# BAY
# BLUEPRINT
# 2070

ABM

ASSOCIATION OF BAYSIDE MUNICIPALITIES

# ACKNOWLEDGEMENTS

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Michael Nolan, Joana Correia, Elizabeth Ryan, Benjamin McMenamin, Paul Lewis and Paty Galan (UN Global Compact – Cities Programme); Helen Scott, Dr. Karyn Bosomworth, Dr. Alberto Posso, Prof. Darryn McEvoy, Alexei Trundle, Dr. Judy Rogers, Karolina Bartkowicz, Dr. Ifte Ahmed (RMIT University); Dr. Mahesh Prakash, Fletcher Woolard (CSIRO); Lalitha Ramachandran (EcoSens).

**2070 adaptation visualisations prepared by Masters of Landscape Architecture and Urban Planning students (RMIT University):**

Harry Angley, Amber Bell, Yinjie Chen, Stephanie D'Costa, Meghan Doherty, Robert Egerton, Zhimo He, Andrea Hesketh, Karen Lin, Liam Mullen, Brayden Murrihy, Ilias Paraskevakis, Devindya Prasadhi Perera, Dian Sheng, Jack Small, Weichu Zeng.

**Editor:** EKB Consulting

**Graphic Design:** Green Scribble

**Project Management:** City of Port Phillip

**Project Control Group:** Renae Walton, Caroline Chandler, Nick Alsop (City of Port Phillip), Marc Cassanet, Heather McClaren, Fiona Stevenson, Tessa O'Brien (City of Wyndham), Simon Finlay (City of Bayside), Bernie Cotter (Project Manager), Victoria Butcher and Annette Hatten (DELWP), Jacquie White (ABM, Executive Officer).

Victorian Adaptation and Sustainability Partnership Program

Image 1

# CONTENTS

# FOREWORD

The Bay Blueprint 2070 is the culmination of many years' effort and investment by the Association of Bayside Municipalities (ABM) in advocating for greater knowledge, awareness and action on climate change.

The ABM represents the interests of the ten councils with coastal frontage to Port Phillip Bay. Established in 1974, the ABM has forged a strong reputation as the voice of local government for Port Phillip Bay, and plays a pivotal role in ensuring this unique and precious natural ecosystem is protected and its economic viability maintained. This includes upholding the community's vision and values for the Bay environment, particularly around safety, the maintenance of clean beaches, ensuring appropriate water quality and protecting native terrestrial and marine life.

Understanding the potential impacts of climate change on our coast is critical if we are to sustainably safeguard the Bay for the future. The ten councils of the ABM have a long history of working together. We will continue to strengthen our collaboration with Bay stakeholders, while also building partnerships nationally and internationally to ensure we have access to leading edge knowledge and resources for climate change adaptation. The Bay Blueprint 2070 was funded through the Department of Environment, Land, Water and Planning's Victorian Adaptation and Sustainability Partnership program.

The ABM looks forward to strengthening this partnership with State Government, working together to achieve a whole-of-bay approach to coastal climate adaptation in Port Phillip Bay.

Thank you to the UN Global Compact Cities Programme, RMIT University, CSIRO and EcoSens for working with us to develop the Bay Blueprint 2070. We also thank the RMIT Masters of Landscape Architecture and Urban Planning students who created the visualisations and challenged our thinking as to what a future Port Phillip Bay might look like.

On behalf of the ABM, thank you to the council staff who have invested significant time and expertise in developing and project managing the Bay Blueprint 2070. I encourage you all to actively participate in the development and delivery of stage 3 of the Bay Blueprint 2070, as we embed the knowledge and resources to support climate change adaptation around the Bay.

**Cr. Steve Toms,**
**ABM President**

**Cr. Bev Colomb,**
**Immediate Past President**

*Image 2*

*Image 3*

# INTRODUCTION

**The Association of Bayside Municipalities (ABM), with funding support from the Victorian State Government has developed the *Bay Blueprint 2070* - a guide to exploring regional coastal adaptation opportunities for Port Phillip Bay in response to climate change.**

Port Phillip Bay is of significant social, economic and environmental value to Victoria. The coastal and marine environments support recreational and commercial activities. Its rocky reefs, sandy shorelines, foreshore reserves and rugged cliffs provide habitat and amenity, as well as protection for private and public coastal assets. The beauty and magnificence of the 140+ beaches that encompass Port Phillip Bay attracts 6.9 million day visitors and 3.1 million overnight visitors each year (Draft Port Phillip Bay Environmental Management Plan, 2016).

Research has demonstrated a strong and important link between the quality of the coastal environment and the quality of life for many Victorians (Victorian Coastal Strategy, 2014).

The recreational activity of tourists and locals results in approximately $320 million annual revenue for the Port Phillip Bay region (Draft Port Phillip Bay Environmental Management Plan, 2016). The Association of Bayside Municipalities (ABM), in partnership with other Bay stakeholders, is focused on ensuring these values and assets are protected and sustainably managed for future generations.

The impacts of climate change are likely to reshape the Bay as we know it. Increased wave action, storm surges and sea level rise will alter sand movements and increase erosion rates. Combined with population pressures, catchment degradation and ageing infrastructure the impacts on our coastline will escalate in coming years. Additionally, unprecedented population growth will place further pressure on Port Phillip Bay as it becomes a recreational beacon for not only coastal communities but the broader Victorian population.

## The Bay Blueprint 2070 aims to provide coastal land managers and decision makers with:

- a shared understanding of the impacts of climate change on Port Phillip Bay
- a framework to guide local and regional adaptation coastal climate planning, decision-making, investment and implementation towards 2070
- a suite of adaptation approaches tailored to common coastal typologies found around Port Phillip Bay
- resources to inform local and regional climate change adaptation approaches

## Why 2070?

A 2070 timeframe was important in developing the Bay Blueprint. Envisioning a 2070 future allowed the project team and stakeholders to imagine the Bay well beyond the influences of current political and business operating cycles. The ABM engaged RMIT University Masters of Landscape Architecture students to work on ten nominated sites around the Bay, exploring different 2070 climate adaptation scenarios.

These visualisations create a powerful catalyst for conversation (see Section 2).

The Bay Blueprint 2070 aims to facilitate action on climate adaptation for all Bay stakeholders.

The visualisations are intended to be thought provoking, providing inspiration for what adaptation solutions around Port Phillip Bay could look like.

The Bay Blueprint 2070 is part of the *Regional Coastal Adaptation Framework for Port Phillip Bay* – a three-stage project funded by the Victorian State Government.

- Stage 1: Bay Blueprint Framework Report (published 2015 www.abm.org.au)
- Stage 2: Bay Blueprint 2070 (this document)
- Stage 3: Bay Blueprint 2070 training and capacity building program (commencing 2017)

The Framework Report (stage 1) provides a synthesis of knowledge, research, programs and stakeholder engagement – identifying key challenges to climate adaptation and resilience. The report identified significant knowledge and data gaps, particularly relating to understanding future coastal and catchment pressures and vulnerabilities.

The Framework Report also identified that with worsening physical and climatic impacts, the current localised and inconsistent approach to Bay management will not be viable into the future. It proposed a whole-of-bay management approach to improve local level decision making and prioritisation of actions.


Image 4

# SECTION 1
# COASTAL CLIMATE ADAPTATION

## In 2070 Port Phillip Bay will face increasing pressure from many sources. Climate change will escalate natural processes such as wave action, sand migration and erosion. Increasing population and urbanisation will accelerate degradation of natural and infrastructure assets.

### Coastal processes and hazards

The coastline of Port Phillip Bay is naturally dynamic – constantly changing and evolving in response to coastal processes such as waves, tides and wind. Rising sea levels and more frequent storm events have the potential to turn these coastal processes into significant coastal hazards, impacting the Bay ecosystem along with vast areas of public and private land along the coast.

### Coastal governance

Governance of Port Phillip Bay is complex and challenging. Management responsibilities are currently shared across 64 coastal land managers (Map 1). Overlapping governance arrangements, the complexity of roles and responsibilities and varying organisational capacity and capability hinders regional, integrated and adaptive responses to climate change.

**Map 1: Indicative map of foreshore managers in Port Phillip Bay**


- Parks Victoria
- Committee of Management
- Local Council
- Department of Environment, Land, Water & Planning
- Port Authorities or local port manager
- Commonwealth
- Crown lease
- Private / Freehold
- Water corporations
- Phillip Island Nature Parks
- Other

*Source: adapted from Central Coastal Board, Central Regional Coastal Plan 2015-2020.*

**Figure 1: Coastal Squeeze**

The phenomenon of 'coastal squeeze' affects the Bay through a combination of climate and non-climate pressures (Pontee 2013). This 'squeeze' is caused by an increase in demand (population growth and development) for coastal resources, which are rapidly diminishing through land use changes and coastal erosion.

Changes in climate, sea level rise and storm surges contribute to coastal erosion and accelerate the degradation of coastal assets and values. Ocean acidification and salt water intrusion will impact the water quality, marine ecosystems and recreational value of our beaches, estuaries and waterways.

The compounding effect of coastal squeeze decreases the availability, amenity and usability of the coastline. A greater understanding, and effective management of these issues is critical in managing climate adaptation risks into the future.

# INTRODUCING ADAPTATION PATHWAYS

'Adaptation pathways' is an emerging decision-oriented approach to planning for uncertainty in the face of climate change. It focuses more on the decision-making process rather than the outcome by exploring the robustness of current and possible future actions using different scenarios.

The concept of adaptation pathways combines the importance of both decision timing and decision context, and frames adaptation as evolving over time. Instead of seeing pathways as only a sequence of decisions, the pathways concept helps consider adaptation in terms of the evolution of systems, values, rules, and knowledge (Wise et al 2014).

It also implies an iterative and ongoing approach, informed by a strategic vision which enables experimentation and learning so that choices along pathways can be altered (Rosenzweig & Solecki 2013).

This helps broaden the perspective away from problems and helps in understanding the importance of uncertainty and learning as integral parts of the adaptation process (Wise et al 2014).

Pathway thinking considers the implications of pathway dependencies and situations where the values and interests of institutions constrain responses to change (Wise et al 2014).

Considering adaptation pathways in this context empowers decision makers to integrate incremental actions based around societal needs, creating a multitude of adaptation options. Integral to the adaptation pathways approach is recognising that planning for 'one possible' future is not adequate, multiple futures need to be identified and analysed.

Adaptation pathways was selected as the preferred methodology for developing the Bay Blueprint 2070. Whilst the application of adaptation pathways is complicated, it is a popular approach to climate change adaptation (Wise et al 2014). It is regarded as the most responsive approach, that takes into consideration the political context in which we operate.

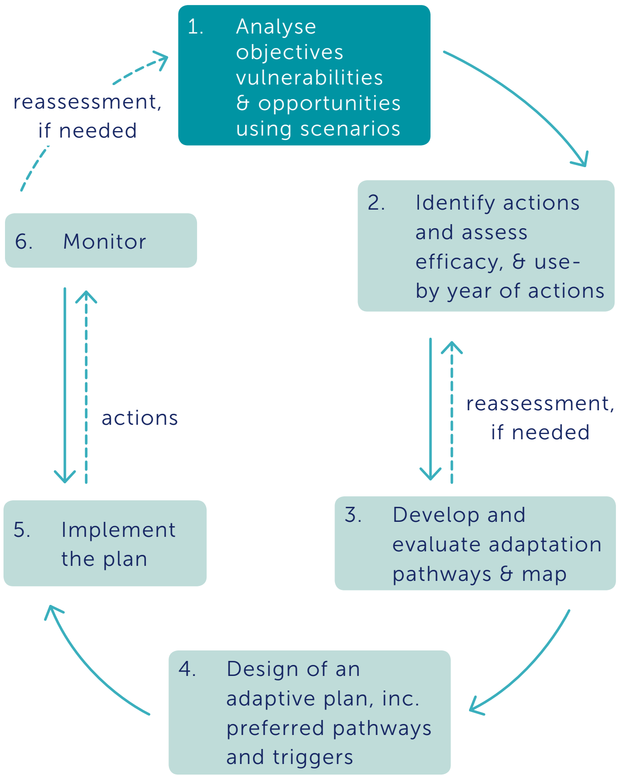
Whilst much of the background information required to undertake adaptation pathways planning for Port Phillip Bay exists, time and funding limitations meant this process could not be fully implemented as part of the Bay Blueprint 2070 stage 2.

Bay Blueprint 2070 has focused on 'step 1' (Figure 2), and "analysed objectives, vulnerabilities and opportunities using scenarios".

Stage 3 of the Bay Blueprint 2070 will focus on engaging Port Philip Bay stakeholders in the adaptation pathways process - undertaking analysis and planning tailored to local challenges and opportunities.

**Figure 2. Adaptation Pathways Approach**

*Adopted from Hassnoot et al 2013*



# ADAPTATION PLANNING

There are three important considerations in adaptation planning:

1. Risk assessment
2. Decision timing
3. Decision context

## 1. Risk Assessment

A climate risk assessment is an important first step in adaptation planning – assessing assets and operations before looking at how to manage them through adaptive responses. Climate risk assessments must take into account the geographical location and the projected effects of climate change. The identification of pressures alone is not sufficient to inform climate adaptation and management decisions for the Bay's future.

The following three factors (see Figure 3), and the interaction between them, must be taken into account in the decision-making process. A risk assessment combines hazards, vulnerabilities and exposure to develop a decision-making matrix that can be used to understand and manage risks.

