

m p rogers & associates pl
creating better coasts and ports



Draft Coastal Hazard Risk Management and Adaptation Plan

2023 - 2033

DRAFT

ACKNOWLEDGEMENTS

The City engaged MP Rogers and Associates to develop a technical Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for the City which was completed in 2022. All the technical information presented within this document is sourced from the MP Rogers and Associates technical CHRMAP.

The City engaged Water Technology to create this community-facing CHRMAP using the MP Rogers & Associates technical CHRMAP.

The City of Joondalup acknowledges the Traditional Custodians of this land, the Whadjuk people of the Noongar nation and pay our respects to Elders past, present and emerging as well as all Aboriginal and Torres Strait Islander peoples.

DRAFT

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1 INTRODUCTION

The City of Joondalup (the City) covers an area of 99 km² and includes 17 km of coastline from Marmion in the south to Burns Beach in the north. The City's coastline is highly valued by the community and its visitors, and it supports a variety of land uses including recreation, conservation, residential and commercial. The coastline includes foreshore reserves with regionally significant vegetation and Bush Forever sites.

The City's coastal zone is already affected by coastal hazards, such as erosion, and it is anticipated that the effects of these hazards will increase into the future, due to climate change and sea level rise. A Coastal Hazard Assessment was completed in 2016¹ to determine the potential extent of coastal erosion and inundation hazards, across a 100-year planning timeframe. A risk and vulnerability assessment was then completed to highlight the most vulnerable areas and assets across the City's coastline, and outline a plan for these areas.

A Coastal Hazard Risk Management and Adaptation Plan (CHRMAP)² has been developed to define areas of the coastline which could be vulnerable to coastal hazards and to outline the preferred approach and pathways to manage these hazards. The CHRMAP process is designed to be ongoing with regular reviews incorporating the emergence of new information. The CHRMAP has been developed to follow the requirements of Western Australian State Planning Policy No. 2.6: State Coastal Planning Policy (SPP2.6)² and supporting guidelines.

The CHRMAP considers the potential risks posed by coastal hazards over a 100-year planning timeframe, highlighting risks in 2015, 2065 and 2115, and acknowledges the need to balance environmental, social, and economic values to ensure the City's coastline is sustainable in the long term.

1.1 What is a CHRMAP?

A CHRMAP is a strategic long-term plan that informs the City and the community about the expected coastal hazards, such as erosion and inundation (flooding), over the next 100-years and provides options and pathways to adapt to these hazards and changing conditions over time.

The potential vulnerability of the coastal zone and the subsequent risk to the community, economy and environment needs to be considered for the City's coastline, which holds significant natural and built assets close to the shoreline.

Climate change and sea level rise increase the risk of coastal hazards, which pose a risk to the assets located within the coastal zone. These assets include both built and natural assets, which provide a range of values to the community, including social, environmental, economic and heritage values.

The key benefit of a CHRMAP is to develop a risk-based adaptation framework to protect and manage assets that could be at risk of impacts from coastal hazards over the relevant planning timeframes.

1.2 Purpose & objectives

The main purpose of a CHRMAP is to identify current and future coastal hazard risks and provide a framework for adapting to coastal hazards over a 100-year timeframe.

¹ MP Rogers and Associates 2016

² WAPC 2013

The objectives of this CHRMAP are to:



Protect, conserve, and enhance coastal zone values including environmental, social, cultural significance and economic values.



Identify the coastal hazard risks over the next 100 years.



Develop and prioritise adaptation pathways and options to help mitigate coastal hazard risks, where necessary, over the 100-year planning timeframe.



Engage stakeholders and the community in the coastal hazard planning and decision-making process.

1.3 Why does the City need a CHRMAP?

The global mean sea level has been rising for the last 100-years and levels are predicted to rise at an increasing rate in the future. Rising sea levels and intensifying storm activity will increase the risk of temporary coastal flooding (coastal inundation) and coastal erosion.

The City's coastal zone is already subject to the impacts of coastal hazards, and it is essential that the City has a framework in place to manage the effects of these coastal hazards now, and into the future. The CHRMAP provides the City with a long-term strategic direction, while identifying risks and proposing triggers and pathways for adaptation options.

The area around the Marmion Angling and Aquatic Club (MAAC) in Marmion has been identified as one of 55 erosion hotspot priority areas in Western Australia, by the Department of Planning, Lands and Heritage and the Department of Transport³.

Mullaloo Surf Life Saving Club has also been included as a watchlist location in the assessment of coastal erosion hotspots in WA. Watchlist locations have some coastal assets but there are possible reasons why erosion may not affect the location, the assets susceptible to erosion hazard are deemed to be of low or moderate value or the existing management actions and plans reduce the overall hazard³.

Pinnaroo Point in Hillarys has also been identified as an area susceptible to coastal erosion and has experienced substantial erosion to date^{4,5}.

³ Seashore Engineering Pty Ltd 2019

⁴ Department of Climate Change 2009

⁵ Jones et al. 2005

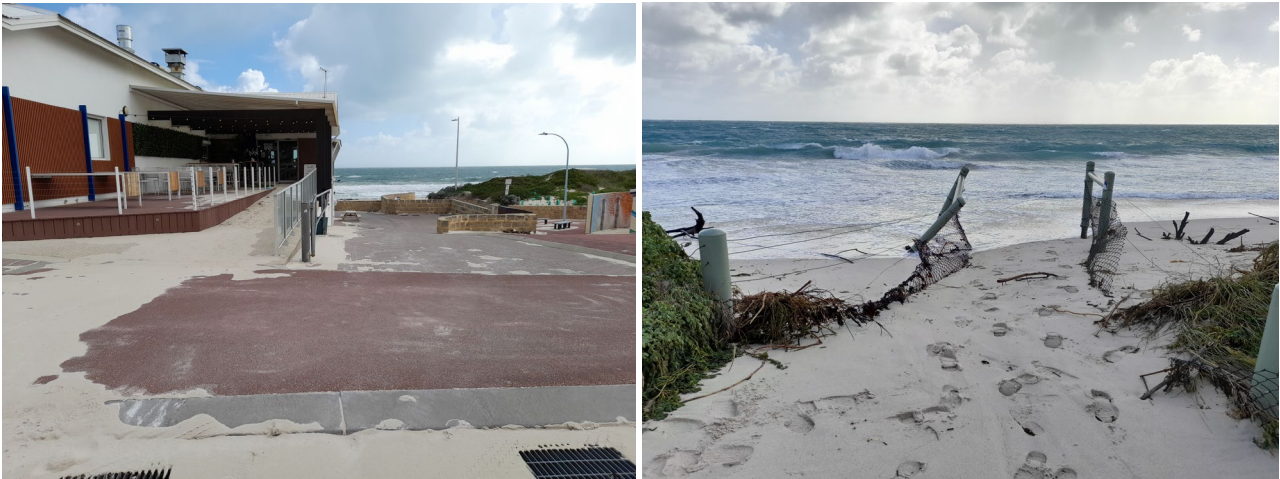


Figure 1-1 Examples of coastal erosion at Mullaloo Foreshore Reserve, Mullaloo and Pinnaroo Point, Hillarys

A Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) is required under the State's Coastal Planning Policy 2.6² (SPP2.6), under the *Planning and Development Act 2005*. This CHRMAP aligns with the following SPP2.6 overarching objectives:

- Ensure that development and the location of coastal facilities consider coastal processes, landform stability, coastal hazards, climate change and biophysical criteria.
- Ensure the identification of appropriate areas for the sustainable use of the coast for housing, tourism, recreation, ocean access, maritime industry, commercial and other activities.
- Provide for public coastal foreshore reserves and appropriate coastal access.
- Protect, conserve and enhance the coastal zone values particularly in areas of landscape, biodiversity and ecosystem integrity, indigenous and cultural significance.

The CHRMAP was developed to also align with the WA Coastal Zone Strategy⁶, which aims to conserve the State's natural coastal values and assets, ensure safe public access to the coast, provide for the sustainable use of natural coastal resources, ensure infrastructure locations are sustainable and suitable, and build community confidence in coastal planning and management.

The CHRMAP aligns with the City's Strategic Community Plan 2022-2032 outcomes: 2-1 Managed and protected and 2-4 Resilient and prepared. Community consultation was conducted to inform the development of the Strategic Community Plan 2022-2032 and beach management was ranked in the top five priorities that are most important to the community. The City's strategic environmental framework is outlined in Figure 1-2.

⁶ Department of Planning, Lands and Heritage 2021



Figure 1-2 City of Joondalup Strategic Environmental Framework

1.4 How have we developed this CHRMAP?

The City's CHRMAP development has included the following steps (see Figure 1-3):

- **Stage 1** (completed in 2016) identify the vulnerable areas, by assessing the ongoing coastal monitoring program results, and identify the City's coastal hazards through a Coastal Hazard Assessment.
- **Stage 2** (completed in 2018) define the City's community coastal values through a Community Coastal Values Survey and assess the coastal infrastructure through the Coastal Infrastructure Adaptation Plan.
- **Stage 3** (completed in 2022) engage certified engineers, MP Rogers and Associates, to analyse the existing data and develop a technical CHRMAP for the City which included:
 - Identifying the City's coastal hazards and their likely impacts today, in 2065 and 2115.
 - A detailed risk analysis for the assets within the City's coastal zone.
 - A range of proposed adaptation options for each coastal management zone.
 - A Multi-Criteria Analysis and Cost Benefit Analysis for each of the proposed adaptation options.
 - A list of preferred adaption options, based on the outcomes of the Multi-Criteria Analysis and Cost Benefit Analysis, for each asset and coastal management zone.
- **Stage 4** (in progress) involves using the technical information from the technical CHRMAP to develop a community-facing CHRMAP and implementation plan. The community-facing CHRMAP will be released for community consultation in 2023.
- Once the final CHRMAP is complete, the City will continue to monitor for adaptation triggers and will update and change the plan if required.

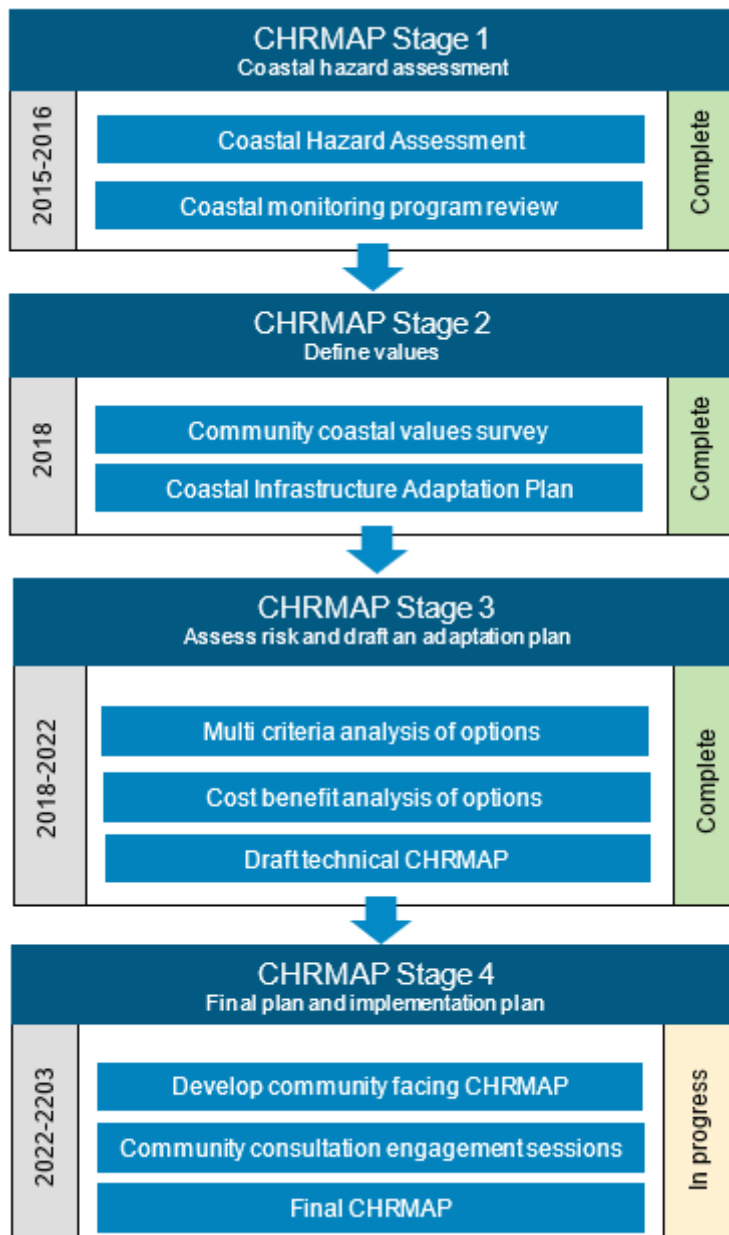


Figure 1-3 CHRMAP development stages

2 STUDY AREA

This CHRMAP applies to the City's entire 17 km of coastline from Marmion on the south boundary, adjacent to the City of Stirling, and Burns Beach on the north boundary, adjacent to the City of Wanneroo.

