation and drought. Increasing temperatures will also exacerbate and contribute to soil shrinkage and subsidence, particularly in clay soil areas. This can lead to faster deterioration in soil stability and hence the structural condition of concrete and building foundations.

Example actions

- Monitor soil and land structure, structural review **(B) (PR) (PU)**
- Amend & augment design standards **(B) (PR) (PU)**
- Infrastructure strengthening **(B) (PR) (PU)**
- Strengthen building foundations **(B) (PR) (PU)**
- Use of different building materials **(B) (PR) (PU)**

Photos

Extreme rainfall event (flooding)

Detention / Retention / Infiltration

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Variable	Type	Scale	Cost	Co-benefits	Effort
	Adapt				

Description

Storage and retention measures aim to manage storm water runoff, prevent flooding and erosion, improve water quality and support the restoration of the water cycle by retaining water in the areas where it falls as rain. This can be designed through hard engineering solutions such as constructing underground storage tanks, or through more natural measures. Natural water retention measures aim to safeguard and enhance the water storage potential of landscapes, soil and aquifers by restoring an ecosystem's natural features and a water course's natural characteristics and processes. Storage and retention measures support other specifically designed infrastructure (blue and green) by contributing to integrated goals such as biodiversity conservation and restoration and landscaping etc. In addition, they improve the quality of their environment and allow for groundwater recharge. Water retention basins are sometimes also referred to as wet ponds. A water retention landscape consists of a series of interconnected retention spaces, from pond-sized up to lake-sized, in which the rainwater can collect behind a dam constructed from natural material. The retention spaces themselves are not sealed with concrete or any artificial layer, so the water can slowly but steadily diffuse into the ground.

Responses and actions in Tables below relating to retention landscapes and infiltration may only be appropriate in modified ways as the Urban Renewal Area contains areas of contaminated soils and a high-water table.

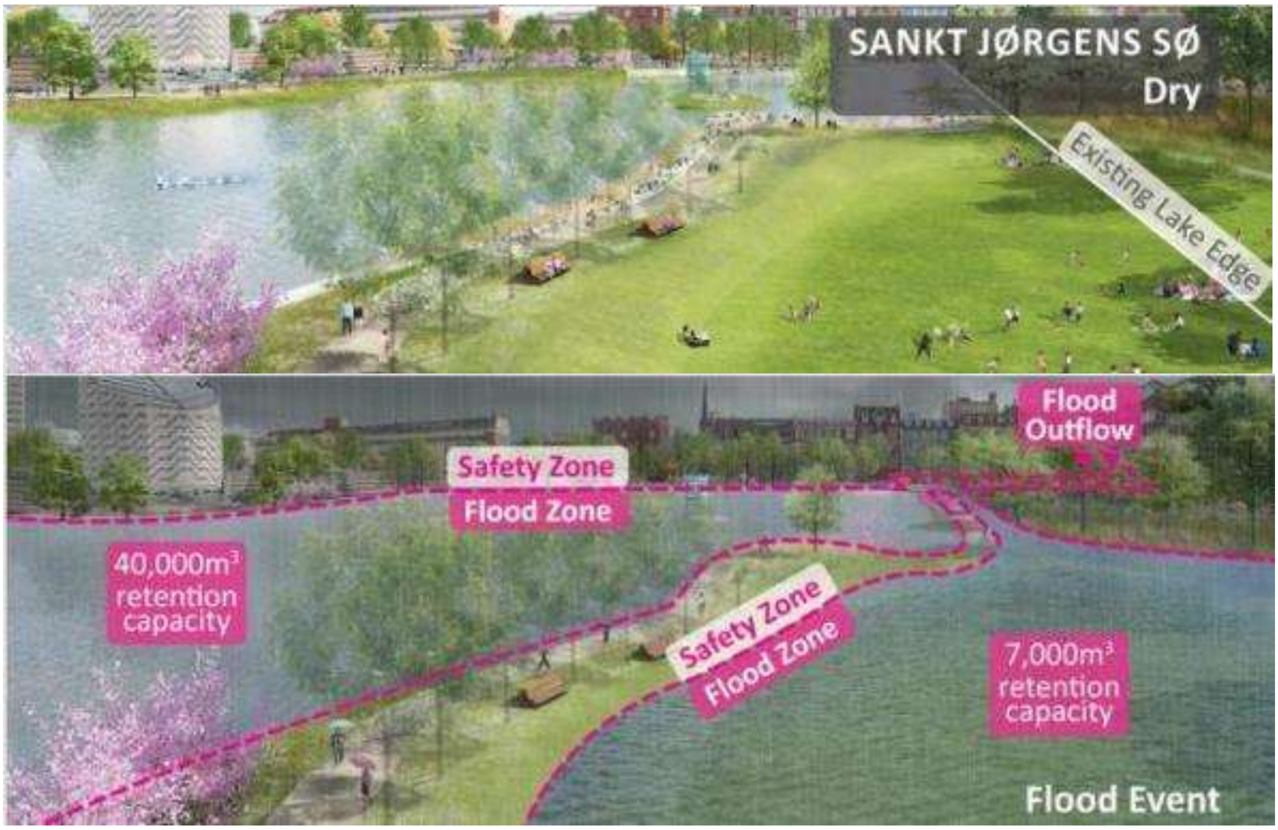
The idea to catch water where it falls is implemented through techniques such as enabling artificial infiltration and retardation, reducing impermeable area, pervious pavements and parking lots, local storages (ponds, building storages, groundwater cisterns); roof planting. It also includes increasing river system storage which can be achieved by the development of flood plains, polders, and wetlands. Permeability taxation can enhance reconstruction of green areas in cities. By promoting infiltration, storage and trapping water in the catchments, flood peaks can be lowered. Improvement of drainage systems can also enhance water storing.

These adaptation measures use nature to regulate the flow and transport of water to smooth peaks and moderate extreme events (floods, droughts and salination). They are usually a better environmental option for flood risk management as they reduce vulnerability of water resources to climate change and they can also improve water quality.

Example actions

- Green roofs **(B) (PR) (PU)**
- Rainwater harvesting **(B) (PR) (PU)**
- Permeable surfaces **(B) (PR) (PU)**
- Swales **(B) (PR) (PU)**
- Channels and rills **(PR) (PU)**
- Filter strips **(B) (PR) (PU)**
- Soakaways **(B) (PR) (PU)**
- Infiltration trenches **(PR) (PU)**
- Rain gardens **(B) (PR) (PU)**
- Detention basins **(PR) (PU)**
- Small scale Retention ponds and landscapes (where applicable) **(PR) (PU)**
- Small scale infiltration basins (where applicable) **(B) (PR) (PU)**

Photos


SANKT JØRGENS SØ
Dry
Existing Lake Edge
Flood
Outflow
Safety Zone
Flood Zone
40,000m³
retention
capacity
Safety Zone
Flood Zone
7,000m³
retention
capacity
Flood Event


SØNDERBOULEVARD
Dry
Existing Street Profile
Safety Zone
Flood Pathway
3,300 l/s flow capacity
Flood Event

Planning Measures and Urban Layout

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Variable	Type	Scale	Cost	Co-benefits	Effort
	Protect / Adapt				

Description

By reducing or carefully planning settlements and reinforcing built structures in a hazard zone, exposure and vulnerability to climate change will be reduced. Land uses need to respond to the type, nature, and risk levels of extreme events likely to occur in the area. This may involve restricting buildings in areas with particularly high risk levels. Risk levels can be studied and analysed in detail, to identify zones with high risk levels. Where possible the following approach should be considered: (1) new construction is prohibited or controlled in the extreme hazard zones, (2) relocation is considered to outside extreme hazard zones, and (3) efforts are made to reduce land use intensity in the extreme hazard zones. In addition, buffer zones are protected or enhanced in an effort to reduce impacts on the area.

Example actions

- High resolution flood mapping, incorporating SLR and storm surge into the future and confluence flooding (including also future predicted extreme precipitation) **(PR) (PU)**
- Retreat from high-risk areas (including relocation of critical infrastructure) **(PR) (PU)**
- Constraints on development - Avoid or regulate development in vulnerable locations **(PR) (PU)**
- Sustainable Urban Drainage (SUDS) **(PR) (PU)**Drainage and Wastewater management planning incorporating climate change projections **(PR) (PU)**
- Water sensitive urban and building design **(PR) (PU)**
- Incorporate Water Sensitive Urban Design (WSUD) in design phase **(PR) (PU)**
- Adoption of Integrated Land Use Planning **(PR) (PU)**

Photos


Building Design and Infrastructure Standards

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Variable	Type	Scale	Cost	Co-benefits	Effort
	Protect / Adapt				

Description

Building codes establish a building's quality, safety and energy performance for years to come, because initial design and construction decisions determine operational and maintenance requirements throughout the life of the building. Implementing controls and technical specifications for development will need to reflect the range of possible climate impacts and environmental conditions that the development will have to withstand.