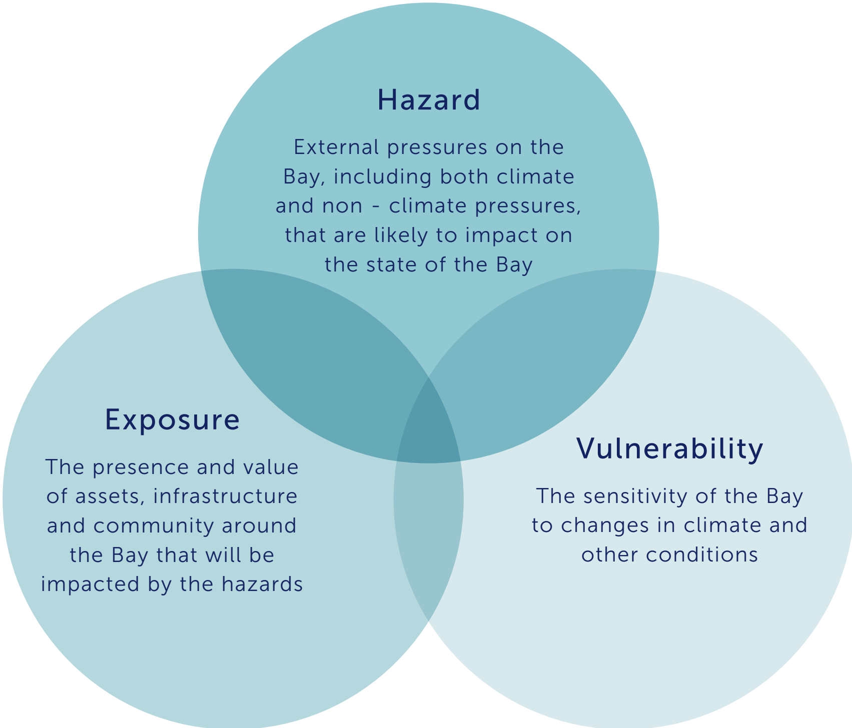
In keeping with the long-term approach required for coastal climate change adaptation, risk assessments should consider risks now and in the medium-to-long term. An understanding of these risks, through assessing hazards, exposure and vulnerability in a consistent way, will assist in prioritising local and regional actions.

The identification of risks can then be used as the basis for future risk management decision-making.

Risk assessments have been undertaken by individual local governments around Port Phillip Bay in the past. All were specific in their geographical and risk focus.

**A comprehensive risk assessment for Port Phillip Bay is required, with a focus on coastal climate change.**

**Figure 3: Risk assessment decision making**



## 2. Decision timing

Thinking about the timing of decisions along a pathway is important for the framing of adaptation. There should be a series of decisions over time, instead of one-off choices. Adaptation options selected now may become ineffective or even redundant in the future, especially when thinking long term (such as 2070).

Central to adaptation pathways are adaptation tipping points, which are the conditions under which an action no longer meets the clearly specified objectives (Kwadijk et al 2010).

The timing of the tipping point for a given action is scenario dependent. It might be the point at which an asset needs replacing, the exposure of an asset to wave action where it has previously been protected or the changing of a regulation which opens up pathway options previously not available.

Thinking about decision timing (and tipping points) helps give context to how important it is to take a long-term approach in order to avoid inadvertently setting out along an undesirable path (Stanford Smith et al 2011).

After reaching a tipping point, additional actions are needed and as a result, a new pathway emerges (Haasnoot et al 2013).

The adaptation pathways approach presents a sequence of possible actions after a tipping point in the form of adaptation trees (see Figure 4). Any given route through the tree is an adaptation pathway.

## 3. Decision Context

Adaptation Planning focuses on the decision process and inputs, rather than on the decision context. When exploring adaptation options context is important, taking into consideration the environment in which decision are made.

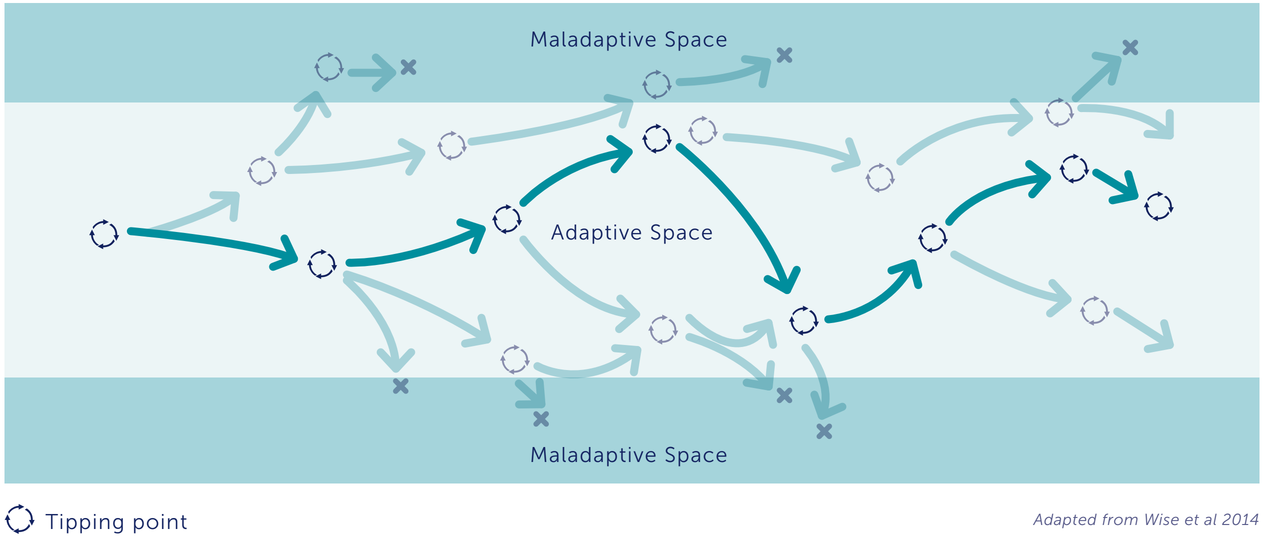
Adaptation options can be influenced by societal values, rules (legislation) and available knowledge relevant to that point in time (see Figure 5).

Recognising how values, rules and knowledge influence decisions means that as knowledge grows or rules and values change decisions can be reassessed, often revealing new pathways (adaptation responses).

As with any new approach, methodologies and tools are still emerging. Adaptation pathways is an approach that requires time and solid information to analyse different options and identify appropriate tipping points.

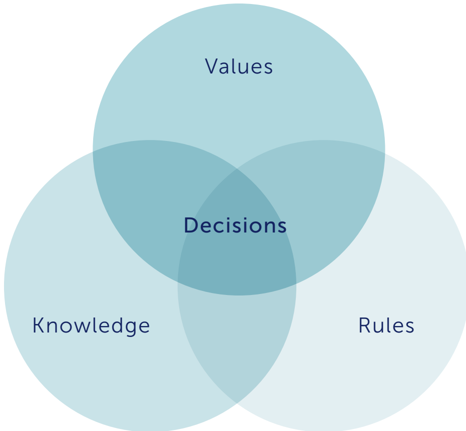
The analysis of tipping points can be lengthy and complicated. Undertaking such an approach for Port Phillip Bay was outside the scope of the Bay Blueprint project. However it is important to understand its role in the overall adaptation pathways process.

**Figure 4: Iterative Decision Cycles**




*Adapted from Wise et al 2014*

**Figure 5: Influences on adaptation options**




*Adapted from Gorddard et al 2016*

**Climate adaptation** is about increasing public and private resilience to climate risks through making better decisions about managing our built and natural environment. Adapting to climate change is a substantial, continuous and transformational process. It means taking action to manage or reduce the adverse consequences of a changed climate. To manage current and future climate an organisation will need to adapt its resources, operations or assets.

**Adaptation planning** is the process of analysing, selecting and prioritising the possible response pathways.


*Image 5*



# SECTION 2
# CLIMATE ADAPTATION PLANNING AS APPLIED TO PORT PHILLIP BAY

Image 6



## Planning for climate change in Port Phillip Bay means planning for change and uncertainty.

Adaptation planning requires consideration of multiple possible futures or 'pathways' that lead to a variety of solutions – ones that are 'robust' or 'flexible' or a combination of both. Robust options work well across multiple future scenarios, but can be expensive and difficult to change. Flexible options allow for changes (environmental, climatic, social or political) and avoid 'locking in' to one solution. Consideration also needs to be given to reducing risk to lives, property, amenity and commerce; the cost to implement and maintain and; determining the detrimental or beneficial impacts of an option.

## Future climate change scenarios

Guided by CSIRO, two hypothetical climate change scenarios for Port Phillip Bay were used to develop adaptation options for each coastal typology.

### Moderate Climate Change Scenario

> Sea level rise 0.13m
> Storm surge
> High tide 1.04m
> Moderate increase in beach and cliff erosion
> 5-10m erosion of sandy shorelines
> Air temperatures 1.5 degrees higher
> Sea surface temperatures 1 degree warmer

### Extreme Climate Change Scenario

> Sea level rise 0.8m
> Storm surge
> High tide 2.4m
> Significant increase in beach and cliff erosion^
> Air temperature 2.5 degrees higher
> Sea surface temperature 2 degrees warmer

*^ Based on technical advice from RMIT and CSIRO the degree of beach and cliff erosion is referred to as 'significant' rather than a set range for the following reasons:*

- *Once sea level rise moves towards 0.8m beach erosion is less likely to follow the 'Bruun Rule' (where a 0.1m rise in sea level = 5m to 10m inland retreat of sandy coastline).*
- *Erosion of a sandy shoreline is influenced by many other factors, including the geomorphology (for example, increasing sand creation and deposition in some locations and decreasing it in other locations).*
- *The simplistic level of sandy shoreline erosion for 0.8m rise in sea level would be 40m-80m shoreline retreat. However it is important to acknowledge this is a 'best guess' and not likely to be accurate at a local level. There are site specific detailed evaluations besides Bruun Rule that can be used to refine this estimation to beach segments that were beyond the scope or budget of the Bay Blueprint 2070.*
- *The erosion of rocky cliffs is very specific to structure, location and geology. To provide a rate or extent of erosion is problematic but acknowledges that overall the impact will be a significant acceleration of erosion.*

# INSPIRING COASTAL ADAPTATION TO 2070

The Bay Blueprint 2070 has identified four typical coastal typologies common to Port Phillip Bay and explored possible coastal climate adaptation approaches for each.

The resulting 'case studies' provide a broad range of design ideas and adaptation approaches designed to guide and inspire practitioners and decision makers, and prompt conversation about climate change adaptation in Port Phillip Bay.

Case studies have been developed for the following coastal typologies common to Port Phillip Bay:

1. sandy shoreline;
2. rocky shoreline;
3. highly urbanised (hard shoreline);
4. estuaries and wetlands; and
5. generic – options that can be applied to any coastal typology

Each case study is set in the context of a moderate or extreme climate change scenario, using future climate change scenarios for Port Phillip Bay provided by CSIRO (see previous page).

Each case study showcases a range of 'visualisations', along with local, national and international examples of coastal climate adaptation.

The case studies offer a range of possible approaches to climate change adaptation, that consider:

1. unique site attributes - attributes specific to each coastal typology such as water and sand movement, human use of and interaction with the coast, consideration of its use for commercial or recreational purposes, or role as a transport route.
2. adaptation pathways - robust and responsive solutions
3. bio-mimicry - approaches that work with climate and nature, and consider how hard and soft engineering can complement each other.

The case studies are intended to be thought provoking and present inspiration for what adaptation solutions around Port Phillip Bay could look like. They also provide valuable input to future conversations locally and regionally as part of stage 3 of the Bay Blueprint 2070.

Please note that a full adaptation pathways process and analysis was not undertaken as part of developing the case studies.

A suite of 'visualisations' were developed by RMIT Masters of Landscape Architecture and Urban Planning Students, based on ten selected sites around Port Phillip Bay. The visualisations draw on evidence from CSIRO, VICDATA coastal inundation data, hydrodynamic and integrated coastal and catchment modelling as well as input from Bay stakeholders.

Elements of these visualisations have been incorporated into the Bay Blueprint 2070 case studies.

*Visit www.abm.org.au to view the full exhibition of visualisations developed by RMIT Masters of Landscape Architecture and Urban Planning students.*

# CASE STUDY 01

Image 7

# SANDY SHORELINE

Sandy shores or beaches are loose deposits of sand, gravel or shells that cover the shoreline. Beaches serve as buffer zones or shock absorbers that protect the coastline, sea cliffs or dunes from direct wave attack. They are dynamic, with materials in constant flux of deposition and erosion (Töpke 2013).

## Sand Renourishment

Sand renourishment is a protective approach adopted by many sandy shoreline managers already. However, it is an expensive option which with increasing wave action within Port Phillip Bay is unlikely to be a sustainable, long term response.

Coastal environments are dynamic and sand migration will always occur. Port Phillip Bay may reach a point where beaches must be prioritised for protection and some left to 'wash away' (providing adequate alternative protection to beach retreat is in place).

*Image 8*

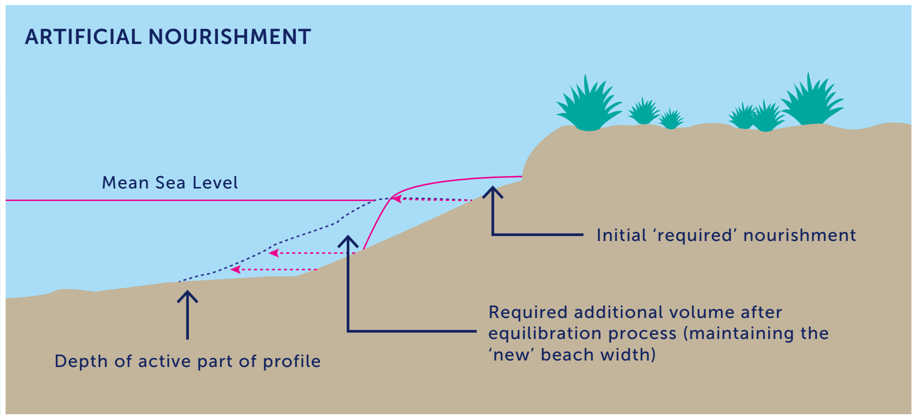



*Image 9*

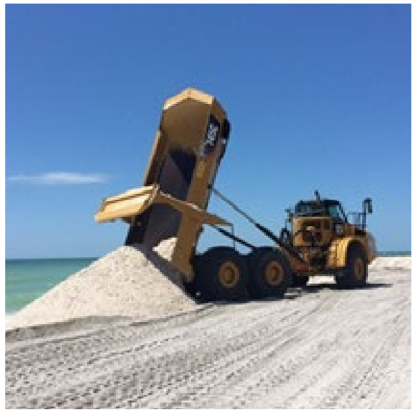


*Image 10*

*Image 11*

## Dune Restoration & Protection

Dune protection through fencing and vegetation is a well established current practice to reduce dune erosion. This is an adequate response to moderate climate change but is unlikely to withstand extreme climate change scenarios.

A slightly more engineered approach called 'living shorelines' using plants, sand (sand fences / sand traps) and limited rocks may provide shoreline protection and maintain valuable habitat under more extreme climate change conditions. Dunes provide habitat and biodiversity so should be restored and protected where viable.