The area has been divided into seven management zones, based on geographic and coastal characteristics, as well as the coastal uses along the City's coastline. The seven coastal management zones are:

1. Marmion
2. Sorrento
3. Hillarys to Kallaroo
4. Mullaloo
5. Ocean Reef
6. Iluka
7. Burns Beach

The Ocean Reef Boat Harbour, within the Ocean Reef Coastal Management Zone, is not included in this CHRMAP. A new large-scale Ocean Reef Marina development is currently underway which requires its own dedicated CHRMAP. Likewise, Hillarys Boat Harbour, between the Hillarys and Sorrento coastal management zones, is owned and managed by the Department of Transport and therefore not included in this CHRMAP. The impact on coastal processes and adjacent zones from both existing harbours is captured by the Coastal Hazard Assessment report.⁷



⁷ MP Rogers and Associates 2016

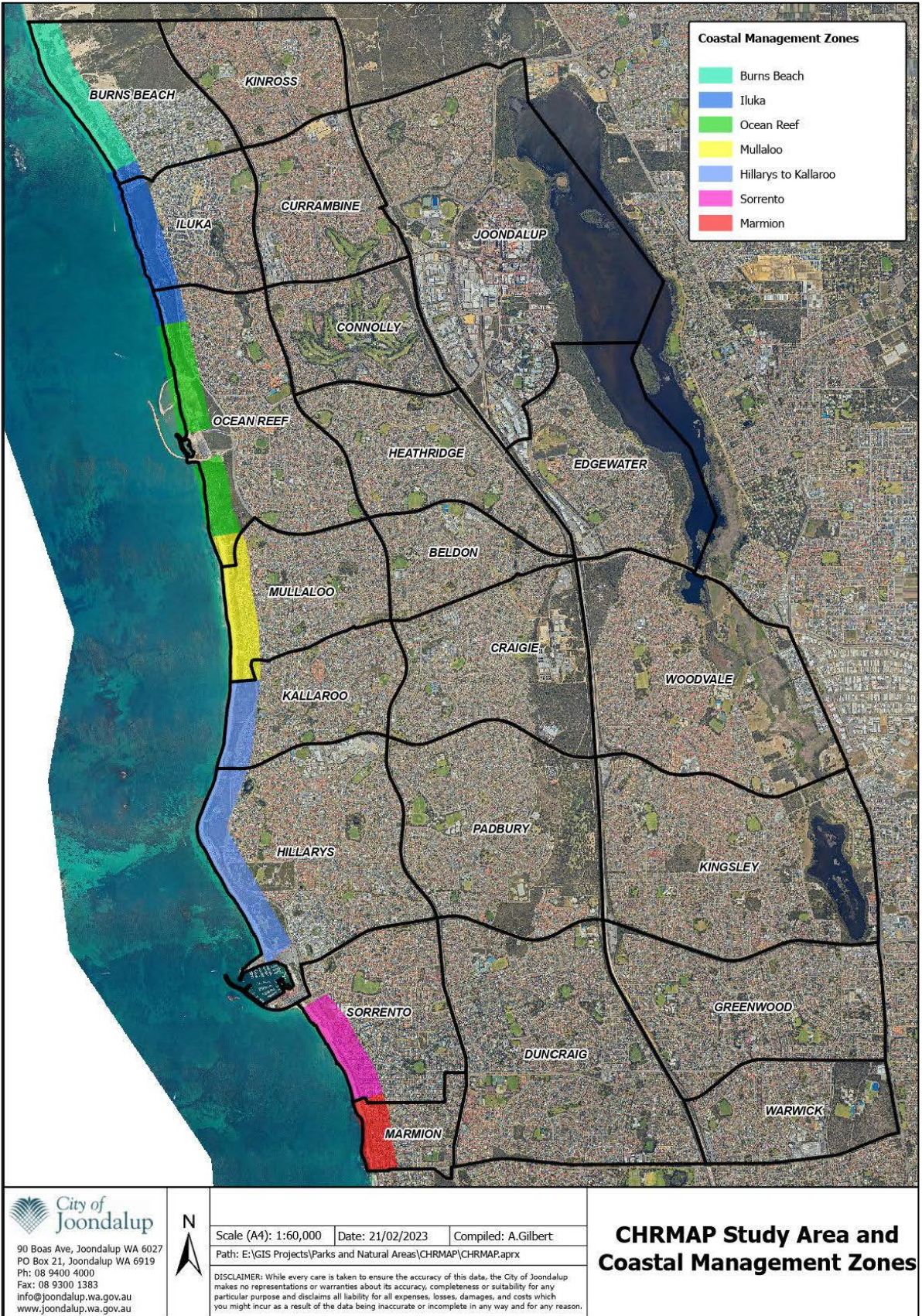


Figure 2-1 Study area and coastal management zones

3 EXISTING ENVIRONMENT

3.1 Climate

The City of Joondalup has a Mediterranean climate of hot, dry summers and mild, wet winters. Mean annual rainfall is 730 mm, with around 80% of the annual rainfall falling between May and September⁸. The daily mean temperature range is 12°C to 19°C in winter and 18°C to 30°C in summer⁸.

3.2 Hydrology

No natural wetlands occur within the foreshore reserves, however there is one artificial wetland located south of Hillarys Beach Park.

Groundwater across the City is a part of the Gnangara Groundwater System. The groundwater comprises of four aquifer layers, in order of increasing depth: Superficial, Mirrabooka, Leederville and Yarragadee aquifers.

3.3 Biodiversity

The coastal foreshore reserve is an area of high conservation significance, and the majority is designated as Bush Forever (site 325 and 322). The coastal foreshore reserve contains threatened ecological communities, priority ecological communities and threatened and priority plant and animal species.

The City's coastal foreshore reserves are home to many species of plants and animals including birds, reptiles, invertebrates and mammals. The coastal reserves also provide resting and breeding sites for a variety of seabirds, including several migratory species which are protected under international treaties.

3.4 Geology

The City's coastline lies on the Swan Coastal Plain and presents a variety of features including limestone cliffs, headlands, nearshore reef platforms, straight and pocket sandy beaches, and dune systems.