Example actions

- Conduct detailed review of the design capacity of critical infrastructure **(PR) (PU)**
- Dry-proofing facilities (Sealable buildings) **(PR) (PU)**
- Check valve/non-return valves **(PR) (PU)**
- Wet-proofing facilities **(PR) (PU)**
- Design for flood/ inundation risk **(PR) (PU)**Roof drainage increased capacity for heavy rain events
- Floating and Amphibious Buildings
- Structure stability
- Raising land **(PR) (PU)**

Photos

Building-scale Protection

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Variable	Type	Scale	Cost	Co-benefits	Effort
	Protect				

Description

Building scale protection refers to a range of actions that can be implemented in buildings to increase their resilience to extreme events. For example, dry proofing buildings, involves the exterior of buildings being made waterproof to prevent flood water entering the building. In case of a flood the building will not be damaged and normal operation can immediately restart after the water has subsided. Alternatively, wet-proofing buildings, involves the interior of buildings or infrastructure in flood sensitive areas being made waterproof. Instead of using water sensitive materials like wood or plaster-like building blocks more robust materials like concrete, steel and glass are used. If the building is flooded, damage is minimised and after a flood normal operation can restart much faster.

Example actions

- Check structure stability Dry-proofing facilities (Sealable buildings) **(B) (PR)** Check valve/non-return valves**(B) (PR)**
- Wet-proofing facilities **(B) (PR)**
- Floating and Amphibious Buildings/Assets (where applicable) **(B) (PR)**

Photos



Precinct-scale Protection

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Variable	Type	Scale	Cost	Co-benefits	Effort
	Protect / Adapt				

Description

Precinct scale protection refers to a range of actions that are of a larger scale then building level actions, whereby the entire precinct can benefit from the intervention. Actions often consider the capacity of stormwater and sewerage systems, and aim to provide solutions to increase these systems capabilities under extreme events. For example, sustainable urban drainage systems (SUDS) provide an alternative approach to conventional urban drainage systems. By mimicking the natural movement of water, these systems can help to retain water on an urban site hence allowing the storage and use of water, contributing to a reduction in flood risk, as well as benefiting water quality. It can include: water detention, separation of sewage and sewer relief from flood waters (offsite pumping and other solutions). Beside SUDS the improvement of drainage capacity can also be necessary. One-way valves on sewer lines, installing pumps for water extraction at the floods events, and other solutions like permeable pavements can also be included.

Implementation is at the local project or precinct level, though SUDS may be an approach incorporated within higher-level policy objectives. Taking a systems approach is considered innovative as it represents a shift from conventional engineering solutions to a more natural approach to flood risk management. This involves learning to live with, rather than work against, natural processes.

Example actions

- Check adequacy of drainage capacity **(PR) (PU)**
- Increase capacity of sewer and stormwater systems **(PR) (PU)**
- Disconnecting paved surfaces from sewer system
- Remove/minimise impervious surfaces **(B) (PR) (PU)**
- Disconnect combined sewer/stormwater systems **(PR) (PU)**
- Drainage corridors **(PR) (PU)**
- Smart-drain (groundwater) **(PR) (PU)**
- Construction/improvement of small scale dykes (also consider mounds and evacuation hills) **(PR) (PU)**
- Storm surge gates / flood barriers **(PR) (PU)**
  Permeable paving **(PR) (PU)**

Photos

Catchment-scale Protection

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Variable	Type	Scale	Cost	Co-benefits	Effort
	Protect	-			

Description

Catchment-scale protections consider the wider natural drainage area, and include actions that better manage collected and discharged water throughout a catchment. Like the precinct scale protection this can include a wide range of actions that are of a catchment scale rather than precinct or building level actions, whereby the entire catchment can benefit from the interventions. Actions often consider the capacity of stormwater and sewerage systems, and aim to provide solutions to increase the capabilities of these systems under extreme events. For example, catchment level implementation of sustainable urban drainage systems (SUDS). Actions at the catchment level can also include: dams, waterways dredging and aquifer recharge.

Example actions

- Increasing water discharge capacity of rivers and floodplains **(PR) (PU)**
- Flow-through dam for flood-control **(PR) (PU)**
- Construction/improvement of upstream dams **(PR) (PU)**
- Dredge waterways/streams etc. to enhance flow **(PR) (PU)**
- Develop floodplain risk management plan **(PR) (PU)**
- Managed aquifer recharge **(PR) (PU)**
- Sustainable urban drainage systems (SUDS) **(PR) (PU)**

Photos

Emergency Management Protocols

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Variable	Type	Scale	Cost	Co-benefits	Effort
	Protect / Adapt			-	

Description

Evacuation plans, or a Community Resilience Plan, should be prepared for local levels in advance of foreseeable disasters. They need to provide the details of disaster prevention actions to be implemented prior to the event, as well as implementation timing and implementing bodies. In the event of a disaster community groups, residents and businesses will find they have insufficient resources to protect assets and individuals, so agencies and others have the responsibility to enable residents and occupants to take practical resilience steps ahead of any event. The disaster prevention actions described in these plans should include, for example, mobilisation of staff, administrative procedures related to emergency response, preparation of shelters, evacuation orders, halting of public transportation, and emergency evacuation of support staff. Preparation of the action plan involves the preparation plans for multiple damage scenarios, and listing of actions for each responsible agency (National Government, State Government and agencies and local governments), and identification of priority items to protect, as well as coordination arrangements among the relevant agencies. By effectively using the time before the occurrence of a disaster or extreme event and working to maximise the disaster prevention activities, it is possible to mitigate potential damage. The Plan should include emergency contact, emergency shelter locations and a listing of communication channels during an emergency etc.

Example actions

- Reduction in reliance on one form of transport in the event of failure/flooding of one mode **(PR) (PU)**
- Standby mobilisation of bus services with early warnings of severe storms for improved response times and safe transfer of people **(PR) (PU)**
- Building and precinct scale evacuation modelling and optimisation plan to ensure emergency passage and access **(B) (PR) (PU)**
- Video service screenings on emergency preparedness **(PR) (PU)**
- Emergency pumps either located in, or rapidly deployed to, high risk areas **(PR) (PU)**
- Public education and communication strategy about stormwater and flood **(PR) (PU)**
- Rapid response to cordon-off areas as safe locations & refuges **(PR) (PU)**
- Backup power supply **(B)(PR) (PU)**
- City cameras **(PR) (PU)**
- Ensure website (and related emergency notices) are operable from a back-up server **(PR) (PU)**
- Early Warning System **(PR) (PU)**
- Plan and establish alternative or on-site power supply **(PR) (PU)**

Temporary Protection

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Variable	Type	Scale	Cost	Co-benefits	Effort
	Protect				

Description

Temporary and mobile flood barriers are mainly used in urban areas with limited space or capacity for permanent and integrated solutions. Their size and weight depends on the water level which needs to be secured. They can be built entirely from steel plates and pillars, or movable structures. Mobile barriers are made between pillars which are fixed at certain points or with structures behind the wall to ensure stability. The parts are as light as possible because cranes or humans need to handle them quickly to be in place in time. They also have to have sufficient capacity to ensure effective flood protection. These solutions may also be complemented by pumps to remove water that the structure does not prevented from intruding into the area.

Example actions

- Mobile/Temporary flood protection **(PR) (PU)** structures
- Increase fixed pump capacity **(PR) (PU)**
- Emergency pumps **(PR) (PU)**

Photos

Resilient Critical Infrastructure

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Variable	Type	Scale	Cost	Co-benefits	Effort
	Protect	-			

Description

This response involves climate proofing roads, bridges and other transport links in flood prone and coastal areas to withstand extreme events (sea level rise and storm surge, rise in river debris, storms, extreme heat etc.). The threshold performance levels of critical infrastructure need to be understood. It is critical to enable and ensure adequate access and egress out of and into the precinct to enable communications, livelihood and business activities, as well as provide services. Augmentation of flood impacted infrastructure could include elevating flood wall or ring dykes around vital infrastructure or elevating or flood proofing the infrastructure itself.

Increased precinct/area resilience is ensured by guaranteeing that transport links remain active despite increased flooding risk etc. Increased economic resilience is assured by guaranteeing physical access to economic zones and market access. Increased health resilience is enabled through ensuring access to health centres, hospitals and other social and health services

Life support facilities and dangerous goods and plants (particularly relevant for port and other industrial zones) should be well defended against climate extremes. Vital social and health infrastructure should be operational even during extreme conditions. Power generators can provide backup power. Some vulnerable or vital objects need to be operational at all times and facilities with these vital services need to consider installation of back-up generators. For instance, life support systems in hospitals or vital infrastructure like storm surge barriers.

Example actions

- Conduct detailed review of the design capacity of critical infrastructure **(PR) (PU)**
- Install remote and automated monitoring and control systems for vital equipment and infrastructure **(PR) (PU)**
- Diverse or redundant supply and transmission options for energy supply **(PR) (PU)**
- Elevating or flood proofing flood-prone structures **(PR) (PU)**
- Construct overhead service lines **(PR) (PU)**
- Floating or elevated roads**(PR) (PU)**
- Elevated flood wall/ring dyke for vital infrastructure **(PR) (PU)**

Changing Maintenance / Operational Routines

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Variable	Type	Scale	Cost	Co-benefits	Effort
	Protect / Adapt				

Description

Maintenance routines and asset management plans will need to take account of increasing frequencies and intensities of extreme events. If assets already perform poorly in extreme events (e.g. leaks, poorly attached fittings, etc.), these will need to be updated. Trees and outdoor furniture may need more diligent inspection to reduce damage and the possibility of production of unwanted debris in extreme events. Stormwater and other drainage systems need to be maintained to operate at full capacity in extreme events.