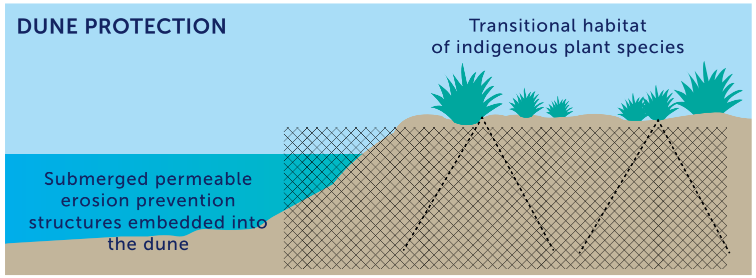
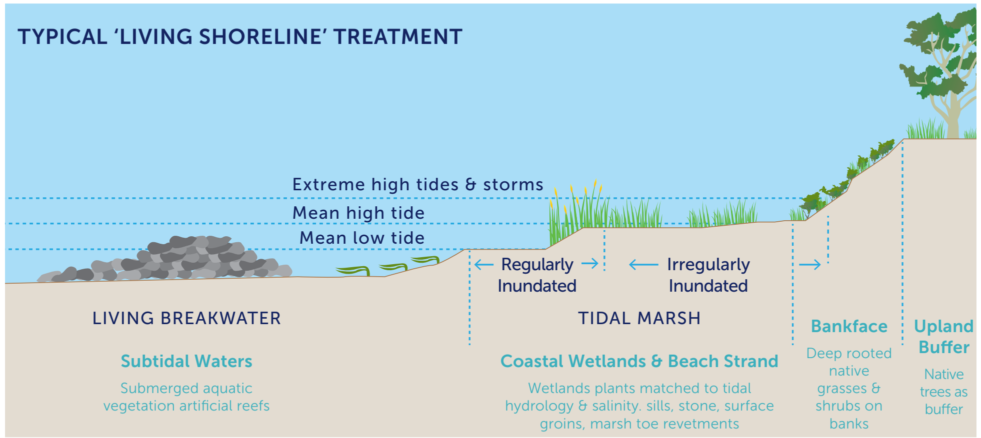



*Image 12*

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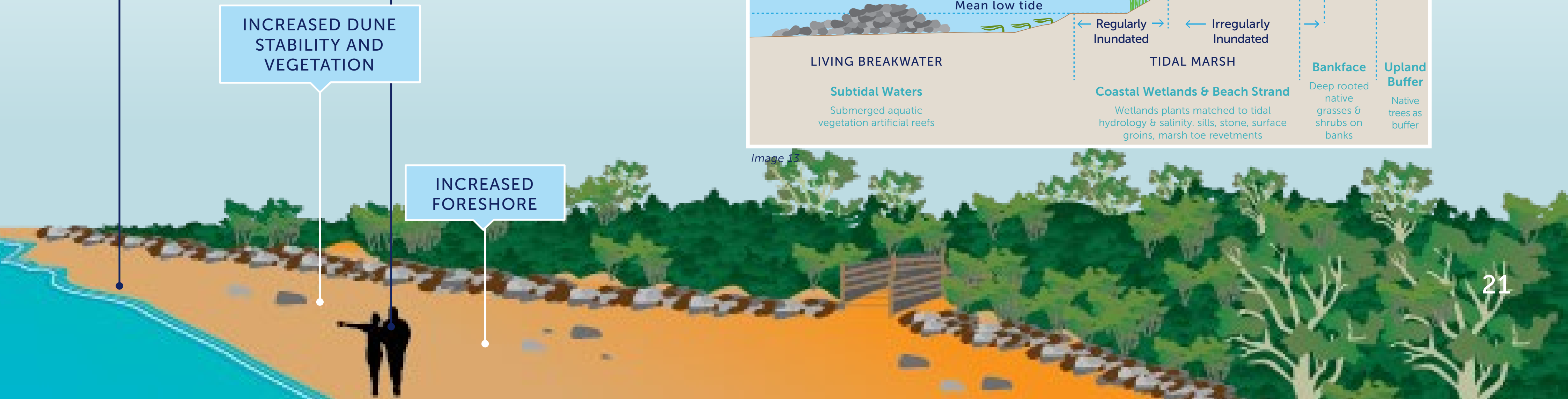


# CASE STUDY 01

## EXTREME CLIMATE CHANGE SCENARIO

### Seawall

Constructing an erosion rock wall or seawall to protect foreshore assets and ensure beach accessibility is a hard engineering response to climate change impacts.

Seawalls can impede the exchange of sediment between sea and land, thus changing local sand movement dynamics which can have unforeseen consequences.


*Image 14*


*Image 15*


*Image 16*


*Image 17*

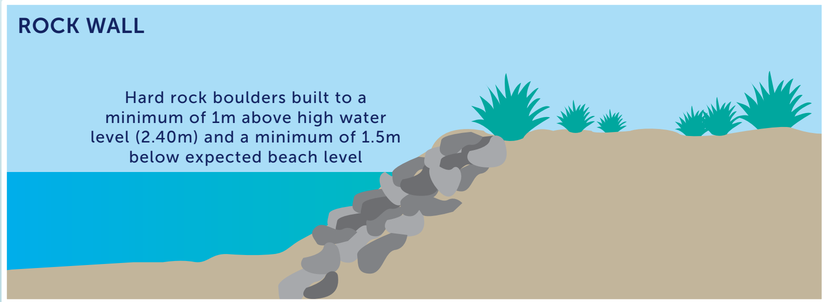


*Image 18*

*Image 19*

*Image 20*

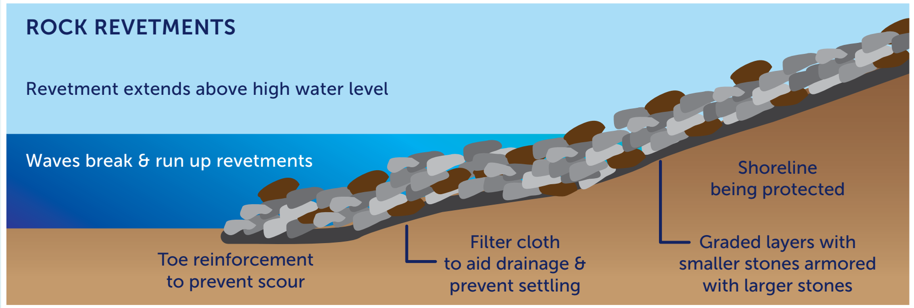
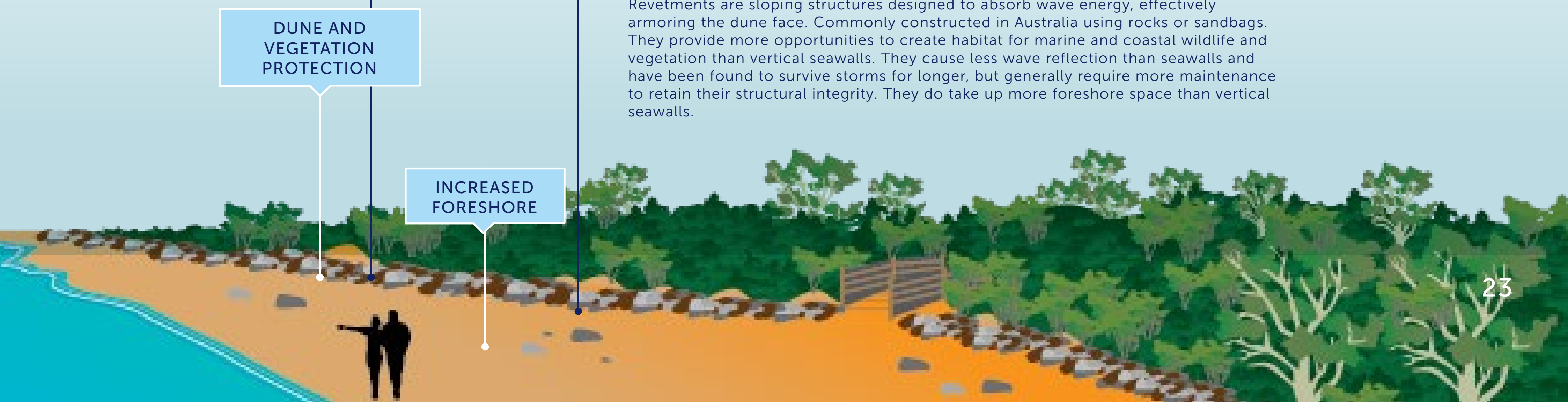



*Image 21*

## Revetments

Revetments are sloping structures designed to absorb wave energy, effectively armoring the dune face. Commonly constructed in Australia using rocks or sandbags. They provide more opportunities to create habitat for marine and coastal wildlife and vegetation than vertical seawalls. They cause less wave reflection than seawalls and have been found to survive storms for longer, but generally require more maintenance to retain their structural integrity. They do take up more foreshore space than vertical seawalls.



# CASE STUDY 02

Image 22



# ROCKY SHORELINE



**A rocky shoreline is an intertidal area where solid rock predominates the landscape. It is often a biologically rich environment and can include many different geomorphological features such as steep rocky cliffs, platforms and rock pools. Because of continued exposure to tidal action, it is characterised by erosional features (Töpke 2015).**

# CASE STUDY 02

## MODERATE CLIMATE CHANGE SCENARIO

### Breakwaters

Construction and design of any breakwater in this context is about wave attenuation - limiting wave attack on cliffs or rocky outcrops in an attempt to reduce erosion. This can be achieved through submerged sandy banks, living breakwaters or artificial reefs. It should be noted these solutions have high maintenance requirements due to scouring around the ends, which can result in weakening of the structure. Environmental benefits (such as habitat creation) are limited in such a high energy context.

Image 23

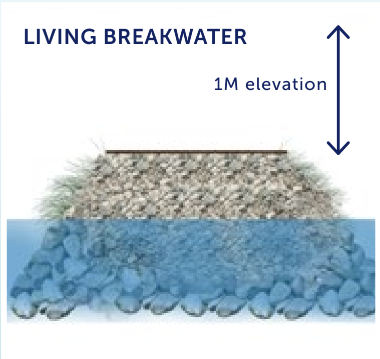



Image 24

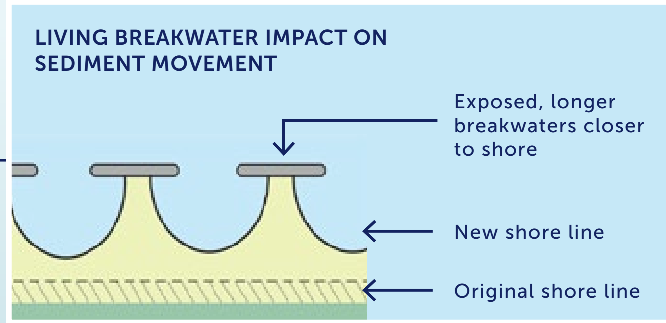



Image 25

Image 26

## Vegetation

Planting native and/or salt tolerant shrubs, trees and grasses in order to retain sand dunes and strengthen cliffs is a common current practice. In considering responses to moderate climate change this practice should be more broadly implemented. However, this response alone is unlikely to provide adequate protection and should be considered in conjunction with hard engineering responses. Planting vegetation is a low cost option, increasing biodiversity and habitat; but plant loss is likely to be high and plant establishment and growth can take some time. Thus implementing this response early will have greater medium to longer term benefits.

Image 27

Image 28

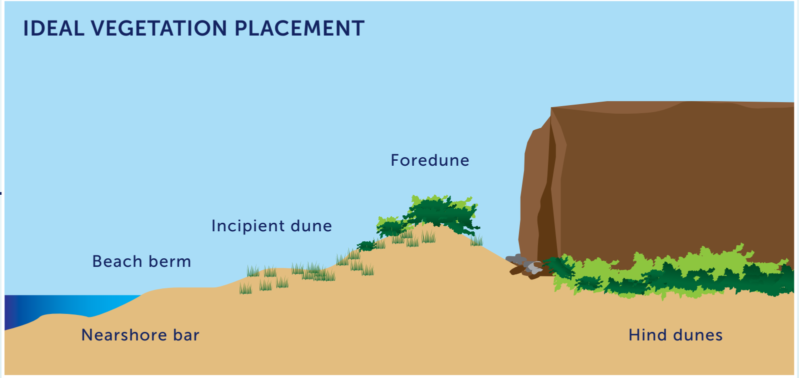
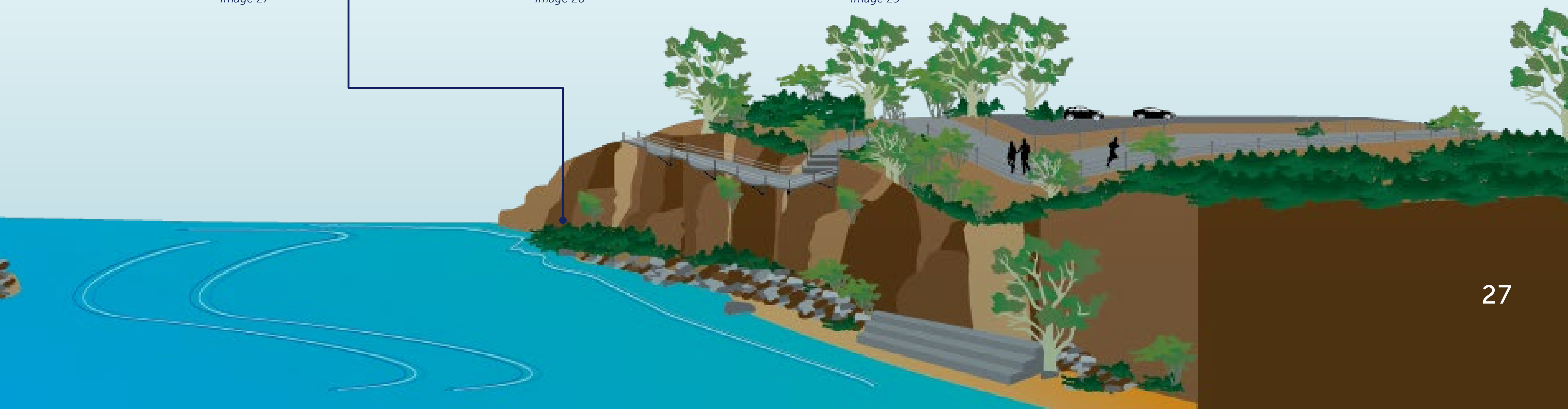



Image 29



# CASE STUDY 02

## EXTREME CLIMATE CHANGE SCENARIO

### Boardwalks

Boardwalks provide limited erosional protection from wave attenuation. The main role of constructed boardwalks is restricting human access to fragile cliffs. Boardwalks ensure public access to coastal areas by providing scenic linkages and can be designed with picnic / rest areas. Boardwalks can also be used as a design element to soften the visual impacts of hard engineering coastal protection structures.