- **Marmion:** Beaches on the southern edge of the City's boundary consist largely of rock cliffs, interspersed with small sandy bays and pocket beaches. The sandy beach areas include a thin layer of sand overlying rock, which is exposed over winter.
- **Sorrento:** Further north, the shoreline becomes sandier, with less rock present on the shoreline and inshore areas.
- **Hillarys to Kallaroo:** the shoreline becomes sandier, with a narrow beach and high dunes. The Hillarys Boat Harbour offers some protection to the beach to the north of the harbour.
- **Mullaloo:** the beach is characterised by sandy beaches with coastal dunes of varying heights.
- **Ocean Reef:** the shoreline is predominately limestone cliffs, with sand moving in and out of the region seasonally.
- **Iluka:** the shoreline is mostly limestone cliffs interspersed with small sandy bays, with the sandy bays consisting of thin layers of sand overlying rock.
- **Burns Beach:** the northern-most section of shoreline is generally sandy, with high coastal dunes. For large parts of this section, the beach is narrow and there is nearshore rock and reef present.

⁸ Bureau of Meteorology 2023



Figure 3-1 Example a of sandy shoreline at Hillarys Beach, Hillarys



Figure 3-2 Example of a rocky shoreline at Ocean Reef Foreshore Reserve, Ocean Reef

3.5 Coastal processes

The coast is a narrow dynamic area influenced by complex interactions between winds, waves, tides, and currents with the sand, vegetation and rocks. These interactions shape the shoreline and are called coastal processes. Human activities in the coastal zone can also influence this dynamic area.

The coastal processes impact sand movement, coastal landforms, and shorelines, either gradually over time or abruptly during storm events.

3.5.1 Wind

The City experiences typical wind patterns for the area. The summer months are characterised by constant and moderate to strong south-westerly sea breezes which develop in the afternoon. The winter months are characterised by intermittent low-pressure systems, shifting the dominant wind direction to north-westerly, sometimes exceeding 20 m/s. Wind is one of the major means of sand movement within the foreshore dunes and is responsible for carrying sand from the beach further inland.

3.5.2 Waves

The swell is seasonal, with higher wave energy during winter. During summer most of the waves are locally generated by the sea breeze from the south and southwest. In winter, the storms are frequent and come from southerly offshore winds¹.

Severe storm events can cause increased erosion to shorelines, through higher, steeper waves from strong winds. When the storms are combined with increased water levels, the storm waves can erode the upper parts of the beach that are not normally vulnerable to wave attack¹.

3.5.3 Currents

Local ocean currents transport sand and sediment along the City's coastline and can cause erosion and accretion at different locations. The erosion and accretion rates depend on the site-specific coastal processes across the coastline, such as high and low energy zones in the water, wave intensity, wind, tides, and the presence of natural or built structures that block or intensify the currents.

3.5.4 Sea level and storm surges

The sea level is determined by the tides and storm surge, barometric pressure changes, and wind (piling up water on the coast). Sea level is also predicted to increase over time due to climate change impacts.

The tides on the Perth coast are mainly diurnal (one high and one low tide per day) and have a low range, rising the sea level up to 0.9 m. In the City, the coastal processes are dominated by waves and wind, rather than tides. Storm surges are the rise of the sea level because of strong wind piling up the water on the coast and atmospheric pressure changes associated with a storm. Storm surges can add up to 1.2 m of water on top of the tides.

Usually, the same storm that causes a storm surge also produces higher waves, and these two working together on a beach can have a significant impact on the coast, causing higher waves to reach higher up the beach and increasing erosion impacts.

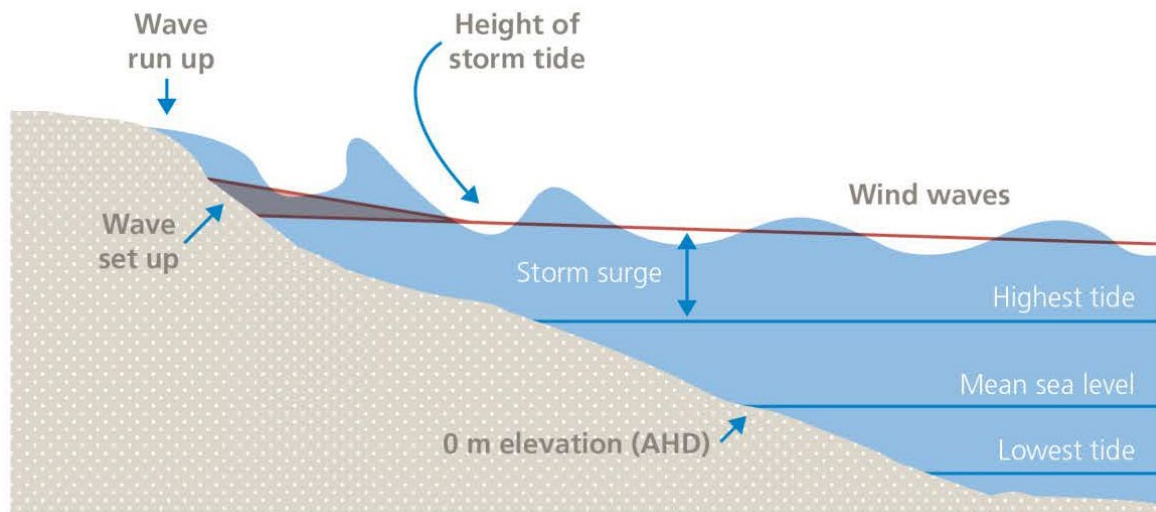


Figure 3-3 Storm surge and water levels (Source: CoastAdapt⁹)

3.6 Climate change

Climate change studies predict higher sea levels and more frequent sea level extremes¹⁰. By 2030, sea levels in the Perth region are projected to increase by 0.12 m, and between 0.46 m - 0.61 m by 2090, depending on emission rates¹⁰. These increases in sea level height cause the ocean to extend further inland⁹. Sea level rise also allows waves to reach further inland, increasing erosion risks.

Beaches with rocks and nearshore reefs are less vulnerable to erosion than sandy beaches because these structures dissipate the wave energy. However, with sea level rise, more wave energy can reach the shoreline and cause more erosion. The vulnerability of the coastline is projected to increase exponentially overtime due to climate change and sea level rise impacts.