Example actions

- Investigate the integrity of the roof structure to ensure leakages and subsequent water damage is minimised **(B) (PR) (PU)**
- Continued tree replacement program **(B) (PR) (PU)**
- Locally Based Energy Systems **(B) (PR) (PU)**
- Install infrastructure to improve storm water quality **(B) (PR) (PU)**
- Minimise pollution to waterways in floods **(PR) (PU)**
- Restrict use times / review of sewerage operations to mitigate overflow risks **(B) (PR) (PU)**
- Clean up response **(B) (PR) (PU)**
- Flood insurance and preparation measures **(PR) (PU)**
- Revise asset management plans to include consideration of climate projections **(B) (PR) (PU)**
- Vegetation maintenance to prevent wind damage/debris **(B) (PR) (PU)**
- Review and improve stormwater cleaning/maintenance schedule to minimise debris build-up in drainage system **(B) (PR) (PU)**
- Multiple mode and flexible route options for transport in urban areas **(PR) (PU)**
- Identify flood points in transport network **(PR) (PU)**
- Cleaning of stormwater and other drains **(B) (PR) (PU)**

Photos

Ecosystem-based Adaptation

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Variable	Type	Scale	Cost	Co-benefits	Effort
	Protect			-	

Description

Ecosystem-based approaches to adaptation, including conservation, sustainable land management and restoration of ecosystems, aims to increase resilience to climate change through utilising and leveraging ecosystem processes and services. The methods complement or even substitutes for other adaptation measures, such as hard or ‘grey’ infrastructure measures. In addition, the ecosystem-based and natural solutions tend to generate valuable co-benefits, such as carbon sequestration, biodiversity conservation, or food production, and are often more cost efficient. Responses and actions in Tables below relating to retention landscapes and infiltration may only be appropriate in modified ways as the Urban Renewal Area contains areas of contaminated soils and a high-water table.

Example actions

- Constructed wetlands **(PR) (PU)**
- Creation of small scale natural buffer zones **(PR) (PU)**
- Enhanced public space **(PR) (PU)**
- Rehabilitation and restoration of rivers/stream/waterways (including riparian buffers) **(PR) (PU)**
- Tree planting and native vegetation areas **(PR) (PU)**

Photos

Sea Level Rise

Planning Measures and Urban Layout

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Variable	Type	Scale	Cost	Co-benefits	Effort
	Protect / Adapt			-	

Description

Integrated land use planning is a strategy to prevent or reduce climate impacts (storm surge, flooding and inundation). It also avoids or reduces exposure of valuable elements to risks. Land use can positively affect the location, type and design of land uses and development and convey hazard and risk information to stakeholders.

Introducing controls to encourage or require the planting of trees and vegetation, stabilising coastal areas and assisting to reduce erosion.

Measures to avoid or reduce exposure of valuable urban assets generally involve zoning, building codes, such as minimum floor heights and water proofing, as well as land use permits. For example, land use zones can be established to include areas where building is strictly prohibited or limited, areas where building is possible but designs have to include climate adaptation responses, and other areas with no restrictions. The use of maps and plans provide information regarding hazard and these restrictions. Therefore, planning principles should include:

- Avoidance or restrict development and construction in vulnerable or hazardous coastal locations
- Concentration of development in low hazard areas
- Integrate protection works and drainage upgrades in vulnerable areas.

Example actions

- Coastal inundation modelling to include SLR, storm surge and rainfall data **(PR) (PU)**
- Develop vision and planning/zoning**(**guidelines/laws for coastal areas **(PR) (PU)**
- SLR and adaptation strategies in long term coastal planning.**(PR) (PU)**
- Assess coastal access **(PR) (PU)**
- Coastal 'worst case' scenario planning **(PR) (PU)**
- Coastal infrastructure standards **(PR) (PU)**
- Building structures above flood levels **(PR) (PU)**
- Constraints on development - avoid or regulate development in vulnerable locations **(PR) (PU)**
- **I**ncorporate SLR into boating and harbour planning
- Land buy-back or relocation of assets **(PR) (PU)**
- Multiple mode and route options for transport in urban coastal areas **(PR) (PU)**
- Protecting / raising coastal land**(PR) (PU)**

Education and Awareness

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Variable	Type	Scale	Cost	Co-benefits	Effort
	Protect / Adapt			-	

Description

- Education, communication and awareness raising are all important adaptation responses to inform and enable appropriate community action. The aim is to increase community resilience through communication and education. Education enables individuals to effectively accomplish their own actions and goals. Clear communication of sea level rise risks is essential in achieving broad community-wide resilience. Community resilience will draw on the strengths of diverse communities, to pursue shared interests, embrace differences and be stronger together. Resilience can be built in many ways, directly and indirectly, consciously and otherwise. Education will help communities prepare for change and whatever the future may hold. The aim is to empower communities to take active responsibility for their own and each other's wellbeing, safety and health in the face of climate change. Local nuances and complexities needs to be understood in terms of coincidence with fluvial flooding, storm surges, and extraction of groundwater. Community action will be set within social contexts and norms, be bound with the actions of others, and when coordinated can work together to accomplish collective objectives.

Example actions

- Clear communication materials on the findings and safety precautions of coastal inundation modelling **(PR) (PU)**
- Mentoring programs **(PR) (PU)**
- Innovative business resilience networks **(PR) (PU)**
- Community events and programs **(PR) (PU)**
- SLR communication strategies **(PR) (PU)**
- Guidebooks and toolkits **(PR) (PU)**
- Information packages (residents, businesses) **(PR) (PU)**
- Neighbourhood resilience projects **(PR) (PU)**
- Emergency preparedness training **(PR) (PU)**

Photos

Building Scale Adaptation

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Variable	Type	Scale	Cost	Co-benefits	Effort
	Protect / Adapt			-	

Description

Building scale protection against sea level rise and storm surge refers to a range of actions that can be implemented in buildings to increase their resilience. Primarily, this involves integrating considerations of sea level rise early in the building design phase, but can also include creating provisions in engineering standards and local planning controls. Measures could include: building entry and egress points (including board walks and finished landscaped levels at the foreshore) providing additional height to the finished ground plane level; basement waterproofing and tanking systems specifically designed to tolerate and operate in heavily saturated saline environments; basement structures and building façades utilizing high specification galvanising designed for marine grade exposure; treated coatings on glazing facades; systems designed with screens to prevent storm debris entering the system and complete isolation of basement plant from the sea water intrusion etc.

Example actions

- Review asset management plan to incorporate SLR**(B)(PR) (PU)**
- Identify and prioritise assets and asset components at risk to sea level rise and storm surge**(B)(PR) (PU)**
- Incorporate projected sea level rise into building/engineering standards **(PR) (PU)**
- Building design elements for facades, basements, access and egress points etc. **(PR) (PU)**

Photos


Off-shore Protection

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Variable	Type	Scale	Cost	Co-benefits	Effort
	Protect			-	

Description

Off-shore protection measure are often wave breaking structures built parallel to the shoreline that are used to reduce erosion and stimulate sedimentation, for example, coastal breakwaters are a modern and protective adaptation technology. The structures are often porous, which reduces the force of wave energy and traps sand within the coastal zone to reduce the extent of coastal erosion. These are often a pre-requisite for beach nourishment, land reclamation or coastal mangrove rehabilitation (where applicable). The length of the breakwater, the distance of the breakwater to the shoreline, the number of single breakwaters in a segmented breakwater, and the length of the gaps all determine the extent of sedimentation trapping. Though typically constructed of materials such as stone, concrete and geotextiles, they can also be created using local materials and structured in different forms. For example, T-fences can be used to connect existing headlands and recreate eroded floodplains.

Example actions

- Breakwater construction)**(PR) (PU)**
- Artificial reefs **(PR) (PU)**
- Floating barriers **(PR) (PU)**

Photos

On-shore Protection

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Variable	Type	Scale	Cost	Co-benefits	Effort
	Protect			-	

Description

Hard structures on-shore can be used for protecting land from coastal flooding, particularly during high tide and storm surges. In residential areas, or areas with limited space available, seawalls (or bulkheads, flood walls) are commonly applied solutions for coastal protection. Seawalls are passive, shore-based structures that protect against flooding and shoreline erosion. These protection measures are generally very solid constructions that are designed to withstand storm wave attack and high storm surge levels. Many different types of seawalls exist in practice, and these are mostly classified in four main types: vertical seawalls, curved seawalls, stepped seawalls, sloping revetments and mound seawalls (often referred to as rock armour or ripraps (rock rubble).

Hybrid solutions are a combination of a soft and hard solutions. Both have their own function and working principles. The soft solution, usually dunes, are used as a first line of protection and need to be wide and high enough for predicted storm surges. When the first line of defence is washed away due to erosion the secondary solution (hard) is needed. Depending on the kind of structure: seawall, dike and revetments, the structures need to be high and stable enough to handle storm surge and protect the low-lying area for flood. Responses and actions in Tables below relating to buffer and coastal zones and structures may only be appropriate in modified ways as the Urban Renewal Area in highly constrained for available land for such measures.