Image 30

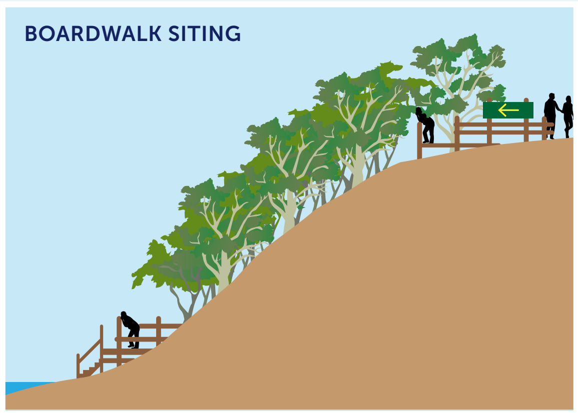



Image 31

Image 32

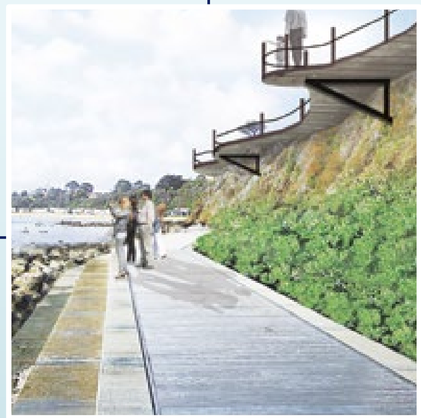


Image 33

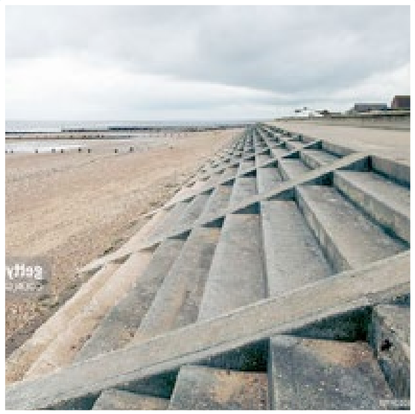


Image 34

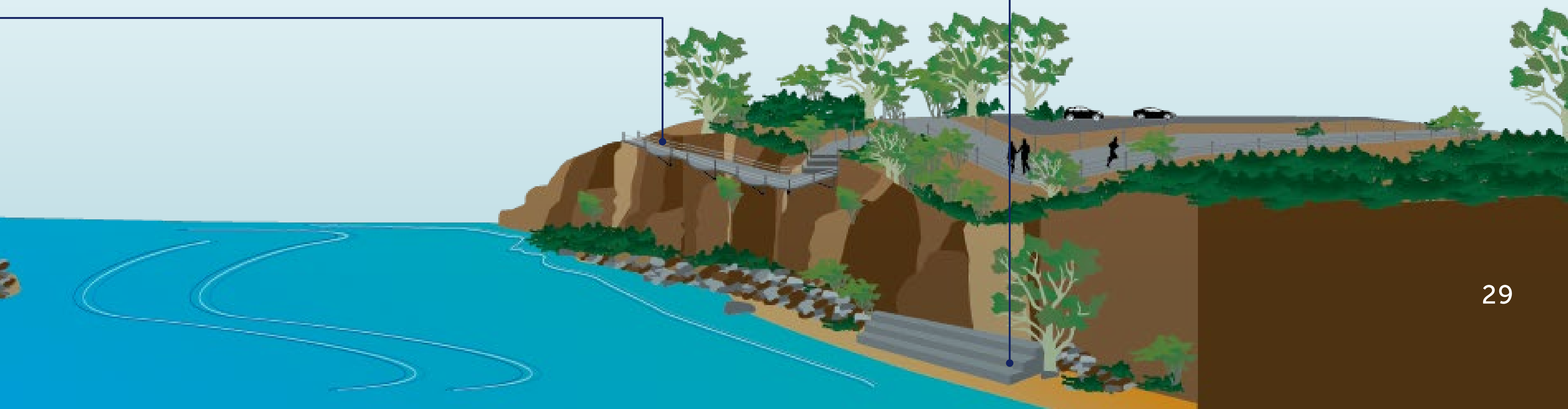

Image 35


Image 36


Image 37

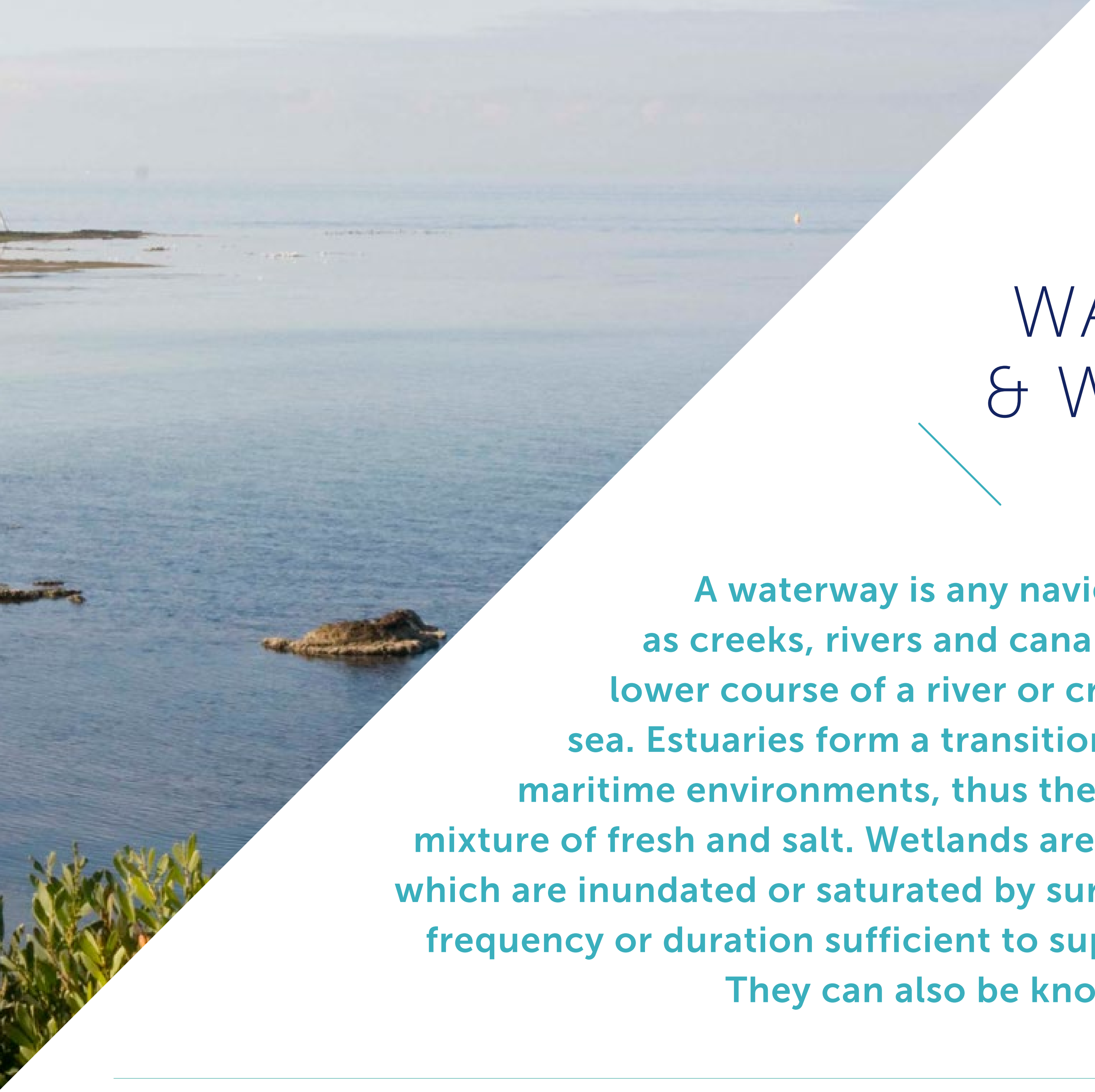
## Stepped Walls

Constructing a basic concrete stepped wall at the base of cliffs can reduce cliff retreat and erosion, protecting against wave action. To be effective stepped walls need to be highly engineered, inflexible structures and are generally expensive to construct (UNFCC 1999). They have limited environmental benefits, but can provide social benefits such as informal seating.



# CASE STUDY 03

*Image 38*





# WATERWAYS & WETLANDS



A waterway is any navigable body of water such as creeks, rivers and canals. An estuary is the wide, lower course of a river or creek where it flows to the sea. Estuaries form a transition zone between river and maritime environments, thus the water is a changing tidal mixture of fresh and salt. Wetlands are considered areas of land which are inundated or saturated by surface or groundwater at a frequency or duration sufficient to support aquatic vegetation. They can also be known as a swamp or marsh.

# CASE STUDY 03

## MODERATE CLIMATE CHANGE SCENARIO

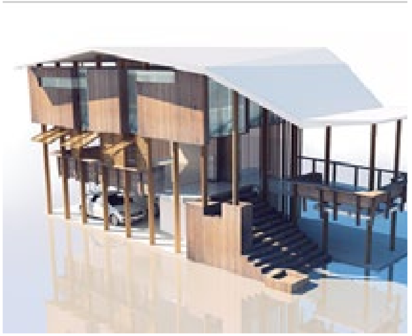


Image 39

### Coastal Inundation and Erosion Overlay

Raising homes and infrastructure in low lying areas is a logical long term goal. The most effective approach is to do this incrementally through new building design, rather than altering existing structures. The creation of a Coastal Inundation and Erosion Overlay would require buildings to be raised by a minimum of 1.5m (based on projected sea level rise) – either on stilts or designed as two story structures with the lower structure designed to flood. Other requirements of new homes include raising the height of electrical sockets, heating and ventilation systems.

**WET PROOFING -** Measures to make the building more resilient to flooding

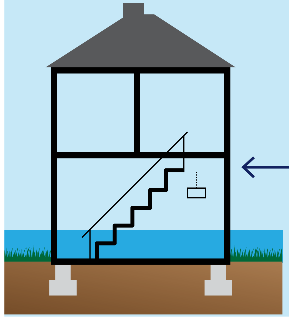



Image 40

**DRY PROOFING -** Measures to keep water out of building

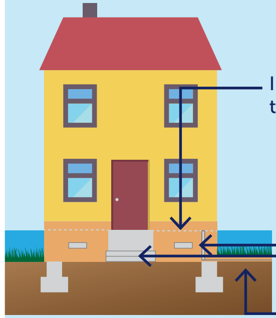



Image 41

*Image 42*

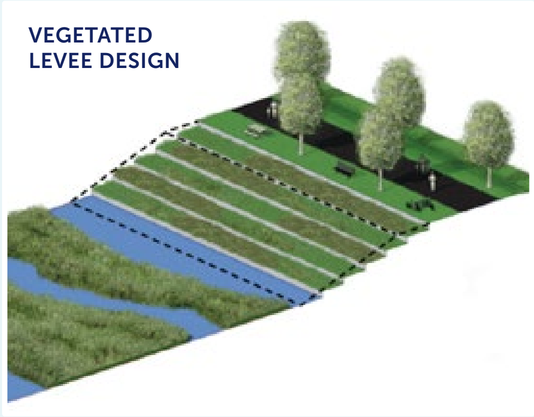



*Image 43*

## Levees

Levees can be built out of a range of materials - location and conditions will determine the most suitable material. Levee banks constructed from earth can be planted to soften their effect on the landscape. Inundation steps are a good way to provide access during non-peak events, this can aid in social acceptance of the approach. Walkways and emergency vehicle access tracks should be designed in. Essential services such as power and water should also be located along these raised structures.

*Image 44*

# CASE STUDY 03

## EXTREME CLIMATE CHANGE SCENARIO

*Image 45*

*Image 46*

*Image 47*

### Elevate and Protect Houses and Infrastructure

This is an extreme option and can be an expensive and disruptive approach. The most effective approach to ensure new developments are protected is to apply an Inundation and Erosion Overlay. It can be much more expensive to adapt existing buildings. Protecting assets in vulnerable locations (such as raising roadways or rail corridors) can provide additional protection for housing and development behind such structures.