⁹ CoastAdapt 2020

¹⁰ Department of Water and Environmental Regulation 2021

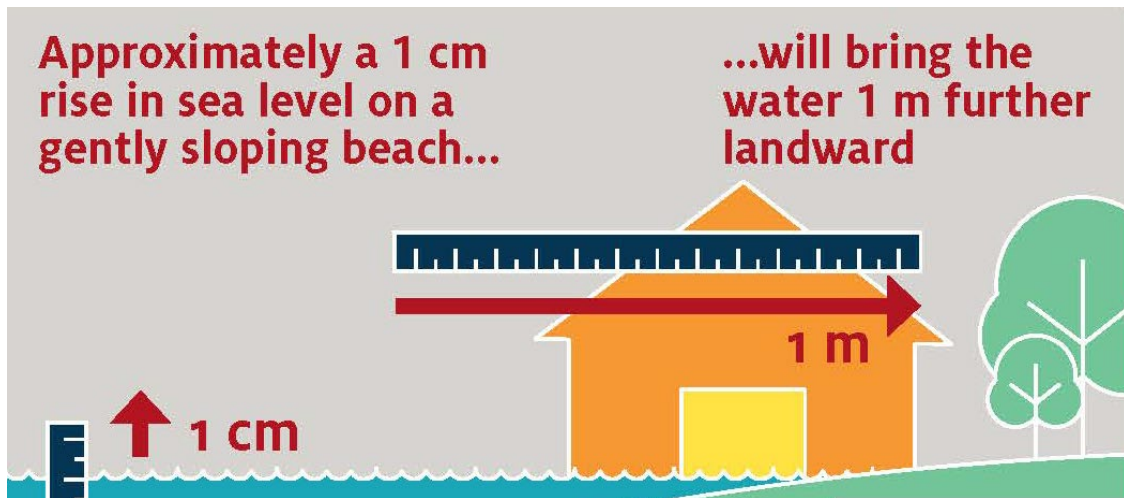


Figure 3-4 Sea level rise causing ocean water to extend further into land (Source: CoastAdapt⁹)

3.7 What is the City already doing?

3.7.1 Existing planning controls

The *State Planning Policy 2.6 – State Coastal Planning Policy (SPP2.6)*² recommends several planning controls, many of which the City is already implementing as outlined below.

Coastal Local Planning Policy

The Council endorsed the Coastal Local Planning Policy in April 2017 to ensure that:

- Coastal hazard risk management and adaptation planning is undertaken by proponents prior to the subdivision or development of larger areas of land in coastal hazard risk areas.
- For the development or subdivision of lots identified by the City as being subject to coastal hazard risk, a condition of those approvals requires the proponent to place a notification on the certificate of title.
- Where a lot is identified by the City as being subject to a coastal hazard risk within the next 100 years, the City will include this information on any Land Purchase Inquiry made in relation to that lot.
- Structure plans and local development plans will also be assessed against the requirements of SPP2.6.

Coastal foreshore reserve management

In 2014, the City developed the Coastal Foreshore Management Plan (2014-2024) to provide an overarching management direction for the coastal reserves, including options to protect and enhance biodiversity values of the natural areas while maintaining community access.

Additionally, five individual Natural Area Management Plans have been developed for specific sections of the coastal foreshore reserve to protect biodiversity values and prevent dune erosion. These management plans identify conservation management actions, such as weeding, revegetation, fencing, access controls and feral animal control.

The City also currently manages sand build-up at Sorrento Beach and Mullaloo Foreshore Reserve, by collecting sand that has built up against retaining walls and fences and moving it back towards the shoreline.

The City supports and works collaboratively with several coastal Friends Groups, providing support such as funding and plants for revegetation works. The City also delivers an annual 'Adopt a Coastline' schools program to educate and involve primary school students in coastal conservation activities.

Coastal Infrastructure Adaptation Plan

In 2018, the City developed the Coastal Infrastructure Adaptation Plan (2018-2026) and has been implementing the recommendations in this plan, such as completing maintenance, monitoring and inspecting coastal infrastructure, establishing processes to respond to coastal erosion events and identifying coastal hazards early in the planning stages of coastal projects.

3.7.2 Existing protection controls

Sand bypassing program

The Hillarys Boat Harbour has caused changes to the way sand moves across the City's coastal zone, with sand building up on beaches south of the harbour and eroding away from the beaches on the north side of the harbour. Since 2018, the City has been completing a sand bypassing program – extracting sand from Sorrento Beach (south of the harbour) and depositing it onto Hillarys Beach (north of the harbour).

Sand bypassing is generally completed once per year, moving approximately 8,000 cubic meters of sand. The frequency of sand bypassing and the sand volumes are likely to increase in the future, with an estimated 10,000 cubic meters of sand likely to be required to be moved annually from Sorrento Beach to Hillarys Beach¹¹.

Coastal protection assets

The City currently manages several coastal protection assets such as seawalls, groynes and breakwaters. The estimated structure replacement costs provided below were estimated in the *Coastal Protection Assets Condition Inspection Report*¹². The actual coastal asset replacement costs may have increased from the following estimates made in 2017:

- **Burns Beach groyne** is 60 m long and is constructed from limestone rock. It was constructed in the late 1960s to early 1970s and was upgraded in 2009.
 - Estimated replacement cost: \$825,000
- Ocean Reef Boat Harbour breakwaters (not assessed in this CHRMAP)
- **Mullaloo Surf Life Saving Club seawall** is a limestone retaining wall approximately 130 m long that provides some protection to the Mullaloo Surf Life Saving Club. It is estimated that this seawall was constructed in the late 1980s to early 1990s.
 - Estimated replacement cost: \$500,000
- **Sorrento Beach groynes** (3) are limestone and granite rock structures constructed in the early 1980s. These three groynes are 60 m, 80 m and 100 m long respectively.
 - Estimated replacement cost: \$1,100,000 for each groyne
- **Sorrento Surf Life Saving Club seawall** is a limestone block retaining wall approximately 220 m long adjacent to the Sorrento Surf Life Saving club.
 - Estimated replacement cost: \$1,300,000

¹¹ MP Rogers and Associates 2022

¹² MP Rogers and Associates 2017

- **Marmion Angling and Aquatic Club (MAAC) seawall** is 100 m long and was constructed in the 1970s using limestone rocks. It provides protection to the MAAC clubrooms and small sections of the carpark. The State Government has identified the MAAC seawall as a coastal erosion hotspot where appropriate management of coastal assets is required.
 - Estimated replacement cost: \$1,100,000.

The City conducts coastal protection asset condition inspections every 3-5 years on existing coastal protection assets. Maintenance and monitoring of the Burns Beach groyne and sea walls at Marmion, Sorrento and Mullaloo are addressed separately to this CHRMAP as they are not considered to be primary coastal protection assets (see Section 9.3.6 for further information).