Example actions

- Construction/improvement of small scale dykes (also consider mounds and evacuation hills) (where possible) **(PR) (PU)**
- Improve coastal drainage systems **(PR) (PU)**
- Small scale constructed wetlands **(PR) (PU)**
- Improve pumps for backflow prevention **(PR) (PU)**
- Protect buffer vegetation in shore zones (where possible) **(PR) (PU)**
- Restoration and management of small scale coastal wetland areas/features) **(**where applicable) **(PR) (PU)**
- Coastal protection with built structures (Groynes, revetments, breakwaters, artificial reefs, seawalls) (where possible) **(PR) (PU)**
- Retreat from high-risk areas (including relocation of critical infrastructure)**(PR) (PU)**
- Investigate & install storm surge gates / flood barriers **(PR) (PU)**

Photos - Seawall with beach nourishment, hybrid solution

Saline Intrusion and Material Resistance

Scale	Cost (to implement)	Cost (avoided)	Effort	Existing Strategy	Co-benefits

Variable	Type	Scale	Cost	Co-benefits	Effort
	Protect / Adapt			-	

Description

Sea level rise and overexploitation of coastal aquifers increases the chance of saltwater intrusion in groundwater bodies, particularly in low-lying areas. In general, reduced precipitation, increased water needs and increased inundation especially sea water, all put groundwater resources at risk. The intrusion of saltwater also impacts the structural integrity of infrastructure and building materials. Salt water inundation and sea spray from surges and sea level rise may degrade structures, foundations and landscaping, causing property damage, health and safety issues and business interruption. The precinct, buildings and infrastructure, need to be designed to adapt to higher risk of saltwater intrusion, which often necessitates designing beyond current minimum compliance and current building standards. This can included basement waterproofing and tanking systems (utilising hydrophilic gaskets, sealants and membrane technologies) to reduce the amount of salt water which comes in contact with structures. Constructions can be specifically designed to tolerate and operate in heavily saturated saline environments. In addition cathodic protection can be provided within the basement envelopes, in particular, to safeguard against risks of steel corrosion within basement structures. Other measures include: building façades utilising high specification galvanising thicknesses, anodising and powder coating systems designed for marine grade environment exposure and glazing treatments for facades. Another way of mitigating this threat is by systematically maintaining higher groundwater water table levels, thus reducing the seawater hydrological gradient and preventing saltwater intrusion. Saltwater barriers, dams, pumping and extraction can all assist in managing saltwater intrusion.

Example actions

- Saltwater intrusion barriers**(PR) (PU)**
- Extraction of saline and brackish groundwater**(PR) (PU)**
- Modifying pumping practice through reduction of withdrawal rates or adequate relocation of extraction wells **(PR) (PU)**
- Small scale land reclamation and creating a foreshore (where possible) **(PR) (PU)**
- Increase of (artificial) recharge in upper catchment areas**(B) (PR) (PU)**
- Salt resilient building façades**(B) (PR) (PU)**
- Install low-head dam for saltwater wedge and freshwater pool separation **(PR) (PU)**
- Creation of physical barriers, such as sheet piles, clay trenches and injection of chemicals**(B) (PR) (PU)**
- Cathodic protection within the basement envelopes**(B) (PR) (PU)**
- Designing beyond current minimum compliance and current building standards**(B)(PR) (PU)**

Appendix D

Best practice adaptation case studies

Appendix D Best practice adaptation case studies

Contents:

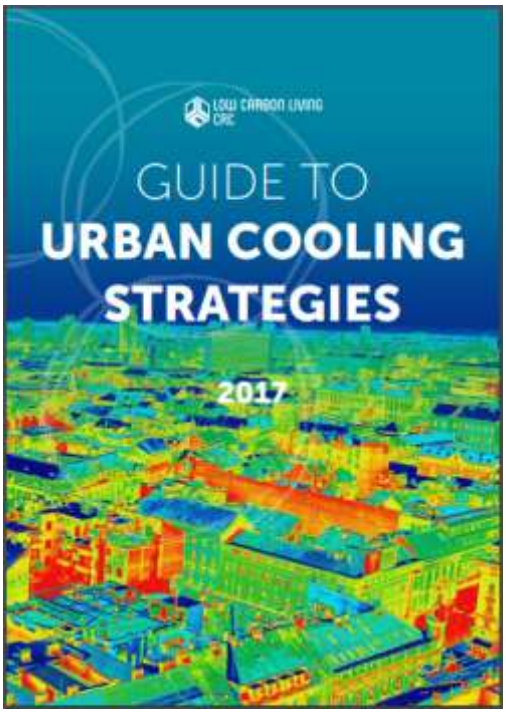
General adaptation planning

Project Name	Co-benefits/other sustainable initiatives
Resilient New Orleans	Consideration of social and economic benefits of urban water management projects.
Location	**Scale** (people, building/asset, precinct, suburb/LGA)
New Orleans, Louisiana	City wide plan
Adaptation Claim/Response	**Champion** (government, asset owner, community)
City-wide adaptation planning	City of New Orleans
Funding source (government, private, hybrid)	**Recipient of benefits** (users/occupants, asset owners)
Multiple sources – city and federal government and not-for-profit funding through 100 Resilient Cities Pioneered by the Rockefeller Foundation	City wide benefits, residents, businesses, users of open space.
Description of project	**Photo(s)**
Adaptation of New Orleans to rising sea levels and potential increased inundation. Specific to sea level rise, the plan includes leveraging critical resources for coastal projects. This would access financial resources from the federal government to improve the flood protection provided by coastal wetlands. This would be achieved through a combination of “structural” flood protection and “non-structural” approaches. Another key element of the plan is investing in innovative urban water management. Projects would be prioritised through a detailed analysis focused on hydrology, economy, and social equity. Additionally, a retrofit program would be developed to provide incentives for resident to upgrade their homes to enhance resilience to storms and flooding.	

Case study of adaptation responses for specific climate impacts

Extreme heat and heatwave

Project Name	Co-benefits/other sustainable initiatives
Chicago, IL Adapts to Improve Extreme Heat Preparedness	Using the identified urban heat island areas to target green infrastructure and heat island mitigation efforts.
Location	**Scale** (people, building/asset, precinct, suburb/LGA)
Chicago, IL Adapts to Improve Extreme Heat Preparedness	Focus on vulnerable neighbourhoods
Adaptation Claim/Response	**Champion** (government, asset owner, community)
A comprehensive set of actions to reduce deaths related to extreme heat events.	City of Chicago
Funding source (government, private, hybrid)	**Recipient of benefits** (users/occupants, asset owners)
Government	City residents, particularly vulnerable populations and those living in neighbourhoods impacted by extreme heat.
Description of project	**Photo(s)**
The focus of this project was on community preparedness, particularly identified vulnerable populations. Chicago developed a community outreach program that targeted neighbourhoods particularly vulnerable to extreme heat events. This was done through a partnership with the Field Museum, a leader in science education and engagement. The aim of the program was to educate residents on climate vulnerability in their neighbourhood and work with them to identify actions to reduce the impacts of heat events. This was informed by identifying urban heat island areas in Chicago which could be exacerbated by climate change (EPA 2017). Other key actions undertaken included expanding Chicago's text and email notification system, establishing 'cooling centres' and conducting well-being checks on vulnerable individuals.	

Project Name	Co-benefits/other sustainable initiatives
Guide to Urban Cooling Strategies (CRC for Low Carbon Living, 2017)	Thermally comfortable city environments promote outdoor activities, public life and health. Addressing urban heat island effects can mitigate the effects of: • Increased air pollution. • Increased demand for energy and water consumption. • Rates of mortality and health problems exacerbated by heat stress. In addition, many of the strategies can increase the amenity and liveability of the urban environment by increasing green space. Certain measures also assist with balancing the water cycle and managing stormwater.
Location	**Scale** (people, building/asset, precinct, suburb/LGA)
Australia	Building, Precinct, LGA.
Adaptation Claim/Response	**Champion** (government, asset owner, community)
Increased heat and hot spells (Cooling with urban greenery, Cooling with water, Planning measures and urban layout, Building-level cooling strategies, Shading, Behavioural approaches and community education)	Government and Asset Owners
Funding source (government, private, hybrid)	**Recipient of benefits** (users/occupants, asset owners)
Mixed/hybrid	All stakeholders and users within the LGA benefit from thermally comfortable environments.
Description of project	**Photo(s)**
The Guide to Urban Cooling Strategies (CRC for Low Carbon Living, 2017) provides practical guidance for built environment professionals and regulatory agencies seeking to optimise development projects to moderate urban microclimates and mitigate urban heat island effects in major urban centres across a range of climates in Australia. It details a range of urban heat mitigation strategies for streetscapes, plazas, squares, buildings and malls, which are categorised by Australian climate zones (including Melbourne) and for a range of urban typologies. Urban surface properties, vegetation cover, shading and orientation are key variables. Interventions cover both active (e.g. misting systems and operable awnings) and passive systems (street trees, green roofs/walls, water bodies, cool roofs and façades). The effectiveness of each technique varies according to the location, urban context (density, scale) and climate zone.	