*Image 48*


*Image 49*


*Image 50*

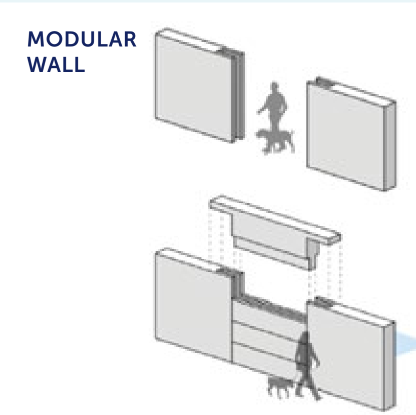


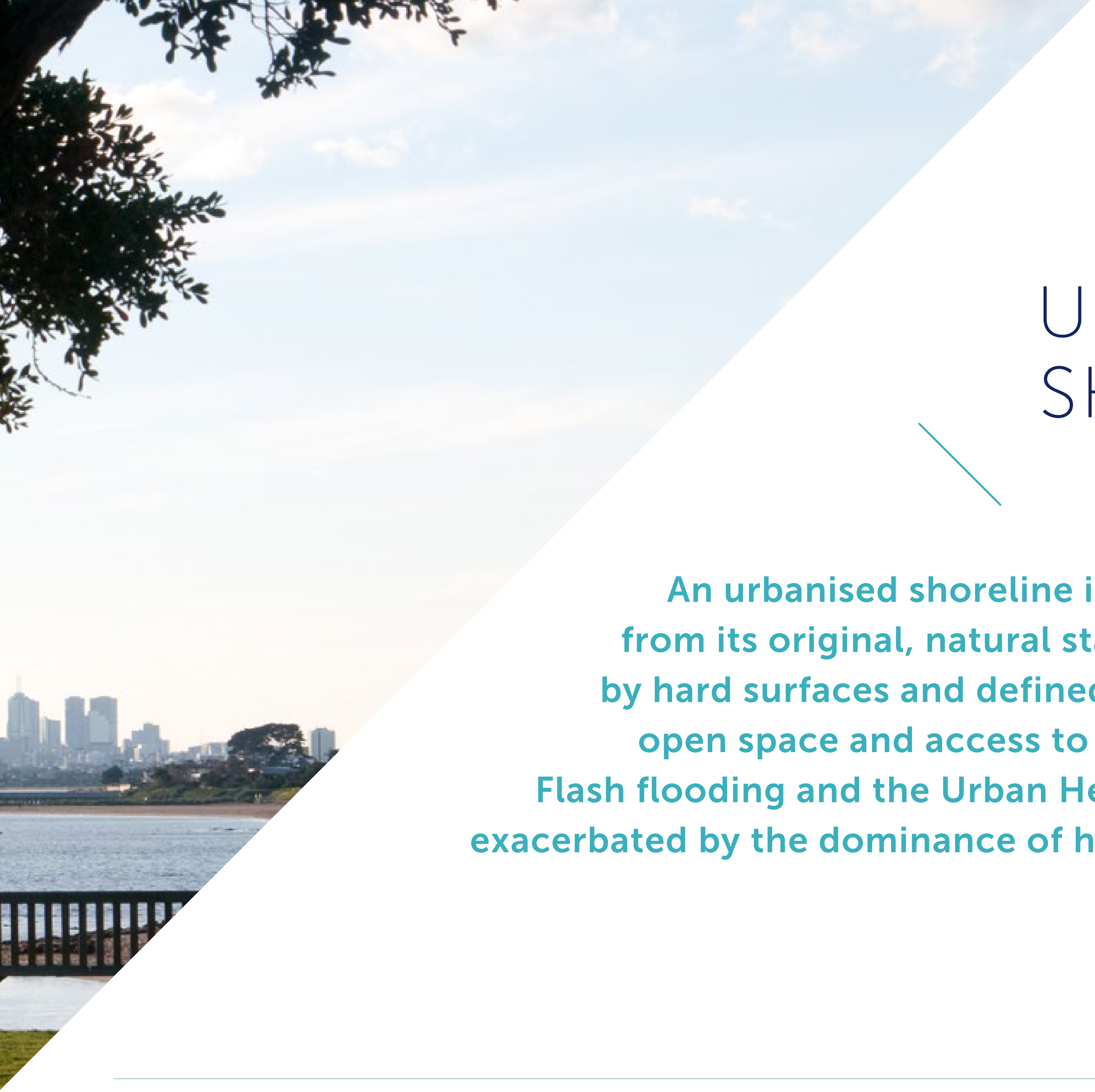
*Image 51*

## Walls

Constructing flood protection walls along creeks, rivers and other waterways must be done in a considered and highly engineered way. They are an excellent response option where space is limited; however, they have a high impact on water dynamics (specifically flood regime) and significantly alter the local environment. This approach can often be perceived by the community as rather extreme, however such walls provide excellent protection for residents and businesses directly abutting the waterway.

# CASE STUDY 04

*Image 52*



# URBANISED SHORELINE

**An urbanised shoreline is already highly modified from its original, natural state. It is often dominated by hard surfaces and defined edges. It can lack green open space and access to the water can be limited. Flash flooding and the Urban Heat Island (UHI) effect are exacerbated by the dominance of hard, impervious surfaces.**

# CASE STUDY 04

## MODERATE CLIMATE CHANGE SCENARIO

### Green Space

Increasing the volume and quality of green space, and ensuring it is multifunctional, is a key climate change adaptation response in highly urbanised areas. However, increasing the volume of green space in urbanised areas can be challenging. Thus it is likely to be through incremental 'greening' that the urban heat island effect is moderated. Approaches include increasing street tree canopy or converting small areas of hard paving into vegetated verges and green roofs. Green spaces can also play a role in reducing localised flooding and minimising storm peak flows. It is important to ensure existing green spaces are of a high quality and accessible. When access to traditional coastal features is limited, green spaces become important recreational and social spaces for the community. Increasing species diversity of both flora and fauna is also important in this context as habitat options are limited.

*Image 53*

*Image 54*

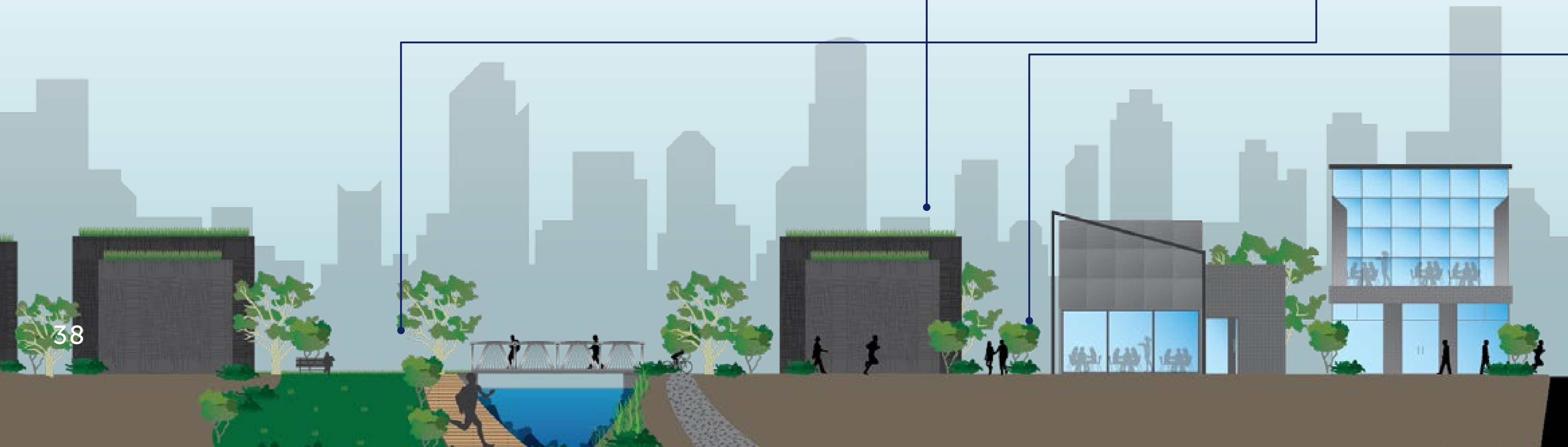


*Image 55*

*Image 56*

## Small Space Water Sensitive Urban Design

Incorporating water sensitive urban design into existing green space in highly developed areas can be perceived as a challenge. Often the community has expectations that the area of green open space previously available will remain. Thus when incorporating 'blue' space it is vital that the quality of the overall open space is improved. It is also crucial that the water infrastructure is readily accessible to the public. Reuse of the treated water to irrigate the open space is also considered good practice.

*Image 57*

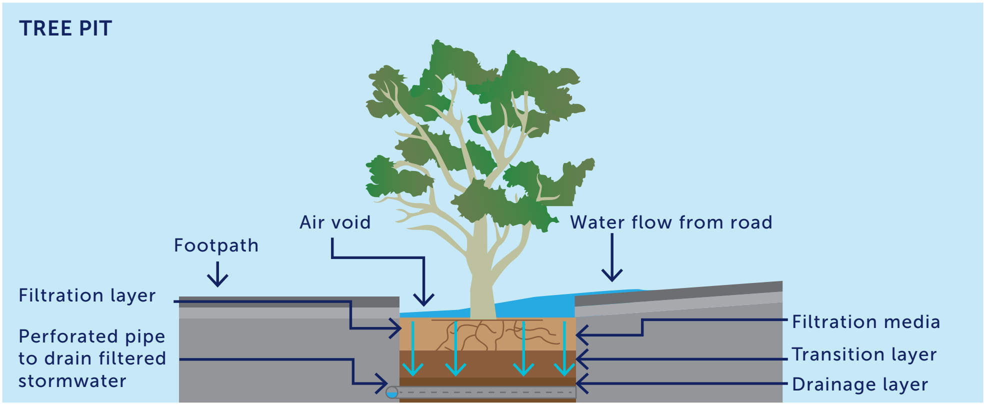
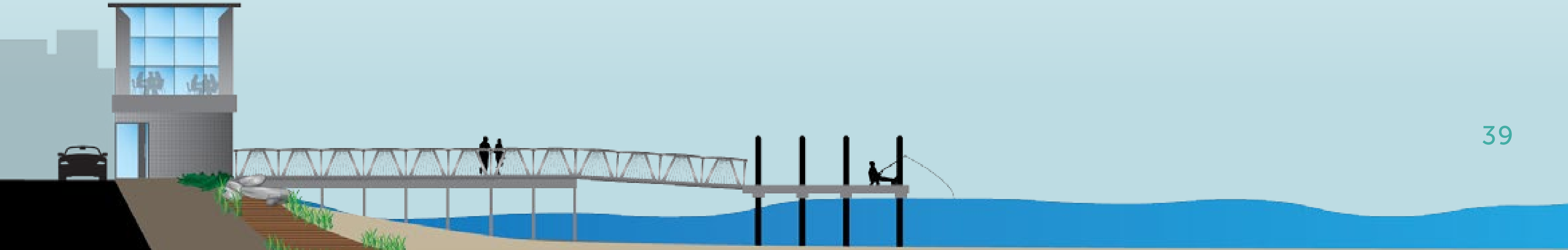



*Image 58*



# CASE STUDY 04

## EXTREME CLIMATE CHANGE SCENARIO

*Image 59*

*Image 60*

### Decks

In this context access to open space can be extremely limited, thus options which allow increased access to the water whilst providing climate change protection are attractive. Decking the foreshore can provide protection from wave attack. Decks can reduce sand movement, but limit access to the sand itself. They have high social benefits with limited environmental benefits. Depending on design decks can increase economic activity in the area by providing better linkages to existing businesses or create opportunities for new businesses to establish.

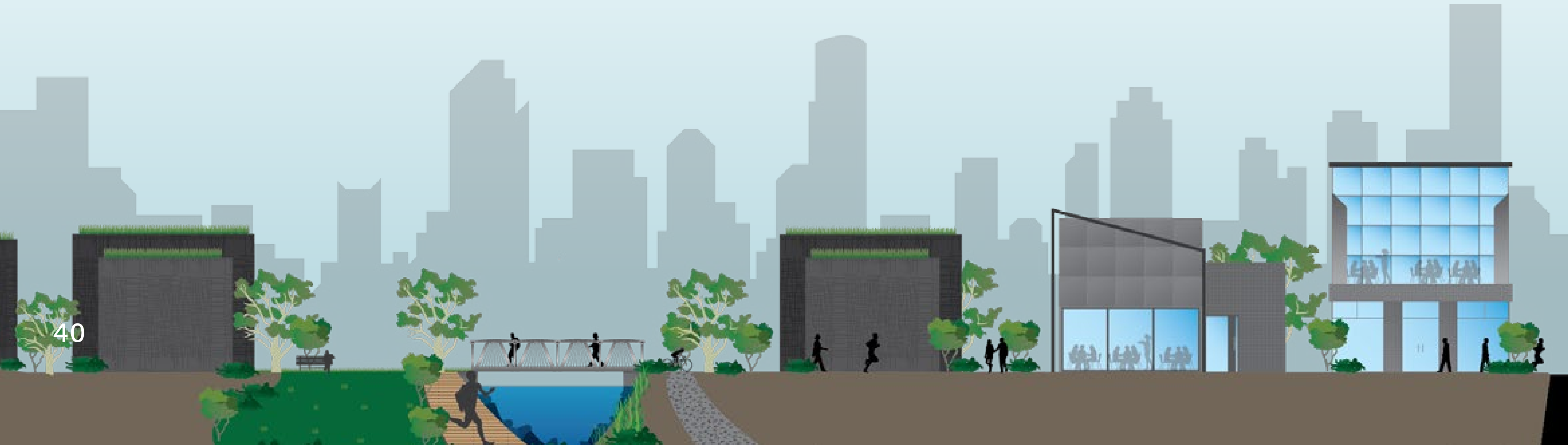


Image 61

Image 62

## Pontoons

Constructing pontoons (floating open space) can increase public access to the foreshore environment. This solution provides very little environmental benefit, but it provides excellent social and economic benefit (temporary trader permits could be provided). Whilst the structure itself provides little protection from climate change hazards, it would play a role in attenuating wave action.

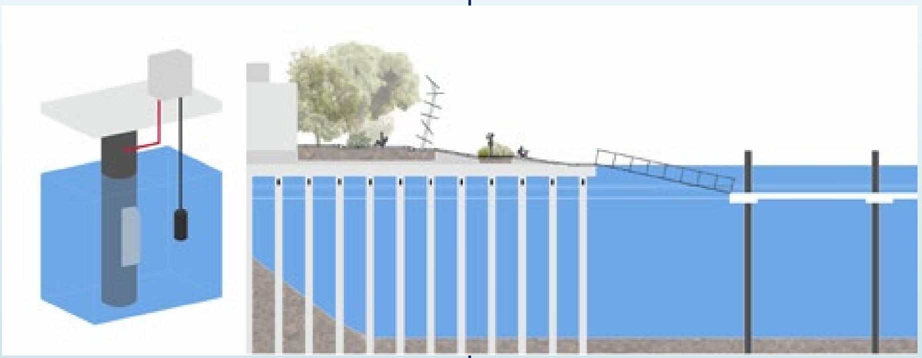
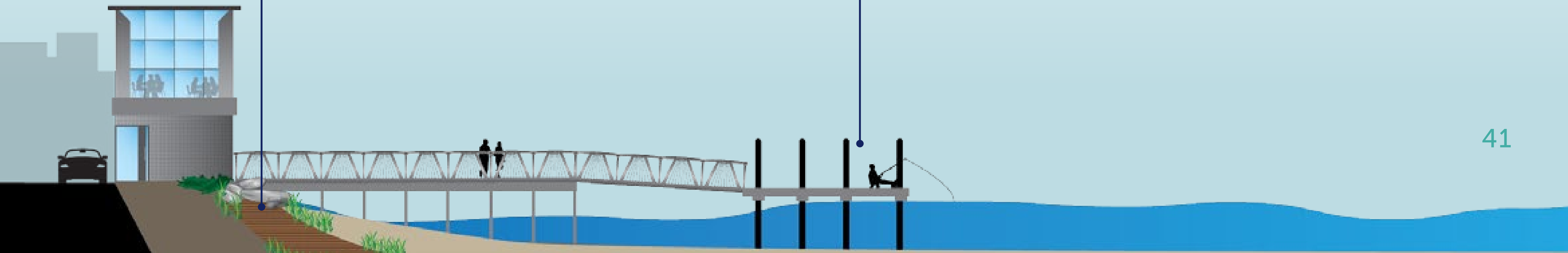


Image 63



# CASE STUDY 05

Image 64



# GENERIC - ANY LOCATION

These climate change adaptation options can be applied in any geographical location, under moderate or extreme climate scenarios.