3.7.3 Coastal monitoring program

The City started monitoring the coastline in 2015/16 to monitor shoreline movement and assist the City to manage coastal assets. The monitoring program runs annually, with a data report provided each year and a full report completed every two years. The monitoring program includes:

- Beach profile and hydrographic surveys (every second year)
- Inspections and photo monitoring of the beach
- Mapping the shoreline from aerial photos.

The results are used to monitor long term trends, such as the change in vegetation lines and shoreline recession. The results are also used to trigger actions, such as beach nourishment works, and inform long-term coastal planning.

4 COMMUNITY & STAKEHOLDER ENGAGEMENT

4.1 Why is engagement important?

Community and stakeholder input is essential for an effective CHRMAP process, helping the City to better understand how people use and value the coast, and providing input into how the coastline should be monitored and managed.

4.2 Community coastal values survey

Community consultation for the City's CHRMAP began with a Community Coastal Values survey to enable the City to better understand how the community uses and values the coast. The survey was open for one month in 2018 and received 1,318 valid responses¹³.

Respondents were asked:

- How do you use the coastline?
- What assets are the most important?
- What adaptation options do you support?
- What factors should be considered when making coastal adaptation decisions?
- Have you noticed areas of erosion along the City's coastline?

The outcomes highlighted that the community value the coastal zone and place a higher value on natural assets, such as the beach and dunes, over public and private buildings. The community strongly opposed 'doing nothing' to manage coastal erosion and supported softer adaptation options such as dune stabilisation and revegetation, rather than hard engineered protection structures.

The outcomes from the survey are summarised below.

How do people use the coastline?

- The **City's coastline is extremely popular**. More than 90% of respondents indicated that visiting the coast was very important to them, with most respondents visiting the coast at least once a week throughout the year, with higher use over summer and spring.
- The most popular activities with 80% of the respondents are beach-based activities (walking, running, sitting, relaxing on the sand), coastal path activities (walking, running, cycling on the coastal paths) and adjacent commercial and leisure activities (cafes, restaurants, shops).

What assets are valued by the community?

- Most valued are the **natural assets**, including the beach and coastal dunes/vegetation, and coastal pathways.
- **Public infrastructure** (surf lifesaving clubs, toilets, changerooms etc) and foreshore parks are the second most valued assets.
- The least valued assets are **private buildings** (residential housing, cafes, shops etc).

¹³ City of Joondalup 2018b

What adaptation options are supported?

- **Dune stabilisation and revegetation** was the most supported adaptation option, with more than 80% of the survey respondents showing positive support for this option.
- **Preventing or limiting further development** in vulnerable areas was the second most supported option.
- Most respondents (70%) were **opposed or strongly opposed to 'doing nothing'**. This was the least supported option.
- Adaptation options that retained a sandy beach were more strongly supported than those options where the sandy beach may be lost.

What factors should be important for consideration when making coastal adaptation decisions?

- The community are highly concerned with **maintaining the natural components of the coast** and are less concerned with protecting public and private buildings.
- Overall, the respondents ranked **maintaining a sandy beach** for amenity and recreational use and ensuring safe access to the beach for all beach users, to be the most important factors to consider when making decisions about coastal adaptation measures.
- The respondents ranked the financial cost of adaptation options as the least important factor to be considered when making coastal adaptation decisions.

Have people noticed increased erosion along the City's coastline?

- Around one third of the survey respondents identified areas of the City's coastline where they have noticed increased erosion.
- Common locations for erosion included Burns Beach Foreshore Reserve, Iluka Foreshore Reserve, Mullaloo Foreshore Reserve, Pinnaroo Point, Hillarys animal exercise beaches and Whitfords Nodes.

The outcomes from the community values survey were used to guide the development of the CHRMAP.

4.3 What community consultation is still to come?

The City will release the draft CHRMAP for public comment in 2023 and will facilitate several community information sessions. The City will be asking the community for feedback around the objectives of the draft CHRMAP and the potential adaptation options and pathways proposed. Outcomes from this consultation will then be incorporated into a final CHRMAP and Implementation Plan which will be presented to Council for endorsement.

Further consultation will be undertaken with the community prior to undertaking adaptation options, in accordance with the City's Community Consultation Policy.

5 COASTAL HAZARDS

5.1 What are coastal hazards and how are they estimated?

Within the CHRMAP process, coastal hazards are defined as coastal erosion and inundation. These hazards have the potential to impact coastal areas and assets along the City's coastline.

The coastal hazards have been modelled for the City's coastline for 2015, 2065 and 2115. Coastal hazard modelling was based on the parameters in SPP2.6, which provides allowances for storm events, historic shoreline movements and future sea level rise.

The modelling resulted in coastal hazard lines being derived for 2015, 2065 and 2115, showing the active limit for coastal hazards at these timeframes. These hazard lines are presented in Section 7 and are used to identify at-risk areas and assets, now and in the future.



Figure 5-1 Causes and drivers of coastal hazards (Source: CoastAdapt⁹)

5.2 Coastal erosion

Coastal erosion happens when the sand and sediments from beaches and dunes are transported away by waves, wind and currents. Erosion can reduce the size of a sandy beach and reduce sand dunes.

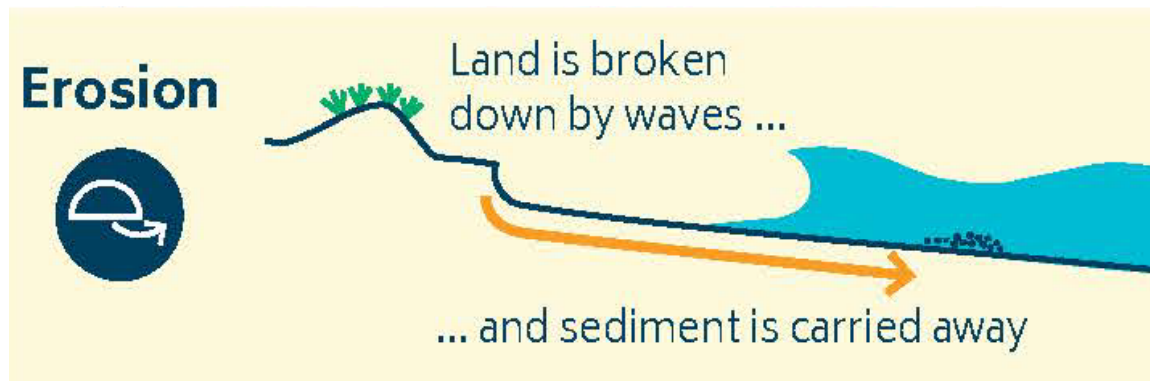


Figure 5-2 Coastal erosion process (Source: CoastAdapt⁹)

Rates of erosion are variable across the City's coastline and depend on:

- the presence of any offshore natural structures, such as reefs and islands, which can offer some protection against erosion by reducing wave intensity.
- the location of engineered structures such as harbours and groynes. Engineered structures change currents and sand movement, usually causing sand to build up on beaches on the south side of the structure and erode on the north.
- the beach composition - rock can offer more protection from erosion than sand.
- dune vegetation cover, as dunes are more vulnerable to wind erosion when they are bare sand and not covered in vegetation.
- the coastal processes such as tides, wind, currents, wave intensity, storm intensity and sea level rise.