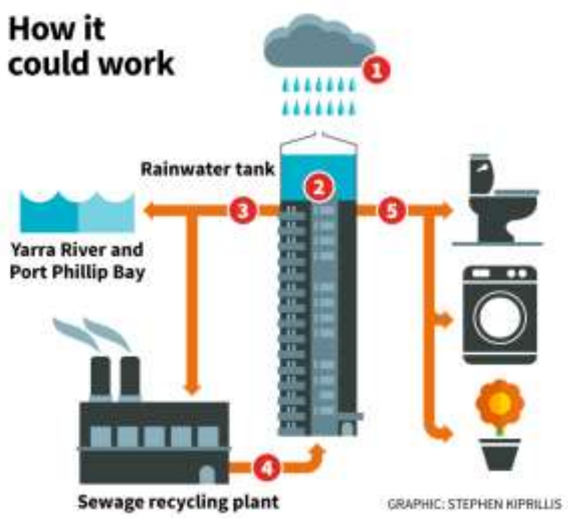
Drought and reduced rainfall

Project Name	Co-benefits/other sustainable initiatives
Open space water management plan – toward a water sensitive city	Complementary to urban greening and urban forest strategies
Location	**Scale** (people, building/asset, precinct, suburb/LGA)
City of Port Phillip	Parks and open spaces across CoPP
Adaptation Claim/Response	**Champion** (government, asset owner, community)
Review of water requirements and development of a framework and implementation plan for management of water in open spaces within the CoPP.	City of Port Philip
Funding source (government, private, hybrid)	**Recipient of benefits** (users/occupants, asset owners)
Government	State wide benefit from reducing potable water use. Users of these open spaces.
Description of project	**Photo(s)**
Development of a framework and implementation plan for management of water in open spaces within the City of Port Phillip. Key elements of this project included modelling water requirements of the city's open spaces, reviewing methods for increasing water efficiency, developing a hierarchy for future investment and developing a four year implementation plan. The project assessed optimal water requirements for different types of urban spaces based on vegetation and turf species, frequency and type of use and kind of open space. This was then used to make a desktop analysis for specific open spaces within CoPP. Recommendations include increased use of alternative water management options, drought turf management practices, community education and the use of passive and sub-surface irrigation services.	

Project Name	Co-benefits/other sustainable initiatives
South East Water Integrated Water Servicing Strategy for Fishermans Bend	Expected liveability outcomes include creating efficient wastewater systems, reducing reliance on drinking water supplies, reducing flooding and transforming urban amenity. Creation of a green, cool landscape (including urban forests, open spaces, street trees, green walls) which combats heat stress and is sustained through a drought proof supply.
Location	**Scale** (people, building/asset, precinct, suburb/LGA)
Fishermans Bend, Victoria	Building, Precinct.
Adaptation Claim/Response	**Champion** (government, asset owner, community)
Reduced mean precipitation / drought (Storage and retention)	State Government, local council, South East and Water.
Funding source (government, private, hybrid)	**Recipient of benefits** (users/occupants, asset owners)
The cost of the preferred option is higher than business as usual for the water utility and as such, collaborative financing options such as developer contributions or Federal and/or State funding are being explored.	Asset owners and the wider community
Description of project	**Photo(s)**

Fishermans Bend is recognised as an opportunity to showcase sustainable, leading-edge solutions to transition the area into a water sensitive city/precinct. Integrated water management is a central part of achieving these sustainability and liveability objectives. In conjunction with City of Melbourne, City of Port Philip, Department of Environment, Land, Water and Planning, Melbourne Water, Environment Protection Authority and Fishermans Bend Hub, South East Water has developed an Integrated Water Servicing Strategy for the redevelopment of Fishermans Bend. This includes:

- Use of recycled water supplied from a sewer mining plant for non-potable use.
- Stormwater storage to reduce flooding frequency.
- Distributed storage will be achieved through the widespread use of rainwater tanks.
- Water sensitive urban design principles have been embedded into precinct plans from an early stage to 'set-the-scene' for a water sensitive precinct.
- Latest technologies for digital metering, pressure sewer systems and intelligent networks to overcome some of the specific development challenges.



Extreme rainfall (flooding), hail and wind

Project Name	Co-benefits/other sustainable initiatives
Climate change Adaptation & Community Resilience Barangaroo South	Consideration of social and economic benefits of urban water management projects.
Location	**Scale** (people, building/asset, precinct, suburb/LGA)
Sydney, NSW Australia	City wide plan
Adaptation Claim/Response	**Champion** (government, asset owner, community)
Coincidence (SLR & Extreme precipitation)	City of New Orleans
Funding source (government, private, hybrid)	**Recipient of benefits** (users/occupants, asset owners)
Multiple sources – city and federal government and not-for-profit funding through 100 Resilient Cities Pioneered by the Rockefeller Foundation	City wide benefits, residents, businesses, users of open space.
Description of project	**Photo(s)**
Barangaroo South is amongst Australia's largest urban renewal projects and is a major new extension of the Sydney CBD. This 22-hectare site, $8 billion site, lies between Sydney's CBD and the harbour and is a mixed use precinct consisting of commercial office buildings, residential apartments, an international hotel, shops, cafes, restaurants and cultural facilities. Eighteen key climate risk scenarios were identified for Barangaroo South – extreme and high priority risk included: changing temperature, changing rainfall, sea level rise, severe weather and changing humidity. Adaptation measures for the precinct identified in the adaptation plan are: • Stormwater infrastructure upgrades • Improved stormwater management • Increasing the road height • Installation of new inlet pits to capture overland stormwater flow • Use of onsite stormwater infrastructure • Tailwater levels for all stormwater outlets • Basement and building entry and egress points provide additional height to the finished ground plane level including timber board walks and finished landscaped levels at the foreshore • Stormwater infrastructure designed to take into consideration future sea level rise risk • Basement waterproofing and tanking system • Cathodic protection within the basement envelope to safeguard against risks of steel corrosion within the basement structure • Electrical network within precinct (Triplex N+1) provides redundancy if part of the network is damaged, with onsite backup.	

Project Name	Co-benefits/other sustainable initiatives
Vicinity Centres Develops Flood Management Plan for Shopping Centres in Gympie	-
Location	**Scale** (people, building/asset, precinct, suburb/LGA)
Gympie, Queensland	Building/asset/precinct
Adaptation Claim/Response	**Champion** (government, asset owner, community)
A flood management plan that addresses the risk faced by the centres.	Vicinity Centres
Funding source (government, private, hybrid)	**Recipient of benefits** (users/occupants, asset owners)
Private	Shopping centre visitors and staff, Vicinity Centres
Description of project	**Photo(s)**
The Gympie region is prone to riverine flooding from the Mary River and also local runoff from Deep Creek. Both Gympie Central and Goldfields Plaza which are part of Vicinity Centres portfolio have been impacted from such flooding events. There had been multiple occasions in the past decade where water had entered the surrounding buildings. This presents a problem from an ongoing operation standpoint as not only does this limit access to the centres for customers but also staff and retailers. Sales have been impacted due to this. In order to minimise the risk in the future of such flooding events, Vicinity Centres have developed a Flood Management Plan to inform all stakeholders of appropriate procedures and potential actions to ensure the continued operation of the facilities.	

<table>
<tr><th>Project Name</th><th>Co-benefits/other sustainable initiatives</th></tr>
<tr><td>Copenhagen Cloudburst Management Plan 2012 & 2016</td><td>Multiple co benefits: improved quality of the urban domain, open spaces provision, improvement, active transport opportunities (walking & cycling), improved reliability of public transport, resilient critical infrastructure, community well-being and health, increased amenity, increased preparedness and emergency response etc. The Climate Change Adaptation and Investment Statement (2015) details the effect of each of the cloudburst solutions and who and how many will benefit from the solutions. The potential for export of skills in cloudburst planning and the water and other environment technologies has been a consideration.</td></tr>
<tr><th>Location</th><th>Scale (people, building/asset, precinct, suburb/LGA)</th></tr>
<tr><td>Copenhagen, Denmark</td><td>All scales</td></tr>
<tr><th>Adaptation Claim/Response</th><th>Champion (government, asset owner, community)</th></tr>
<tr><td>Multiple responses under extreme events - hail, wind and flooding:
Dry-proofing facilities
Wetproofing facilities
Precinct-scale protection
Planning measures and urban layout
Building design and infrastructure standards
Climate resilient critical infrastructure</td><td>Copenhagen City Council, leads the initiative with support from the Danish Government (Ministry for the Environment & the Secretariat for Water Supplies) and water utility companies (Greater Copenhagen Utility (HOFOR), Nordvand and Frederiksberg Forsyning).</td></tr>
<tr><th>Funding source (government, private, hybrid)</th><th>Recipient of benefits (users/occupants, asset owners)</th></tr>
<tr><td>Hybrid - City of Copenhagen, Greater Copenhagen Utility (HOFR) and private individuals</td><td>The Copenhagen property market, which comprises 300,000 homes and 355,000 jobs is protected. Businesses, landowners, citizens all benefit from the projects. Neighbouring municipalities also benefit e.g. Frederiksberg, Gentofte and Gladsaxe municipalities.</td></tr>
</table>

Description of project	Photo(s)

The City of Copenhagen is now investing heavily in protecting the City against extreme weather in the future. It has developed an overarching *Copenhagen Climate Adaptation Plan (2014).* The protection of the City will be the catalyst for creating a blue and green city with higher recreational values, more urban quality and increased biodiversity. The City of Copenhagen initiated a combined project with urban district renewal and flood protection management under the *Copenhagen Cloudburst Management Program*. The project designed and implemented cloudburst solutions in the four Northwest Districts in Copenhagen, including the streets Ørnevej, Vibevej and Glente plus the plaza around Nørrebro Station.