# CASE STUDY 05

## ANY CLIMATE SCENARIO

*Image 65*

*Image 66*

### Catchment Scale Raingardens

Raingardens are commonly used throughout the Port Phillip Bay catchment as part of water sensitive urban design (WSUD) practices. Raingardens can reduce catchment flooding and storm surge impacts, as well as improve water quality prior to discharge into the Bay. Depending on scale and design, costs vary, as do environmental impacts.

Raingardens are commonly located within the catchment, rather than the coastal zone because of the land requirements for such treatments. Councils recognise the importance of stormwater management and are striving for more widespread implementation of WSUD within their municipalities (Melbourne Water 2013). A critical element for successful acceptance of raingardens is effective integration within public open space - providing water quality treatment along with opportunity for human interaction. Raingardens also provide opportunities for stormwater re-use, increased habitat diversity and amenity improvements.

## Groynes

Built jutting from the shoreline, groynes, breakwaters and even jetties offer protection from wave attack and longshore drift and provide habitat for land based birds and animals. These forms of coastal protection have the additional benefit of providing opportunity for recreational activities such as fishing.

*Image 67*

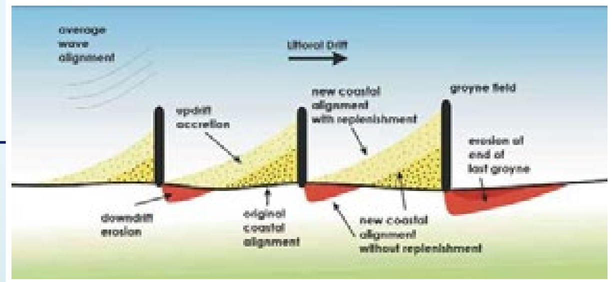



*Image 68*

# CASE STUDY 05

## ANY CLIMATE SCENARIO

*Image 69*

### Elevated Infrastructure

Elevating infrastructure is an extreme option and can be an expensive and disruptive approach. Raising railway lines, walking tracks or roads can be an effective means of protecting infrastructure and the services it provides but also protecting housing and developments behind such structures. Critical services such as power and water should be located along elevated structures to provide greater protection.

*Image 70*

## Elevate and Protect Houses and Businesses

The first step in this response is to construct a physical, hard barrier to protect infrastructure along foreshores, creeks or inlets to ensure climate change impacts are minimised. Whilst the most effective approach to elevating houses is to ensure an Inundation and Erosion Overlay is in place so that incremental change occurs, it might be necessary in highly vulnerable areas to expedite the elevation of homes and businesses. This response has very high social and environmental impacts and should be considered as a last resort option.

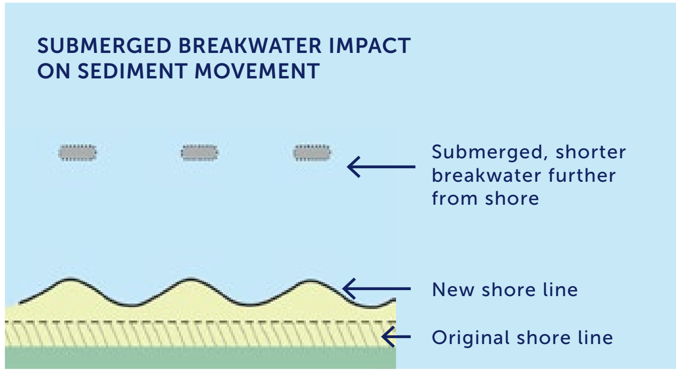



*Image 71*

## Submerged Breakwaters

Akin to an artificial reef, these structures are primarily designed to slow wave action. Decreasing the velocity of wave attack can change conditions from predominantly erosional forces to depository, thus adding sand and enabling beach access to continue under a moderate climate change scenario. The 'calmer' waters can also result in increased biodiversity as more marine flora and fauna can inhabit the waters. Caution should be used if locating submerged breakwaters in or near is frequently navigated areas.

*Image 72*

# SECTION 3
# FRAMEWORK FOR A WHOLE-OF-BAY APPROACH

Climate change does not have boundaries. Vast areas of coastal public and private land have the potential to be impacted by climate change.

Effective coastal climate adaptation and resilience requires an integrated whole-of-bay approach to planning, decision making and action - guiding sound policy and practice at a local level.

To be effective, the diverse network of Bay stakeholders requires:

- **A vision for the future**
  – a clear and shared vision for the Bay to align and integrate the roles and responsibility of all Bay stakeholders.
- **A framework for managing long term climate uncertainty**
  – development of an adaptation pathway for Port Phillip Bay, based on future climate risks and impacts, tipping points, consistent and measurable standards and methodologies.
- **Consistent, collaborative decision making**
  – policy and planning controls to support decision making for coastal land use, assets and infrastructure development.

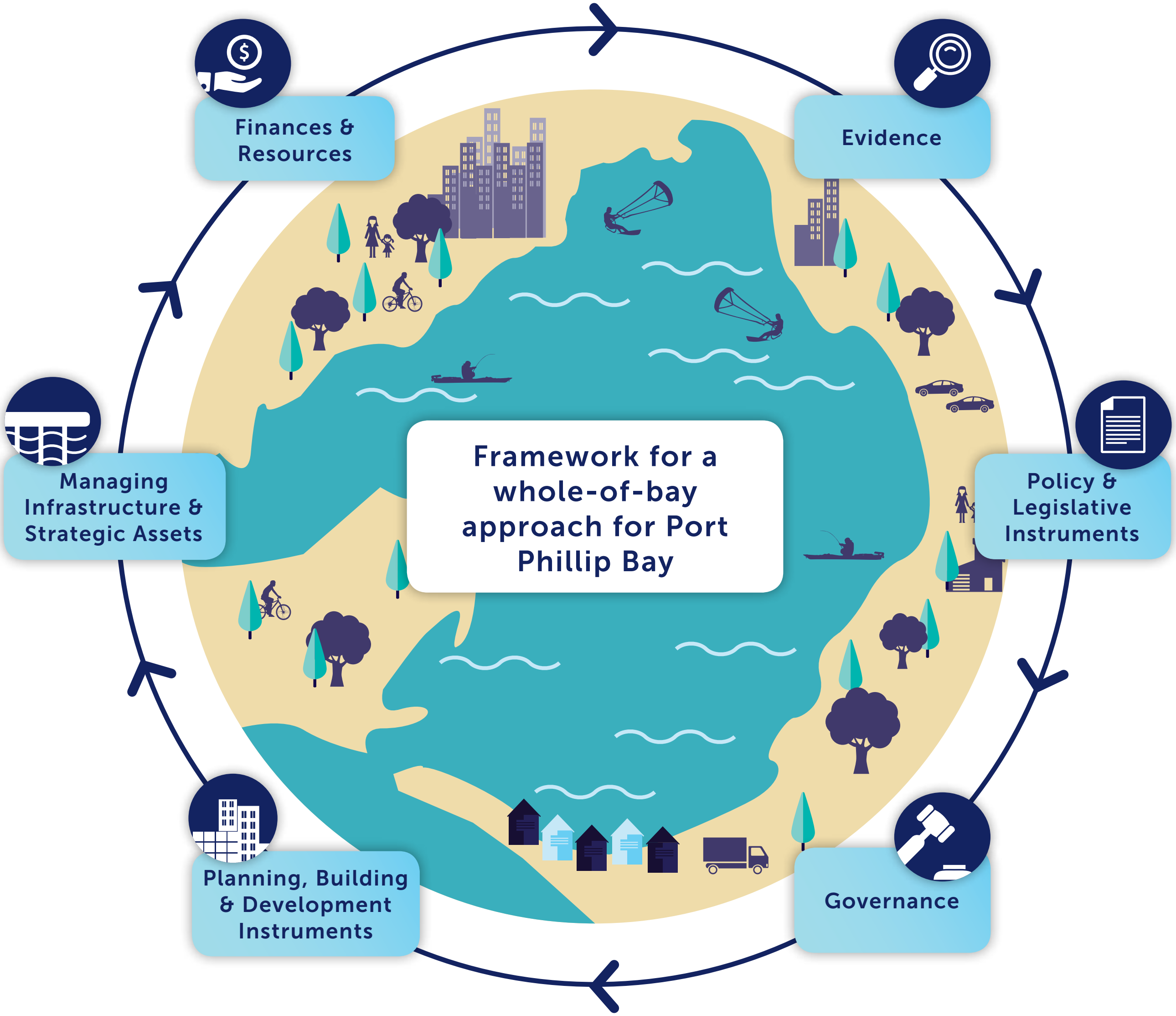
The Bay Blueprint 2070 offers a framework for establishing a whole-of-bay approach to coastal climate adaptation for Port Phillip Bay (see Figure 6). Developed with input from councils and local community groups, the framework is supported by the following 'guiding principles', that reflect the built, natural, economic, social and cultural values of the Bay:

- Living shorelines - managing shifting sands and shorelines, enhance vegetation, preserve environmentally significant vegetation and use of coastal vegetation for soft engineering
- Living better with more water - flood management, coastal and catchment inundation, water retention/detention
- Infrastructure resilience - preserve current access and activity hubs and their supporting infrastructure; ensure designs cater for future community needs
- Progressive adaptation - progressively and collectively build resilience through designs which are fit-for-purpose and responsive

## Proposed Framework

Figure 6 sets out the six areas identified as key to establishing a whole-of-bay framework for coastal climate change adaptation and resilience in Port Phillip Bay. The six areas were identified through stakeholder consultation during stage 1 and 2 of the Bay Blueprint 2070 development. The ABM will work with Bay stakeholders to further refine the framework and approaches as part of stage 3.

**Figure 6: Framework for a whole-of-bay approach for Port Phillip Bay**



## Evidence

Comprehensive and accessible coastal data underpins the effectiveness of coastal climate adaptation approaches. This includes information about flooding, erosion and land use amongst many others. In Victoria, and in almost all other States around Australia, coastal data is not available in a single authoritative location.

The Bay Blueprint 2070 initially set out to identify the locations where coastal hazards will present an increased risk as a result of projected climate change. However, it quickly became apparent that adequate, regional data on existing coastal hazards for Port Phillip Bay does not exist. And where it does exist, methodological inconsistencies make using the data challenging. There is a pressing need to have ongoing, reliable data from which decisions can be made. This requires establishing a collaborative data management system for coastal climate change data, to be stored in an accessible portal.*

To be effective, there needs to be a standardised approach to data collection, monitoring and validation, and the unification of datasets that duplicate.

The ABM will advocate strongly for state and regional investment in targeted data gathering for Port Phillip Bay through development of a coastal hazards and vulnerability assessment, and identification of local and regional priorities for coastal adaptation and protection.

The ABM will work with member councils to increase access to Geographic Information System (GIS) data for the Bay. This includes facilitating access to a comprehensive range of coastal data, modelling and analysis which can be shared openly between councils and other organisations.

## Finance and Resources

A funding mechanism to enable investment in, and resourcing of, strategic coastal adaptation planning and delivery is critical. Funding mechanisms require an equitable approach, considering regional priorities and vulnerable communities.

The insurance industry in Australia does not provide insurance cover for coastal storm surge, inundation and erosion impacts. Investment in enhancing the resilience of coastal properties against coastal impacts should increase the value of these properties but this improvement needs to be recognised in property valuation or provision of insurance cover for lower risk properties.

Local government is not adequately skilled or resourced to provide strategic climate change adaptation for the entire Port Phillip Bay. Proposed changes presented in the Marine and Coastal Act Consultation Paper (DEWLP 2016) to local government's role in coastal management will require adequate funding to support any changes in accountability.

The ABM will advocate strongly for state and federal investment in coastal climate adaptation to support implementation of a whole-of-bay approach to climate change adaptation, beyond local government's current financial capacity.

The ABM will continue to identify and support co-investment and cost sharing opportunities with member councils across all areas of climate adaptation – from research and data collection, through to planning, capacity building and implementation.

## Governance

Throughout the development of stage 1 and 2 of the Bay Blueprint 2070, stakeholders were unanimous in their call for a clear whole-of-bay governance approach for Port Phillip Bay.

The current complexity of roles and responsibilities across the sixty-four coastal managers is seen as an impediment to a whole-of-bay approach to coastal climate adaptation, leading to isolated, inconsistent solutions that are often ineffective and inefficient.

Through stage 3 of the Bay Blueprint 2070 the ABM will continue to build the appetite and capacity for coastal climate adaptation – facilitating collaboration and coordination across coastal management boundaries.

*An example of a best practice data portal – US Data Portal www.data.gov/climate/*

"Our nation's investment in mitigation measures to improve our communities' resilience to natural disasters is well short of what's required to seriously tackle the issue.

It is far surpassed by post-disaster recovery spending. Progress on resilience development is too slow, fragmented and reactive."

*Australian Business Roundtable for Disaster Resilience & Safer Communities. http://australianbusinessroundtable.com.au/*

## Policy and Legislative Instruments

Legislative and policy alignment is required to enable complimentary climate change adaptation criteria and considerations across coastal, catchment, urban planning, investment and growth plans.

The integration of coastal climate adaptation into local and state policies, plans and strategies is critical to practical, on ground capacity and action.

Legislation and policy frameworks which have the potential to include coastal climate adaptation requirements include:

- The Environment Protection Act 1970;
- Coastal Management Act 1995;
- Climate Change Act 2010;
- Local Government Act 1989;
- Emergency Management Act 1986;
- Housing Act 1993;
- Land Act 1958;
- Planning and Environment Act 1987;
- Regional Infrastructure Development Fund Act 1999.
- *Draft* Port Phillip Bay Environmental Management Plan 2017-2027.
- Proposed Marine and Coastal Act

Decision making for coastal land use, assets and infrastructure development will continue to be challenging without legislative support.