For the City's **sandy coasts**, coastal erosion hazard zones were estimated using the following values¹¹:

- an allowance for the current risk of storm erosion based on a 100-year average recurrence interval storm event (S1 erosion).
- an allowance for future erosion based on historic shoreline movement trends (S2 erosion).
- an allowance for future erosion related sea level rise (S3 erosion).
- an additional factor of uncertainty.

These four values for sandy coasts were summed to provide coastal erosion hazard zones, which translate into areas on maps showing the potential erosion lines of the coast at 2015, 2065 and 2115.

For the City's **rocky coasts**, based on geotechnical studies completed within the City, erosion hazard zones were estimated using¹¹:

- an allowance of 5 m to assess risks to existing public and recreational infrastructure with relatively short design lives.
- an allowance of 30 m for leasehold and freehold development.



Figure 5-3 Eroded dunes and damaged fencing and accessway at Hillarys Animal Beach, Hillarys (August 2022)



Figure 5-4 Eroded beach accessway and damaged dunes and vegetation at Pinnaroo Point, Hillarys (August 2022)

5.3 Coastal inundation

Coastal inundation is temporary flooding of areas of land by ocean water, particularly during storm events. Coastal inundation hazard areas were modelled for the City's coastline¹¹. These hazard zones were calculated using the maximum extent of storm surge inundation plus the predicted extent of sea level rise. Storm surge inundation is defined as the maximum water level (tide, storm, wave run-up) during a 1 in 500 years ARI inundation event.

Along the 17 km of coastline, inundation risk was modelled and determined to not significantly impact on natural or built assets across the 100-year planning timeframe. As a result, the inundation risk is low for the City's coastline and assets, with the major coastal hazard being coastal erosion¹¹.

6 COASTAL ASSETS

6.1 Coastal assets

There are many significant natural and built assets within the City's coastal zone that are potentially at risk from coastal hazards over the next 100 years.

To develop appropriate adaptation strategies, the natural and built assets that may be impacted by coastal erosion and inundation hazards over the 100-year planning timeframe were identified and include natural assets, public infrastructure, and private buildings.

Natural assets	Public infrastructure	Private buildings
<ul style="list-style-type: none">• Coastal foreshore reserves• Native vegetation• Sandy and rocky beaches• Dunes	<ul style="list-style-type: none">• Parks and playgrounds• Beach accessways• Roads• Carparks• Coastal pathways• Foreshore park facilities and infrastructure• Surf Life Saving Clubs at Sorrento and Mullaloo• Boat launching facilities• Stormwater pipes and pits	<ul style="list-style-type: none">• Residential properties• Commercial businesses, such as restaurants, shops and cafés

Existing assets within the City's coastal zone have been considered in the development of this CHRMAP. Planned or future assets that are not yet constructed have not been included in the CHRMAP risk assessment or adaptation strategy. Any major new developments by the City on the coast will have their own site specific CHRMAP which will consider the risks identified in this CHRMAP.

6.2 How is the risk and vulnerability assessed?

6.2.1 Risk assessment

A risk assessment was undertaken on assets located in the City's coastal hazard zone. A risk-based approach was used to assess the coastal hazards and to recommend appropriate adaptation options.

The impact of coastal inundation from a 500-year ARI event, with appropriate allowances for sea level rise over the 100-year planning timeframe, was assessed for the City's coastline. The hazard mapping shows that inundation during this storm event is minimal. Along the 17 km of coastline, inundation has been modelled to generally be limited to affecting only several minor assets (several signs, bins, fencing and access tracks/stairs) immediately adjacent to the shoreline. As a result, inundation hazards are not considered to significantly impact the natural or built assets across the City's coastline and the risk assessment was only applied to coastal erosion hazards¹¹.

For coastal erosion hazards, the risk was calculated by analysing¹¹:

- Likelihood: the chance of hazards occurring or how often they impact on existing and future assets and values.
- Consequence: the outcome on the assets if the risk did occur and how the asset responds to the hazards.

6.2.2 Vulnerability assessment

Vulnerability is defined by SPP2.6² as: “the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes”. Vulnerability combines the risk assessment of an asset, as well the asset’s adaptive capacity.

Adaptive capacity is a measure of how sensitive that asset is to the impacts from the hazard, and its ability to respond or adapt¹¹. For example, an asset that is at high risk, but it can be easily adapted, will have a medium vulnerability rating.

Each asset along the City’s coastline was assigned a vulnerability rating. Assets with ‘High’ and ‘Very High’ vulnerability need to be managed to reduce vulnerability levels¹¹. Assets with ‘Medium’ or ‘Low’ vulnerability should also be considered, and adaptation measures should be implemented to reduce vulnerability levels as low as reasonably practical¹¹.



Table 6-1 Vulnerability tolerance scale

Vulnerability level	Vulnerability tolerance	Further action required
Very high	Unacceptable / Intolerable	Asset has minimal capacity to cope with the impacts of coastal hazards without additional action. Adaptation needs to be considered as a priority.
High	Tolerable, if as low as possible	Asset has limited ability to cope with the impacts of coastal hazards. Adaptation should be considered to reduce vulnerability to acceptable levels.
Medium	Tolerable / Acceptable	Asset has some ability to cope with the impacts of coastal hazards. Actions should be considered to reduce vulnerability as low as reasonably practical.
Low	Acceptable	Asset has high resilience and can cope with the impacts of coastal hazards without additional action.

7 WHAT ASSETS ARE VULNERABLE?

Coastal erosion has the potential to impact coastal assets. A list of the public and private assets that are vulnerable to coastal erosion hazards are presented below for each coastal management zone.

The estimated value of the vulnerable public and private assets within the City's coastal zone is approximately \$222 million.

Not all the assets at risk are presented in the following tables, only those that were identified with 'high' and/or 'very high' vulnerabilities over the 100-year planning timeframe are presented in the following tables¹¹.