Essentially the solution is instead of sending the water from torrential downpours down into the sewers, a completely new infrastructure is to be established for storm water management. The alternative infrastructure combines cloudburst management solutions on the surface with cloudburst pipes below the ground, which retain the water and discharge it to lakes and the Copenhagen harbour.

General principles of the '*cloudburs*t' solutions are following:

- Handling of cloudburst water in a manner that causes the least possible damage;
- Blue/green surface solutions;
- Upgrading of the quality of the urban public space;
- Synergies with urban development;
- Flexibility to changes in the climate forecasts.

Sea level rise

Project Name	Co-benefits/other sustainable initiatives
Adapting to inundation in urbanised areas: supporting decision makers in a changing climate: Port Phillip Bay Coastal Adaptation Pathways Project.	The case studies provide cost estimates for adaptation pathways for each of the five sites assessed, which could be utilised by these councils for adaptation planning.
Location	**Scale** (people, building/asset, precinct, suburb/LGA)
Port Phillip Bay, Victoria	Tested at the local council level with small areas along Port Phillip Bay (between 66 ha and 274 ha)
Adaptation Claim/Response	**Champion** (government, asset owner, community)
A framework to the development of adaptation pathways for areas subject to coastal inundation.	Framework prepared for the Municipal Association of Victoria
Funding source (government, private, hybrid)	**Recipient of benefits** (users/occupants, asset owners)
Federal government	Local councils that seek to develop adaptation pathways don't have to develop tools from scratch to identify economically efficient adaptation options.
Description of project	**Photo(s)**
A framework for government bodies to develop economically efficient adaptation options to protect against changing inundation levels as a result of climate change. A key element of this project was the promotion of adaptation pathways, a flexible course of adaptation actions implemented over time. The adaptation pathways would be comprised of cost-effective groupings of options, which either would reduce the extent of inundation or cost associated with damages caused by inundation. The project tested the framework on five sites around Port Phillip Bay (Murray Anderson Catchment, Mordialloc Creek, Elwood Canal, Southbank and Arden Macaulay) in conjunction with local councils, comparing estimated costs of a number of adaptation pathways.	

Project Name	Co-benefits/other sustainable initiatives
East Side Coastal Resiliency Project (Dryline)	Provision of additional benefits to communities, such as public pavilions, bike shelters and seating is integral to the project.
Location	**Scale** (people, building/asset, precinct, suburb/LGA)
New York City, New York	The ribbon is proposed from Montgomery Street to East 23rd Street along the waterfront.
Adaptation Claim/Response	**Champion** (government, asset owner, community)
Development of infrastructure along 9km of Manhattan's waterfront to protect the city from storm surges.	The BIG (Bjarke Ingles Group), a collective of architecture firms based in New York and Copenhagen.
Funding source (government, private, hybrid)	**Recipient of benefits** (users/occupants, asset owners)
The project has been granted funding from the US Federal Government, and has more recently secured finding from the City of New York.	A primary focus of the project is protecting residents living on or near the waterfront, particularly some areas of affordable housing. Users of the waterfront will benefit due to creation of new community spaces.
Description of project	**Photo(s)**
The Dryline project (a section of the Big U) was developed to address the vulnerability of the Manhattan coast to storm surges and flooding. The project proposes a protective 'ribbon' of infrastructure along 9km of coast in Southern Manhattan, which would act as a high-water barrier, protecting the city from inundation. A key element of the project is ensuring the barrier provides multiple benefits to the community, based on particular needs identified in community consultation (LargargeHolcim Foundation 2017).	

Project Name	**Co-benefits/other sustainable initiatives**
Integrated approach to resilient urban design in Rotterdam City	Resilient design is predicated on the idea that cities need to find sustainable solutions to enhance water safety and supply, but also to add value in terms of spatial and ecological quality, social outcomes and economic potential. Liveability and economic viability should be vital aspects of any new program. In this regard, resilient solutions are designed with dual-benefit objectives in mind, including clean air, more green spaces, 'dry feet' (flood and inundation protection), cleaner energy at lower costs, and job creation in the city as well as in the port and industrial complex.
Location	**Scale** (people, building/asset, precinct, suburb/LGA)
Rotterdam, Netherlands	Precinct/City.
Adaptation Claim/Response	**Champion** (government, asset owner, community)
Sea level rise (On-shore protection, Offshore protection, Erosion control / shorefront strengthening)	A number of actors are involved with the various programs in Rotterdam, including NGO partnerships, industry groups, municipal authorities, utilities, design firms, start-ups and private-public consortia.
Funding source (government, private, hybrid)	**Recipient of benefits** (users/occupants, asset owners)
Many of the projects that have been undertaken in Rotterdam have been catalysed by Government or grant funding, though private-public partnerships are common.	The holistic nature of integrated design thinking means that benefits accrue to all stakeholders including the community, local residents and businesses.
Description of project	**Photo(s)**
While protected by levees, dams, embankments and water defences (including 787-foot-long floodgates that can swing open to protect the city against storm surge), high groundwater levels and increasingly extreme weather conditions mean Rotterdam is still vulnerable to flooding. In conjunction with an integrated and holistic approach to resilience and urban design, Rotterdam is investing in a suite of smart, innovative and sustainable solutions. The goal is to make the city climate-proof by the year 2025 through a variety of different measures, including: • Greening of embankments, walls and roofs • Water storage/detention capacity in water squares • Underground water storage/detention in parking garages • Water Sensitive Rotterdam: small scale water storage projects on street and building level are being implemented and will be scaled up.	 

- Tidal Parks: Development of a park in a river that is subject to the ebb and flow of the tide into a thriving green zone to enhance its natural value and ecological quality, as well as promoting and improving the region's recreational potential.
- Room for the River Program: creating additional space for rivers to discharge large volumes of water and simultaneously add more social economic value.
- Floating buildings: Including development of a floating pavilion as a pilot for floating constructions in the Rijnhaven harbour.
- Strengthening crisis management approaches: based on increased knowledge of flood risks.
- Coastal protection

Appendix E

Gap analysis

Appendix E Gap analysis

Variable	Adaptation Response	Action	Scale and Policies												Cost to implement	Cobenefits	Ease of implementation
			Building	Policy	Typology	Specificty	Precinct	Policy	Typology	Specificty	City	Policy	Typology	Specificty			
Reduced mean preciptations and drought	**Storage and Retention** Preserving and enhancing water resources	Adapt	Yes	Fishermans Bend: A water sensitive community (fact sheet) Planning scheme: 21.03 Ecologically Sustainable Development - City of Port Phillip 21.03-1: 1.1, 1.5, 1.6	Residential Buildings Commercial Buildings Industrial Buildings	Policy/Strategy/Requirement in place Action	Yes	Fishermans Bend: A water sensitive community (fact sheet) Planning scheme: 21.03 Ecologically Sustainable Development - City of Port Phillip 21.03-1: 1.4	All	Policy/Strategy/Requirement in place Action	No				Medium	All	Easy
	Contingency Planning and Changing Maintenance Routines Updating maintenance regimes to account for the effects of a changing climate	Adapt	Yes				Yes				Yes				Low	Benefits for urban greenery and ecosystems Increased water efficiency or reduced water use	Easy
	Water efficiency Reducing the demand for water resources	Adapt	Yes	Planning scheme: 21.03 Ecologically Sustainable Development - City of Port Phillip 21.03-1: 1.1, 1.5, 1.6 Planning scheme: 22.13 Environmentally Sustainable Development - City of Port Phillip	Residential Buildings Commercial Buildings Industrial Buildings	Policy/Strategy/Requiren	Yes	Planning scheme: 21.03 Ecologically Sustainable Development - City of Port Phillip 21.03-1: 1.4	All	Policy/Strategy/Requiren	Yes	Water for Victoria Action 5.3	All	In development	Low - Medium	Benefits for urban greenery and ecosystems Increased water efficiency or reduced water use	Easy
	Enhancement of Building and Structural Integrity Considering the implications for changing soil moisture and stability	Adapt	Yes				No				No				Low - High	Benefits for urban greenery and ecosystems	Medium
	Treatment and Alternate Sources Identification of additional water supply sources	Adapt	Yes	Fishermans Bend: A water sensitive community (fact sheet Planning scheme: 22.12 Stormwater management (WSUD) - City of Port Phillip: 22.12-2, 22.13-3, 22.12-4 Planning scheme: 22.13 Environmentally Sustainable Development - City of Port Phillip	Residential Buildings Commercial Buildings Industrial Buildings Utility Infrastructure	Policy/Strategy/Requirement in place Action	No				No				Medium - High	Benefits for urban greenery and ecosystems	Medium
Increased mean temperature and heatwaves	**Cooling with Urban Greenery** Utilising vegetation to provide shade and cooling through evapotranspiratoin	Adapt	Yes	Fishermans Bend Precinct Plan 2015-2025 City of Melbourne Urban Forest Strategy 2012-2023	Residential Buildings Commercial Buildings Industrial Buildings	Action	Yes	Fishermans Bend Precinct Plan 2015-2025	Residential Buildings Commercial Buildings Industrial Buildings Community Infrastructure	Action	Yes	Resilient Melbourne Metropolitan Urban Forest Strategy	All	In development	Low	All	Easy
	Shading Provision of increased structural shading for public spaces	Adapt	No				Yes				Yes				Low	Increased energy efficiency or reduced energy use Benefits for urban greenery and ecosystems Decreased intensity of carbon emissions	Easy
	Cooling with Water Utilising blue solutions for urban cooling	Adapt	Yes				Yes	Fishermans Bend Vision 2016 (Fishermans Bend Taskforce)	Public Realm Infrastructu	Policy/Strategy/Requiren	No				Low - Medium	Increased energy efficiency or reduced energy use Benefits for urban greenery and ecosystems Decreased intensity of carbon emissions	Easy
	Planning Measures and Urban Layout Implementing controls at the planning stage to enable uptake of climate resilient practice, and avoid maladaption	Protect/Adapt	No				Yes	Planning scheme: 22.12 Stormwater management (WSUD) - City of Port Phillip: 22.12-2, 22.13-3, 22.12-4 Fishermans Bend Strategic Framework 2016 Objecitve 7.1, Standards 4.	All	Policy/Strategy/Requiren	Yes	Plan Melbourne	All	Policy/Strategy/Requirement in place In development	Medium	All	Medium
	Building-level Cooling Strategies	Adapt	Yes	Planning scheme: 22.13 Environmentally Sustainable Development - City of Port Phillip Apartment Design Guidelines for Victoria	Residential Buildings Commercial Buildings Industrial Buildings	Policy/Strategy/Requirement in place	No				No				Medium	Increased energy efficiency or reduced energy use Benefits for urban greenery and ecosystems Decreased intensity of carbon emissions	Easy
	Behavioural Approaches and Community Education Building community resilience to heatwaves	Adapt	Yes	City of Port Phillip - Bein	n/a	Policy/Strategy/Requirement in place	Yes	City of Port Phillip - Bein	n/a	Policy/Strategy/Requirement in place	Yes				Low - Medium	n/a	Easy
	Resilient Critical Infrastructure Ensure the reliability and functionality of critical systems in times of extreme heat events	Protect	Yes				Yes				Yes	EMV Critical Infrastructure Resilience Strategy	All	Policy/Strategy/Requiren	Low - High	Increased energy efficiency or reduced energy use Increased water efficiency or reduced water use Decreased intensity of carbon emissions	Medium