**The ABM will advocate for legislation and policy that provides protection for the Bay and enables coastal land managers and decision makers to better plan for and manage the impacts of climate change on the marine and coastal environment.**

For example, the draft Coastal Management Bill NSW (2016) and Victoria's Climate Change Act 2010 are both supported by climate science and advocate for adaptation.

Reforms to national emergency management should also incorporate climate change adaptation requirements. Specifically into coastal land use development and coastal recovery plans.

Coastal hazards must be prioritised in Council Plans, Municipal Strategic Statements and Climate Adaptation policies, and in all resulting coastal and asset management strategies.

**The ABM is committed to supporting members to develop local coastal climate action plans as part of a regional vision for Port Phillip Bay.**

## Planning, Building and Development Instruments

A range of changes and enhancements are required to Victoria's planning, building and development instruments to enable consistent and complementary climate change adaptation. Climate-suitable built form will be a key component to reducing liabilities and emergency management costs in changing climate.

Consistent and responsive planning, building and development instruments for coastal adaptation across all councils are required. For example, local building permit controls on areas subject to inundation.

Councils should consider reviewing Municipal Strategic Statements and local legislation to progressively support flood resilient development and onsite retention/detention. Councils may consider implementing developer contributions that actively contribute to localised climate adaptation and resilience.

Planning, building and development instruments must also consider indigenous, cultural, environmental and built heritage in increasingly inundated areas.

Effective whole-of-bay climate adaptation planning requires development of an Inundation and Erosion Planning overlay for Port Phillip Bay. its purpose would be to identify threats and enable increased protection, investment, maintenance and resilience of bay assets and values.

**ABM will work with the State to develop relevant land use planning tools for coastal hazards and adaptation through the MAV-ABM Port Phillip Bay coastal planning project.**

## Managing infrastructure and strategic assets

Drainage and coastal infrastructure will play an increasingly important role in supporting the growing relationship between catchment and coastal flood management, and building coastal climate change resilience. Coastal engineering is rapidly moving from a culture of static infrastructure designs, standards and maintenance regimes, to designing infrastructure and strategic assets* in ways that manage increasingly dynamic climate impacts.

Climate adaptation must be embedded in future planning, design, strategic management and maintenance of infrastructure assets. Currently, infrastructure and asset standards are set reactively and there are no national or state frameworks that proactively set new infrastructure standards based on medium to long term climate dynamics or tipping points. Infrastructure investment and maintenance is decentralised which creates further complexity in managing infrastructure and their design.

**The ABM will partner with other coastal land managers to advocate for infrastructure standards to be developed based on changing climate – linking climate science to development, enhancement and management of coastal infrastructure.**

A potential partnership with the Institute of Public Works Engineers Australia (IPWEA) and the National Sea Change Taskforce could inform development of State infrastructure resilience design standards. Climate resilience requirements need to be integrated into local government asset plans, coastal capital works, asset renewals, infrastructure development and maintenance.

This will require changes to the business case and capital works project management approaches currently adopted by many councils.

A Port Phillip Bay risk assessment with a clear focus on coastal climate change would support more effective infrastructure and asset protection and management. An understanding of risks, through assessing hazards, exposure and vulnerability in a consistent way will assist in prioritising local and regional action.

**The ABM will look to the State Government to work closely with local government to strategically transition assets to more resilient solutions; and to support coastal inundation and erosion control works specifically targeting future climate resilience.**

**Strategic assets include: critical public utilities, public transport and coastal amenities.*

Integration of roles and responsibilities along the coast was supported by the House of Representatives Standing Committee on Climate Change, Water, Environment and the Arts (2009). Their inquiry into climate change and environmental impacts on coastal communities recommends:

*"That the Australian Government, in cooperation with state, territory and local governments, and in consultation with coastal stakeholders, develop an Intergovernmental Agreement on the Coastal Zone to be endorsed by the Council of Australian Governments" (Recommendation 44)*

http://www.aph.gov.au/parliamentary_business/committees/house_of_representatives_committees?url=ccwea/coastalzone/report.htm

*Image 73*

# NEXT STEPS

## Stage 3 of the Bay Blueprint 2070 focuses on capacity building for coastal climate change adaptation tailored to local government and coastal land managers of Port Phillip Bay.

Commencing in 2017, a suite of information sharing and capacity building initiatives will be delivered, drawing on the information, resources and expertise from stages 1 and 2 of the Bay Blueprint 2070.

This will include:

- how to use climate and non-climate assessment information to inform coastal adaptation planning
- assessment, interpretation and application of current climate change related data for Port Phillip Bay
- sharing technical skills, knowledge and approaches to identifying coastal risks and vulnerabilities
- discussion of regional adaptation opportunities
- showcasing expertise and examples of climate change adaptation from Victoria, interstate and internationally


*Image 74*

# APPENDIX 1
# RESOURCES

The following resources have been gathered during development of the Bay Blueprint 2070 stage 2.

These resources have been identified as useful for local government officers, and other coastal land managers involved in undertaking climate change adaptation planning. They are not a complete or comprehensive suite of resources for effective coastal climate adaptation planning.

Further resources will be sourced and developed as part of Bay Blueprint stage 3.

# RESOURCE 1: ADAPTATION PATHWAYS

## A how to formula for local government

In order to effectively undertake adaptation planning within local government the following needs to be considered before commencing:

- An understanding of the organisations view of climate change adaptation, thus assisting with framing the process
- Existing strategies or policies which can be linked to, leverage or influence adaptation options
- Senior management or political support for exploring or investing in adaptation options
- Opportunities to collaborate within the organisation and beyond
- Appetite for organisational change

There are many resources which outline recommended approaches to undertaking climate change adaptation planning within local government (see Bosomworth, ICLEI, Inglis, Turner and UKCIP in bibliography).

However they all have the following basic principles:

- Gain the evidence base – consider the geomorphology of the site and non-climate pressures such as population growth and development. Determine the combined coastal and catchment inundation impacts and how it progressively affects current land use, infrastructure capacities, strategic coastal assets, development and foreshore management. It is also vital to identify the objectives of the site, which may be derived from unique site assets, values and uses.
- Determine key roles and responsibilities – determine which areas will be affected, what changes are required and who will be responsible for each. Consider modelling, planning, resourcing, design, implementation and maintenance.
- Develop adaptation pathways with tipping points – including climate and opportunistic tipping points with timelines for key action areas. Ensure consistency and integration with existing infrastructure (both public and private), land use and asset provision or enhancement.
- Provide for flexible pathways – provide avenues for flexible and newer solutions as well as regional solutions. Set long-term adaptation pathways linked to adaptation planning, with clear goals (setting three and five year goals works well in the standard local government capital works budget forecasting).

Goals need to be set for key areas including:

> asset management

> infrastructure engineering

> strategic planning

> capital works and project management

> foreshore management

> parks and open space

> drainage engineering

> risk management

> building projects.

- Apply adaptation pathways to annual planning – integrate adaptation planning into key policy and capital works concept plans to ensure integrated and consistent approach to selected adaptation pathways.
- Monitor and evaluate – monitor key indicators that lead to tipping points. Monitor for maladaptation and unintended consequences as a result of implemented initiatives. Learn and adapt the pathway plans over time, as information becomes available and scenarios change. See Figure 7.

**Figure 7: Step-guide to commencing adaptation planning for local government**

STEP 1

## UNDERSTANDING CONTEXT

### Municipal Pressures

Understand the organisation's view of climate change adaptation and political support for exploring the topic. Identify existing strategies or policies which adaptation can be linked, leveraged or influenced. Determine the appetite for organisational change.

### Nominated Site

Define the physical boundary that determines the nominated site.

Define existing unique attributes of the site. Attributes may include:

- Current use, users and behaviours
- Environmental significance and benefits
- Social significance and benefits
- Economic significance and benefits

### Community Engagement

Identify key community leaders who have a relationship with the site

Invite them to participate in the process

### Climate Pressures

Using knowledge and available data, determine the potential impacts of climate change on the nominated site.

### Design Values

Using the Bay Blueprint 2070 case studies, what approaches could be incorporated at this site?

STEP 2

## CONCEPT GENERATION

### Project Brief

Based on the parameters identified in Step 1, a project brief should be developed and signed off by all stakeholders (including community representatives).

### Design Response

- Investigate climate change adaptation responses others have implemented (locally, nationally and internationally).
- Identify elements which are important to be incorporated at the nominated site issues relevant to implementing these at the nominated site should be identified
- Ideally preliminary costings should also be presented

STEP 3

## CONCEPT REFINEMENT

### Design Development

Stakeholders should assess the designs against:

- Has it responded to the brief and values?
- What impact and risk does the design pose to neighbouring sites?
- How does the design build resilience?
- What additional opportunities and benefits does the design bring to the future of the site and its users?

### Implementation Strategy

Develop a staging / implementation strategy based on time, funding and 'flow on effects'.

*Image 75*

## Selecting Options

When selecting adaptation options the following should be considered:

- **Scale** – the level of protection needed and the impact of sea level rise in the area. When choosing an option, consider if it can be added to or built on in the future and how it will be executed.
- **Context** – different adaptation options can have impacts for surrounding land uses. Look forward to consider how the land might be used in future context.
- **Policies** – some things are more or less socially/culturally appropriate in certain locations. Working with an understanding of local, regional and national politics will help guide adaptation options.
- **Criteria** – it is recommended that a multi-criteria analysis is used for selecting the most appropriate adaptation option for the area.

**The following table contains criteria which could be applied when evaluating different coastal adaptation options.**

| Governance | |
|---|---|
| **Criteria G1** | This adaptation option is consistent with, and could be readily implemented under, existing local and state planning policy |
| **Criteria G2** | This adaptation option could be independently implemented by council without involving other levels of government or external agencies |
| **Criteria G3** | This adaptation option is an effective strategy for limiting council liability for losses associated with coastal hazards and sea-level rise |
| **Criteria G4** | Implementing this adaptation option would not infringe upon existing rights of property owners |

| Financial | |
|---|---|
| **Criteria F1** | This adaptation option is effective at protecting coastal properties and/or critical infrastructure from financial damage caused by coastal hazards |
| **Criteria F2** | Implementing this adaptation option would not impose a significant financial burden on council |
| **Criteria F3** | Implementing this adaptation option would not impose a significant financial burden on individual property owners or businesses affected by the adaptation option. |
| **Criteria F4** | Implementation of this adaptation strategy would keep the door open for the pursuit of alternative adaptation options in the future (i.e. preservation of 'real options') |

| Social | |
|---|---|
| **Criteria S1** | This adaptation option is effective at protecting socially or culturally significant locations from damage caused by coastal hazards |
| **Criteria S2** | This adaptation option is effective at protecting public health and safety from coastal hazards |
| **Criteria S3** | This adaptation option could be implemented without reinforcing or enhancing social inequities within the community (e.g. unequal distribution of costs and/or benefits) |
| **Criteria S4** | Implementation of this adaptation option would be readily accepted by the community and/or individual property owners |

| Environmental | |
|---|---|
| **Criteria E1** | This adaptation option is effective at enabling ecological assets (e.g. native vegetation and wetlands) to cope naturally with coastal erosion and inundation |
| **Criteria E2** | Implementing this adaptation option would enhance the natural amenity and/or ecological value of a given location or community |
| **Criteria E3** | Implementing this adaptation option at one location would not contribute to adverse ecological outcomes at other locations |
| **Criteria E4** | Implementing this adaptation option would provide existing and/or future development with a natural buffer from coastal processes and hazards |

# GLOSSARY

**Adaptability** – the capacity of a system to manage resilience, to stop it crossing a threshold thereby maintaining the same system (Cork 2011).

**Adaptation options** – a discrete action or activity taken in response to current or expected climate risks to address impacts such as inundation.

**Adaptation pathways** – a flexible course of action taken over time in response to potential or actual climate risk. The pathway is comprised of cost effective groupings of adaptation options that will help increase the resilience of the area by either reducing the cost of damages and/or the extent of impacts. The purpose of the pathway is to map possible actions and their assumptions to better support flexible decision making in the face of uncertainty.

**Adaptive capacity** – The combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities (IPCC 2012).

**Australian Height Datum (AHD)** – the standard for altitude measurement in Australia. 0m AHD was mean sea level as determined in 1971 by Geoscience Australia and has been adopted by the National Mapping Council as the datum to which all vertical measurement for mapping (and other surveying functions) is to be referred.

**Catchment** – the Victorian Catchment and Land Protection Act 1994 defines a catchment as an area of land which, through run-off or percolation, contributes to the water in a stream or stream system. In this project, catchment also refers to where water joins or drains to Port Phillip Bay.

**Climate change** – A change in climate which can be measured and that persists for an extended period, typically decades or longer. Climate change may be due to natural processes or anthropogenic changes in the composition of the atmosphere[1] (IPCC 2012).

**Climate extreme (extreme weather or climate event)** – the occurrence of a weather or climate variable above (or below) a threshold value near the upper (or lower) end of the range observed. For simplicity, both extreme weather events and extreme climate events are refereed collectively as 'climate extremes' (IPCC 2012)[2].

**Climate scenario** – a plausible and often simplified representation of the future climate, based on a set of climatological relationships (IPCC 2012).

**Coastal geomorphology** – the physical structures, processes and patterns associated with the coast, including landforms, soils, geology and factors that influence them.

**Coastal squeeze** – is the term used to describe what happens to coastal habitats that are trapped between two forces - pressures from the coast (such as sea level rise or storm surges) and pressures from the catchment (such as land use and population growth). The coastal habitat is effectively 'squeezed'.

**Cost benefit analysis** – a well-established systematic process that involves the assessment of costs and benefits of an activity over a defined time period. Costs and benefits are always measured as incremental changes relative to a base case (or 'business as usual' case) – for this study, the impact of coastal inundation without any adaptation. The benefit is therefore the incremental reduction in the expected annual average damages as a result of adaptation. Costs and benefits that occur in different time periods are made comparable in the present time period by converting to Present Value using a process known as discounting.

**Coastal storm event** – a meteorological event that results in elevated tides as a result of high winds and increased waves (also referred to as storm surge).

**Decision-making framework** – a structure for organising complex information to assist with solving a problem, such as to identify a potential adaptation pathway for a defined location.

[1] *This definition differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), where climate change is defined as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes.*

**Disaster** – a sever alteration to the function of a community due to physical events, leading to adverse human, material, economic or environmental effects that require immediate emergency response to satisfy critical human needs and may require external support for recovery (IPCC 2012).