Extreme events (flooding)	**Building-scale Protection** Structural measures to allow passage of flood waters without causing major structural damage, or preventing flood waters from entering facilities in the first place	Protect	No				Yes				No				Low - High	Benefits for urban greenery and ecosystems	Medium
	Precinct-scale Protection Wide scale engineering for the protection of precincts	Protect/Adapt	No				Yes	Planning scheme: 13 Environmental Risks - City of Melbourne Municipal integrated water management plan 2017 - City of Melbourne	All	Policy/Strategy/Requirement in place	Yes	Planning scheme: 13 Environmental Risks - City of Melbourne	All	Policy/Strategy/Requiren	Low - High	Benefits for urban greenery and ecosystems	Medium
	Catchment-scale Protection Upstream and systemic management of water in extreme events	Protect	n/a				n/a				n/a	Catchment Management Authority Regonal Floodplain Management Strategies Victorian Floodplain Management Strategy	All	Policy/Strategy/Requiren	Low - High	Benefits for urban greenery and ecosystems	Medium
	Temporary protection Temporary (and often mobile) solutions which can be built up and used when needed	Protect	Yes				Yes				No				Low - Medium	Benefits for urban greenery and ecosystems	Easy
	Storage and Retention Moderating flows, and preserving and enhancing water resources	Adapt	Yes	Planning scheme: 22.13 Environmentally Sustainable Development - City of Port Phillip	Residential Buildings Commercial Buildings Industrial Buildings	Policy/Strategy/Requirement in place	Yes	Fishermans Bend Strategic Framework Obj 7.2 std 1, 2, 3.	Residential Buildings Commercial Buildings Industrial Buildings	Policy/Strategy/Requirement in place	No				Medium	All	Medium
	Planning Measures and Urban Layout Taking a master-planned approach to increasing resilience to extreme storms	Protect/Adapt	No				Yes	Planning scheme: 13 Environmental Risks - City of Melbourne Fishermans Bend Strategic Framework Obj 7.1 std 1, 4 Municipal integrated water management plan 2017 - City of Melbourne	All	Policy/Strategy/Requirement in place	Yes	Planning scheme: 13 Environmental Risks - City of Melbourne Planning for Sea Level Rise Guidelines (Port Phillip and Westerport Region) 2017 - Melbourne Water Victorian Coastal Strategy 2014	All	Policy/Strategy/Requiren	Medium	All	Medium
	Building Design and Infrastructure Standards Updating design and construction codes and standards to be in suitable alignment with needs under future climate conditions	Protect/Adapt	Yes	City of Port Phillip Climate Adaptation Plan	Residential Buildings Commercial Buildings	In Development	Yes	Fishermans Bend Strategic Framework Obj 7.1 std 1, 4	All	Policy/Strategy/Requirement in place	No				Medium	All	Medium
	Resilient Critical Infrastructure Ensure the reliability and functionality of critical systems in times of flooding and extreme storm	Protect	n/a				n/a	Fishermans Bend Road Raising Investigation (GHD)	Public Realm Infrastructure	In Development	n/a	EMV Critical Infrastructure Resilience Strategy	All	Policy/Strategy/Requiren	Medium - High	Increased energy efficiency or reduced energy use Increased water efficiency or reduced water use Decreased intensity of carbon emissions	Medium
	Changing Maintenance/Operational Routines Ensuring all systems and infrastructure are structurally sound and ready for extreme events	Adapt	Yes	City of Melbourne Total Watermark - City as a Catchment update 2014	All	Policy/Strategy/Requiren	Yes	City of Melbourne Total Watermark - City as a Catchment update 2014	All	Policy/Strategy/Requiren	Yes	City of Melbourne Total Watermark - City as a Catchment update 2014	All	Policy/Strategy/Requiren	Low - Medium	Increased energy efficiency or reduced energy use Increased water efficiency or reduced water use Decreased intensity of carbon emissions	Easy
	Emergency Management Protocols Better prepare emergency response procedures to account for increased frequency of extreme events	Adapt	Yes	City of Melbourne Flood Emergency Plan	Residential Buildings Commercial Buildings Industrial Buildings	Policy/Strategy/Requirement in place	Yes	City of Port Phillip Climate Adaptation Plan Port Phillip City Council Municipal Emergency Management Plan City of Melbourne Flood Emergency Plan	All	Framework	Yes				Medium	n/a	Medium
	Ecosystem-based Adaption	Protect	Yes				Yes				No				Low - High	n/a	Medium
Extreme events (wind and hail)	**Strengthen Infrastructure** Ensuring the reliability and functionality of critical systems in times of extreme heat events	Protect	Yes				Yes				Yes				Low - High	Increased energy efficiency or reduced energy use Increased water efficiency or reduced water use Decreased intensity of carbon emissions	Medium
	Changing Maintenance/Operational Routines	Protect	Yes	Fishermans Bend Strategic Framework Obj 4.1 Std 1, Obj 5.2 Stds 3, 4, 5, Obj 5.3 Std 1	Public Realm Infrastructu	Policy/Strategy/Requiren	Yes	Fishermans Bend Strategic Framework Obj 4.1 Std 1, Obj 5.2 Stds 3, 4, 5, Obj 5.3 Std 1	Public Realm Infrastructu	Policy/Strategy/Requiren	Yes				Low - High	Increased energy efficiency or reduced energy use Increased water efficiency or reduced water use Decreased intensity of carbon emissions	Medium
	Emergency Management Protocols	Protect	Yes				Yes	City of Port Phillip Climate Adaptation Plan Port Phillip City Council Municipal Emergency Management Plan	All	Policy/Strategy/Requiren	Yes				Low - High	Increased energy efficiency or reduced energy use Increased water efficiency or reduced water use Decreased intensity of carbon emissions	Medium
Sea Level Rise	**On-shore Protection** Both hard and soft engineering approaches to coastal defence	Protect	Yes				Yes				Yes				Medium - High	n/a	Medium
	Off-shore Protection Coastal management techniques and structures to protect land from weather and longshore drift	Protect	No				Yes				Yes				Medium - High	n/a	Medium
	Saline Intrusion and Material Resistance	Protect/Adapt	Yes				Yes				Yes				Medium	n/a	Medium
	Planning Measures and Urban Layout	Protect/Adapt	Yes				Yes	Planning scheme: 13 Environmental Risks - City of Melbourne Planning for Sea Level Rise Guidelines (Port Phillip and Westerport Region) 2017 - Melbourne Water Victorian Coastal Strategy 2014	All	Policy/Strategy/Requiren	Yes	Planning scheme: 13 Environmental Risks - City of Melbourne Planning for Sea Level Rise Guidelines (Port Phillip and Westerport Region) 2017 - Melbourne Water Victorian Coastal Strategy 2014	All	Policy/Strategy/Requiren	Medium	n/a	Medium
	Education and Awareness	Protect/Adapt	Yes				Yes				Yes				Medium	n/a	Medium
	Building Scale Adaptation	Protect/Adapt	Yes				Yes				Yes				Medium	n/a	Medium

Appendix F

Green Star Applications

ADAPTATION AND RESILIENCE

CREDIT 04

PROJECT NAME: FISHERMAN'S BEND REDEVELOPMENT

PROJECT NUMBER: GS-

TOTAL POINTS AVAILABLE: 4 POINTS CLAIMED: 4

No.	Criterion Name	Criterion Description	Points Claimed
4.1	Climate Adaptation	**2 points** are awarded where a project-specific Climate Adaptation Plan (CAP) has been developed.	2
4.2	Community Resilience	**2 points** are awarded where, prior to the occupation of any habitable building on the project site, a project-specific Community Resilience Plan (CRP) has been developed that addresses preparation, during- and post-disaster communication, safety and response.	2

PROJECT SPECIFIC QUERIES (TCS AND CIRS)

There are no project specific queries for this credit.	☑
There are project specific queries for this credit and all responses received from the GBCA are attached.	☐

4.1 CLIMATE ADAPTATION

Describe how the project-specific Climate Adaptation Plan (CAP) meets the compliance requirements for each of the items below.

4.1.1 The CAP must be developed in accordance with a recognised standard by a suitably qualified professional.

Provide the name and contact details of the Suitably Qualified Professional with a formal tertiary environmental science or planning qualification:

Liz Johnstone - Liz.Johnstone@aecom.com (refer to attached CV)

Stella Whitaker - SWhittaker@ramboll.com (refer to attached CV)

The Climate Adaptation Plan has been developed using one of the following recognised standards:

ISO 31000:2009 and the Australian Greenhouse Office (AGO) *Climate Change Risks and Impacts: A Guide for Government and Business* 2006.	☑
Australian Standard AS 5334:2013 *Climate change adaptation for settlements and infrastructure - A risk based approach*.	☐

4.1.2 The CAP must and contain at least the following information:

Requirement	Project's Climate Readiness Strategy (refer to section of the document - page no. paragraph no.)
a. Summary of the project site's characteristics.	*Section 2.0 page 5 - 6*
b. A list of identified assets or asset classes.	*Section 4.0 page 9*
c. Assessment of climate change impacts on the project site using at least two time scales.	*Section 5.1, 5.2 page 14 - 19*
d. Identification of the potential risks (likelihood and consequence) for each identified asset or asset class and the potential risks to people.	*Section 5.3 page 20 - 21*
e. A list of actions and responsibilities for all high and extreme risks identified.	*Section 6.0 page 22 - 37*
f. Details of stakeholder consultation undertaken during plan preparation and how these issues have been incorporated.	*N/A*

4.1.3 The risk identification has considered the resilience of key project assets and key infrastructure.	☑
4.1.4 The CAP includes a timetable for regular review and requires updates where necessary. As a minimum the plan will be reviewed whenever the base information required to develop the relevant climate change scenarios is updated.	☑
4.1.5 The climate change scenarios used were sourced from the Intergovernmental Panel on Climate Change (IPCC) endorsed Global Circulation Models (GCMs) and may include Commonwealth Scientific and Industrial Research Organisation (CSIRO), State or Federal climate projections or more detailed climate modelling software.	☑

Provide details of, and justify the use of ,the climate change scenarios used by the project for the Climate Adaptation Plan:

The site is a major urban renewal site. RCP*.5, a high emissions scenario was used for longer term projections

4.1.6 The assessment of climate change impacts addresses a minimum of two appropriate time scales (e.g. 2030, 2040, 2050 and 2070) for the primary and secondary effects listed in Table 4.1.5.	☑

Which two timescales were used in the Climate Adaptation Report?

2030	☑	2040	☐	2050	☐	2070	☑

The following **primary effects** are addressed in the Climate Adaptation Plan for the two selected timescales:

Compliance Requirement	Project's Climate Readiness Strategy (refer to section of the document – page no.)
Air temperature	*Section 5.2*
Solar radiation	*Section 5.2*
Precipitation	*Section 5.2*
Sea surface temperature	*Section 5.2*
Humidity	*Section 5.2*
Wind	*Section 5.2*

The following **secondary effects** are addressed in the Climate Adaptation Plan for the two selected timescales:

Compliance Requirement	Project's Climate Readiness Strategy (refer to section of the document – page no.)
Relative humidity	*Section 5.2*
Bushfire weather	*Section 5.2*
Sea level rise	*Section 5.2*
Coastal inundation	*Section 5.2*
Cyclones	*Section 5.2*
Flood	*Section 5.2*
Heatwave	*Section 5.2*
Drought	*Section 5.2*

4.1.7 Implementation of the Climate Adaptation Plan.

A minimum of two risk items identified in the risk assessment component of the Climate Adaptation Plan have been addressed by specific design responses.	☐
All risk items identified as 'high' or 'extreme' have been addressed by specific design responses.	☐

Please provide details of the risk items the design responses identified and implemented. (All 'high' or 'extreme' risk items identified must be addressed).

Design responses have not been implemented at this stage of the development. Recommendations for next steps are included in section 7.

Identify where this information can be found within the supporting documentation provided.

Supporting Documentation (Name / title / description of document)	**Reference** (Page no. or section)
Climate Readiness Strategy	Section 5 and 7

DISCUSSION

Outline any issues you would like to highlight and clarify with the Assessment Panel.

The Climate Readiness Strategy provides a framework for further action for the Fisherman's Bend Redevelopment stakeholders to ensure that the development takes the necessary action to minimize the impact of climate change and build a resilient community.

4.2 COMMUNITY RESILIENCE PLAN

Credit Criteria Trigger

No habitable building have been occupied	☐	Got to A
Habitable buildings are occupied	☑	Got to B

A:

The project applicant has committed to the development a Community Resilience Plan prior to the occupation of any habitable building in the project site.	☐

B:

Describe how project-specific Community Resilience Plan (CRP) meets the compliance requirements for each of the items below.

4.1.1 The CRP must be developed by a suitably qualified professional.

Provide the name and contact details of the Suitably Qualified Professional with a formal tertiary environmental science or planning qualification:

4.2.2 The CRP was developed prior to the occupation of any habitable building on the project site.	☑
4.2.3 The CRP addresses the preparation, during- and post-disaster communication, safety and response.	☑

4.2.4 The Community Resilience Plan (CRP) contains the following information:

Compliance Requirement	**Project's Supporting Documents (refer to section of the document – page no.)**
a. Potential (project-specific) risks to the community from extreme events;	Climate Readiness Strategy Section 5.3, page 14 - 16
b. Key community contacts (e.g. local police, senior members of community groups, schools and other community-based leaders);	City of Melbourne Municipal Emergency Management Plan (website) City of Port Phillip Emergency Management Plan
c. Emergency contacts (e.g. emergency Services, local authorities, utility providers, insurance, counselling etc.);	City of Melbourne CBD Safety Plan (page 3) City of Port Phillip Emergency Management Plan
d. Nominated emergency shelter location(s) for the community such as a shopping centre or school hall;	City of Melbourne CBD Safety Plan (section 3, page 13 & 14) City of Port Phillip Emergency Management Plan (Sub Plan 4)
e. Information on how to develop an emergency plan and emergency kit for all visitors to and occupants of the project;	City of Melbourne's 'How Prepared are you for an emergency?' (pages 5 – 9)
f. Comprehensive list of communication channels to enable the community to stay informed (e.g. radio, social media);	City of Melbourne CBD Safety Plan (section 3, page 13) City of Port Phillip Emergency Management Plan (Appendices)
g. Guidelines for disaster prevention at a local level, procedures to follow in the event of an emergency and what to do after an emergency; and	City of Melbourne CBD Safety Plan (section 2 - 4, page 11 - 17) City of Port Phillip Emergency Management Plan (part 4 and 5, pages 39 - 45)
h. Checklists to support the implementation of the CRP information.	Resilience of assets and communities – Implementation checklist

4.2.5 The CRP is aligned with the local disaster management plan(s) prepared by the relevant District, Local Council or State and Territory authorities.	☑

Provide details of any local disaster management plans the Community Resilience Plan is aligned with:

In the current stage of the development, specific information relating to the emergency management of the site is unavailable. Therefore, the City of Melbourne and City of Port Phillip Emergency Management Plans along with the corresponding sub-plans were used to demonstrate compliance with 4.2.4. This approach is acceptable as per the Guidance section of the credit in the submission manual.

4.2.6 The CRP has been and is made available to each dwelling, site or lot owner and tenant within the project.	☐

Identify where this information can be found within the supporting documentation provided.

Supporting Documentation (Name / title / description of document)	**Reference** (Page no. or section)
1. Melbourne CBD Safety Plan (version 4)	Sections 2, 3 ,4
2. City of Melbourne – Municipal Emergency Management Plan	Website
3. City of Melbourne – How Prepared Are You in An Emergency	Pages 5 - 9
4. Port Phillip City Council Municipal Emergency Management Plan (MEMP)	Parts 4 and 5
5. Resilience of assets and communities – Implementation checklist	All

DISCUSSION

Outline any issues you would like to highlight and clarify with the Assessment Panel.

DECLARATION

I confirm that the information provided in this document is truthful and accurate at the time of completion.

Provide author details, including name, position and email address:

27/09/2017

REVISIONS AND AMENDMENTS

Revision No.	Date Released	Description
r1	13/08/2015	Initial Release
r1.1	09/2016	Release for v1.1

—— **Report end** ——