**Exposure** – having no protection from something harmful

**Greenhouse Alliance** – ten groups established around Victoria as formal partnerships between local government to share information, coordinate emissions reductions and adaptive activities.

**Hazard** – a natural or human-induced physical event that may cause loss of life, injury or other health impact. It also refers to the damage and loss of property, infrastructure, livelihoods, service provision and environmental resources (IPCC 2012).

**Integrated coastal zone management** – a framework that attempts to integrate planning and management in a region, such as the Bay, across the land and sea interface; and the private and public land interface, to treat coastal zone (which includes the catchment) as one biophysical entity.

**Longshore drift -** the geological process of transportation of sediments (clay, silt, sand and shingle) along a coast parallel to the shoreline caused by oblique waves (waves that break at an angle to the shoreline).

**Maladaptation** - A maladaptation is a trait that is (or has become) more harmful than helpful. It can also signify an adaptation that, whilst reasonable at the time, has become less and less suitable and more of a problem or hindrance in its own right, as time goes on. This is because it is possible for an adaptation to be poorly selected or become less appropriate over time.

**Mean sea level** - the average relative sea level over a period, such as a month or a year, long enough to average out transients such as waves and tides (IPCC 2012).

**Mitigation** – when referring to disaster risk it is the lessening of the adverse impact of hazards through actions that reduce hazards, exposure and vulnerability; and increase resilience (IPCC 2012).

**Present value** – The worth of a future amount of money at a specific time point. To calculate discount the interest rate or rate of return from the future amount in order to arrive at the present value (Farlex Financial Dictionary 2012).

**Relative sea level** – sea level measured by tide gauge with respect to the land upon which it is situated. Also see Mean sea level. (IPCC 2012).

**Resilience** – the ability of a system and its component parts to anticipate, absorb, accommodate or recover from the effects of a hazardous event in a timely manner, including through the preservation, restoration or improvement of its basic structures and functions (IPCC 2012).

**Return period** – an estimate of the average time interval between occurrences of an event (e.g. flood or extreme rainfall) of (or below/above) a defined size or intensity (IPCC 2012).

**Risk** – the degree of exposure to a hazard where there is a potential for loss.

**Rollback** – the relocation/replacement/physical movement of at risk property and infrastructure to areas inland away from the eroding coastline (DEFRA 2015).

**Scenarios** – a plausible and often simplified description of how the future may develop based on a set of assumptions about driving forces and key relationships. Scenarios may be derived from projections, but are often based on additional information from other sources, sometimes combined with a narrative storyline. (IPCC 2012).

**Sea level rise (SLR)** – the long-term trend of increasing average sea level height, not caused by seasonal or metrological factors. The cause of sea level rise is attributed to thermal expansion and mass exchange of water between oceans and land. Global warming from increasing greenhouse gas concentrations is a significant driver of both sources.

**Storm surge** – The temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions (low atmospheric pressure and/or strong winds). The storm surge is defined as being the excess above the level expected from the tidal variation alone at that time and place (also referred to as 'coastal storm event' in this project) (IPCC 2012).

**Storm tide** – the total elevated sea height at the coast above a datum during a storm, combining storm surge and the predicted tide height.

**Sustainability** – development that meets the needs of the present without compromising the ability of future generations to meet their own needs (IPCC 2012).

**Threshold or tipping point** – the point in a system at which sudden or rapid change occurs, which may be irreversible.

**Transformation** – the altering of fundamental attributes of a system (including value systems, regulatory, legislative or bureaucratic regimes; financial institutions; and technological or biological systems) (IPCC 2012).

**Urban heat island effect** – the relative warmth of a city compared with surrounding rural areas. Associated with changes in runoff, the concrete jungle effects on heat retention, change in surface albedo, changes in pollution and aerosols, and so on. (IPCC 2012).

**Vulnerability** - The propensity or predisposition to be adversely affected (IPCC 2012).





*[2] The IPCC has a long discussion about how to define 'climate extreme', siting a number of approaches used throughout scientific research. See page 115 of the IPCC 2012: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change*

# BIBLIOGRAPHY

Bosomworth, K. Harwood, A. and Wallis, P. 2015. Adaptation Pathways: a playbook for developing robust options for climate change adaptation in natural resource management. Southern Slopes Climate Change Adaptation Research Partnership.

Central Coastal Board. Central Regional Coastal Plan 2015-2020.

Collaborative for Landscape Planning. 2010. Local Climate Change Visioning and Landscape Visualisation: Guidance manual and executive summary.

Cork, S 2011. A framework for assessing resilience in SoE 2011 reporting. Report prepared for the Australian Government Department of Sustainability, Environment, Water, Population and Communities on behalf of the State of the Environment 2011 Committee. Canberra: DSEWPaC.

Department for Environment Food & Rural Affairs (DEFRA), 2003. Guidance Note on Managed Realignment: Land Purchase, Compensation and Payment for Alternative Beneficial Land Use.

Department for Environment Food & Rural Affairs (DEFRA), 2015. Adapting to Coastal Erosion: Evaluation of rollback and leaseback schemes in Coastal Change Pathfinder projects.

Department of Environment, Land, Water and Planning (DELWP), 2016. Marine and Coastal Act Consultation Paper.

Department of Environment, Land, Water and Planning (DELWP), 2016. Draft Port Phillip Bay Environmental Management Plan 2017-2027.

Farlex Financial Dictionary 2012. www.financial-dictionary.the free dictionary.com

www.financial-dictionary.the free dictionary.com Gorddard, R. Colloff, M. Wise, R. Ware, D & Dunlop, M. 2016 Alues, rules and knowledge: Adaptation as change in the decision context. Environmental Science and Policy 57, 60-69.

Haasnoot, M., Kwakkel, J., Walker, W., ter Maat, J. 2013. Dynamic Adaptive Policy Pathways: A method for crafting robust decisions for a deeply uncertain world. Global Environment Change 23, 485-498.

Hunter & Central Coast Regional Environmental Management Strategy (HCCREMS) 2012. Decision Support for Coastal Adaptation: The Handbook. Hunter Councils NSW.

International Council for Local Environmental Initiatives (ICLEI) Building Adaptive and Resilient Communities Tool (on line resource available at http://www.icleicanada.org/resources/item/2-adaptation-tool).

Inglis, J., Whittaker, S., Dimitriadis, A. and Pillora, S. 2014. Climate Adaptation Manual for Local Government – Embedding resilience to climate change. Australian Centre of Excellence for Local Government, University of Technology, Sydney.

Intergovernmental Panel on Climate Change (IPCC), 2012: Glossary of terms. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 555-564.

Kwadijk, M. Hassnoot, M. Mulder, J. Hooguliet, M. Jeuken, A. van der Krogt, R. van Oostrom, N. Schelfhout, H. van Velzen, E. van Waveren, H. de Wit, M. 2010 Using adaptation tipping points to prepare for climate change and sea level rise: a case study in the Netherlands. Wiley Interdisciplinary Reviews: Climate Change 1, 729-740.

Moretti, C. Siebentritt, M. Spoehr, J. 2015. Learning from the implementation of South Australia's Climate Change Adaptation Planning Framework, Adelaide.

National Oceanic and Atmospheric Administration (NOAA), 2016. Living Shoreline Planning and Implementation.

Page, L & Thorp, V. 2010. Tasmanian Coastal Works Manual: A best practice management guide for changing coastlines. Department of Primary Industries, Parks, Water and Environment – Tasmania.

Pontee, N. 2013. Defining coastal squeeze: A discussion. Ocean & Coastal Management 84 204-207.

Reef Ball Foundation. 2008. A step-by-step guide for grassroots efforts to reef rehabilitation.

Reidy, C. 2012. Engaging Communities in climate change adaptation: a case study from North East Victoria. Coastal Conference 2012.

Rosenzweig, C and Solecki, W. 2014. Hurricane Sandy and Adaptation pathways in New York: Lessons from a first-responder city. Global Environmental Change 28, 395-408.

Stafford Smith, M. S., Horrocks, L., Harvey, A., Hamilton, C. 2011. Rethinking adaptation for a 4ºC World. Philosophical Transactions of the Royal Society A: 369:196-216.

Topke, Katrien. 2015. www.coastalwiki.org

Turner, S. Fünfgeld, H. Robertson, S. 2016. Strategies for Embedding Climate Change Adaptation in Public Sector Organisations: A review of the academic and grey literature. Centre for Urban Research.

UKCIP Adaptation Wizard (on line tool available at http://www.ukcip.org.uk/wizard/).

UNFCCC 1999. Coastal Adaptation Technologies. United Nations Framework Convention on Climate Change.

Melbourne Water. 2013. Water Sensitive Urban Design Guidelines – South East Councils.

Wise, R. Fazey, I. Stafford Smith, M. Park, S. Eakin, H. Archer Van Garden, E. Campbell, B. 2014. Reconceptualising adaptation to climate change as part of pathways of change and response. Global Environmental Change 28, 325-336.

# IMAGE REFERENCES

Image 1: Limeburners Saltmarsh, LimeburnersBay, Corio (City of Greater Geelong).

Image 2: The Dell Clifton Springs (City of Greater Geelong).

Image 3: Andrea Hesketh, RMIT Masters of Landscape Architecture and Urban Planning Design - Bay Blueprint Visualisation, 2016.

Image 4: Frankston City Foreshore and coastline (Skypics).

Image 5: Frankston City foreshore and coastline (SkyPics).

Image 6: Black Rock, Vic (Werner Hennecke).

Image 7: Watkins Bay, Beaumaris (Pauline Reynolds).

Image 8: Middle Park beach renourishment (City of Port Phillip).

Image 9: Adapted from Coastal Wiki - artificial nourishment (www.coastalwiki.org.wiki/artificial_nourishment).

Image 10: beach renourishment at Longboat Key, Florida Beach USA (10 News Tampa Bay).

Image 11: Dune planting at Bend in the Road, Massachusetts USA (Vineyard Gazette).

Image 12: Meghan Doherty, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 13: Adapted from Centre for Coastal Resource Management, Virginia USA.

Image 14: Fossil Beach, Mornington Victoria (The Mornington Peninsula www.themorningtonpeninsula.com).

Image 15: Brayden Murrihy & Zhimo He, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 16: Brayden Murrihy & Zhimo He, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 17: Brayden Murrihy & Zhimo He, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 18: Meghan Doherty, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 19: Rock revetment, Tanilba Bay NSW (Robson Civil Projects).

Image 20: Sandbag revetment, Byron Bay NSW (Flickr).

Image 21: Adapted from Lake Ontario Riparian Alliance.

Image 22: Red Bluff Cliffs, Black Rock (Pauline Reynolds).

Image 23: Meghan Doherty, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 24: Devindya Prasadhi Adikarige & Weichu Zeng, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 25: Meghan Doherty, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 26: Jake Small & Liam Mullen, RMIT Masters of Landscape Architecture and Urban Planning - Bay Blueprint Visualisation, 2016.

Image 27: Coastal tussock grass stabilising cliff, Gippsland Victoria (Wild South East Blog).

Image 28: Mentone Cliffs, Vic (Kingston City Council).

Image 29: Adapted from The Geomorphological Zone of Coastal Dunes Systems (Newman).

Image 30: Ilias Paras & Karen Lin, RMIT Maters of Landscape Architecture and Urban Planning Design Bay Blueprint Visualisation, 2016.

Image 31: Adapted from Siting and Design Guidelines for Structures on the Victorian Coast (Victorian Coastal Council, 1988).

Image 32: Waverley Cliffs walk, NSW (Waverley Council).

Image 33: Ilias Paras & Karen Lin, RMIT Maters of Landscape Architecture and Urban Planning Design Bay Blueprint Visualisation, 2016.

Image 34: Hunstanson stepped wall, UK (Getty images).

Image 35: Andrea Hesketh, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 36: Sea organ zadar, Croatia (Inhabitat).

Image 37: Brayden Murrihy & Zhimo He, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 38: Looking over Watkins Bay from Table Rock, Beaumaris (Pauline Reynolds).

Image 39: Flood resilient Queenslander concept (Cox Rayner Architects).

Image 40: Planning advice note, PAN 69, Scotland (Scottish Government).

Image 41: Planning advice note, PAN 69, Scotland (Scottish Government).

Image 42: North Wagga levee, NSW (The Daily Advertiser).

Image 43: Coulpton Creek design, Los Angeles (LA Creek Freak).

Image 44: Andrea Hesketh, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 45: Resilient house for Far Rockaway, New York (Sustainable. TO Architecture and Building).

Image 46: NYIT's School of Architecture and Design response to Hurrican Sandy (NYIT).

Image 47: Hexagonal units designed to be more resilient to earthquakes and floods (Mapúa student designs, Green Bulb).

Image 48: Meghan Doherty, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 49: Des Plaines River flood wall, Illinois (Illinois construction).

Image 50: Meghan Doherty, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 51: Meghan Doherty, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 52: City views from Green Point, Brighton (Pauline Reynolds).

Image 53: Biodiversity Sensitive Urban Design (Dr. Georgia Garrard, RMIT University).

Image 54: Lyndhurst Estate swale, Victoria (KLM spatial land developers).

Image 55: Water boulevards concept design (Baharash Architecture).

Image 56: Water sensitive city (CRC for Water Sensitive Cities).

Image 57: Raingarden tree pit (City of Melbourne).

Image 58: Jake Small & Liam Mullen, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 59: Jake Small & Liam Mullen, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 60: Jake Small & Liam Mullen, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 61: Jake Small & Liam Mullen, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 62: Jake Small & Liam Mullen, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 63: Jake Small & Liam Mullen, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 64: McCulloch Avenue Boardwalk, Seaford Foreshore (Lisbeth Grosmann).

Image 65: Sydney Park NSW (City of Sydney).

Image 66: Oaklands wetlands, South Australia (City of Marion).

Image 67: Brighton Beach rock groyne (Chris Eastman, Leader Newspaper).

Image 68: Adapted from Coastal Erosion by David Rixon).

Image 69: Meghan Doherty, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 70: Meghan Doherty, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 71: Meghan Doherty, RMIT Masters of Landscape Architecture and Urban Planning – Bay Blueprint Visualisation, 2016.

Image 72: Beachboxes (Werner Hennecke).

Image 73: Frankston City foreshore and coastline (SkyPics).

Image 74: Portsea, Vic (Werner Hennecke).

Image 75: Frankston City foreshore and coastline, Seaford Boardwalk (SkyPics).

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