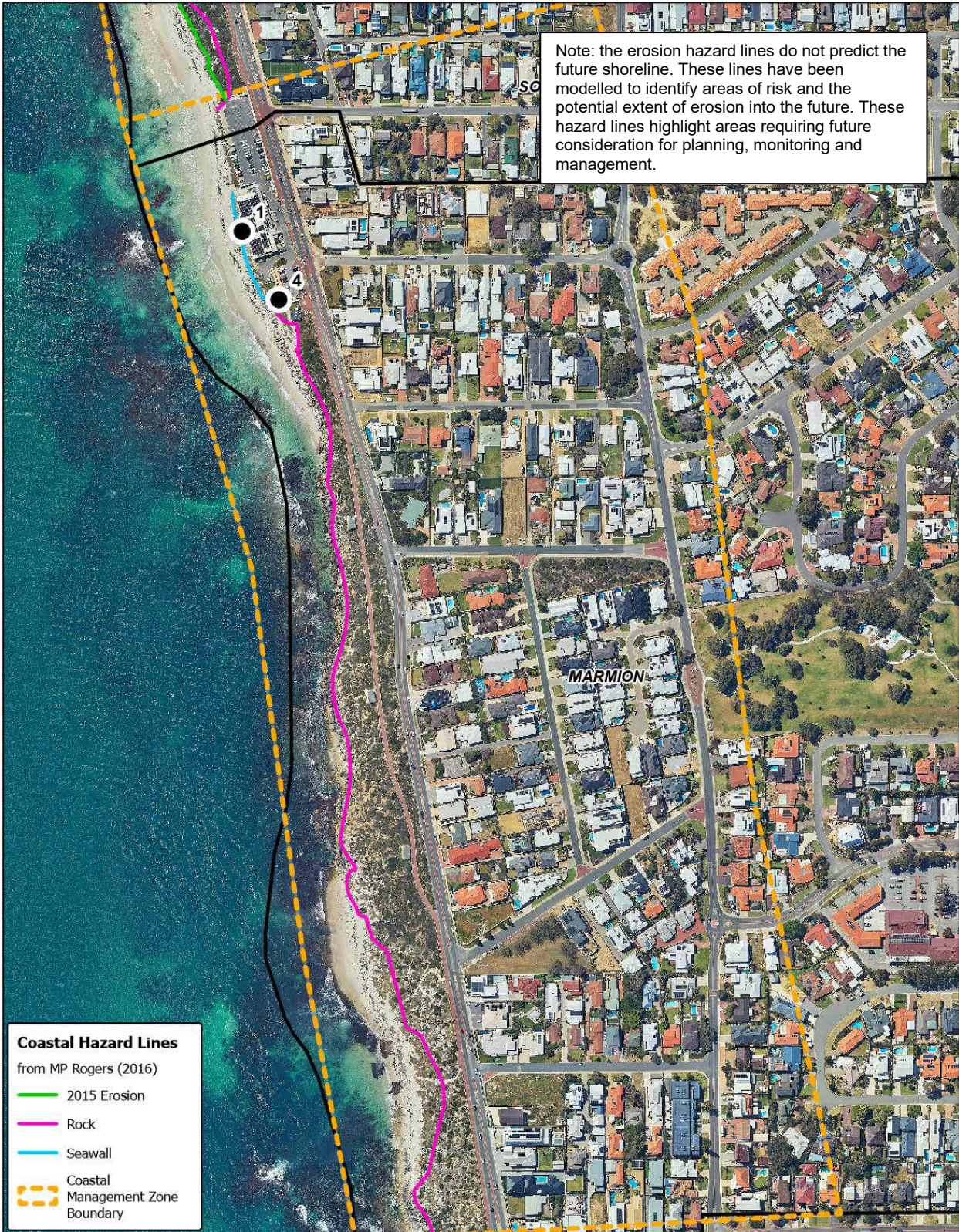
DRAFT

Coastal Management Zone 1: Marmion

		2015	2065	2115
Vulnerability to coastal erosion				
1	MAAC - Marmion Angling and Aquatic Club	●	●	●
2	Beach	●	●	●
3	Beach access ways	●	●	●
4	MAAC carparks	●	●	●

● Low ● Medium ● High ● Very high






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Coastal Management Zone: Marmion

Marmion Coastal Vulnerability

Coastal Management Zone 2: Sorrento

		2015	2065	2115
Vulnerability to coastal erosion				
1	Road – West Coast Dve	●	●	●
2	Beach	●	●	●
3	Coastal dunes and vegetation	●	●	●
4	Beach access ways	●	●	●
5	Residences	●	●	●
6	Commercial premises	●	●	●
7	Sorrento Surf Life Saving Club	●	●	●
8	Sorrento Beach south carpark	●	●	●
9	West Coast Dve buildings carparks	●	●	●
10	Roads – The Plaza, Raleigh Rd, Robin Ave	●	●	●
11	Residences	●	●	●
12	Commercial premises	●	●	●
13	Sorrento Beach north carpark, toilets and changerooms	●	●	●
14	Coastal pathway	●	●	●
15	Sorrento Beach foreshore park	●	●	●

● Low ● Medium ● High ● Very high





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Coastal Management Zone: Sorrento		
Scale (A4): 1:6,000	Date: 9/03/2023	Compiled: A.Gilbert
Path: E:\GIS Projects\Parks and Natural Areas\CHRM\CHRM.aprx		
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Sorrento Coastal Vulnerability


Coastal Management Zone 3: Hillarys to Kallaroo

		2015	2065	2115
Vulnerability to coastal erosion				
1	Road – John Wilkie Trn	●	●	●
2	Pinnaroo Point animal beach carparks	●	●	●
3	Hillarys Beach changerooms and toilets	●	●	●
4	Roads – Northshore Dve and Whitfords Ave	●	●	●
5	Hillarys beach carpark	●	●	●
6	Coastal pathway	●	●	●
7	Residences	●	●	●
8	Pinnaroo Point foreshore park	●	●	●
9	Hillarys beach park	●	●	●
10	Hillarys beach north toilets	●	●	●
11	Pinnaroo Point carpark and toilets	●	●	●
12	Whitfords Nodes toilets and changerooms	●	●	●
13	Northshore Dve carpark	●	●	●
14	Roads – Killarney Hts, Brookevale Rse, Founders Ln, Flinders Ave, Quayside Mws	●	●	●
15	Residences	●	●	●
16	Beach	●	●	●
17	Coastal dunes and significant flora and fauna	●	●	●
18	Beach access ways	●	●	●
19	Ern Halliday Recreation Camp (State gov owned)	●	●	●

● Low ● Medium ● High ● Very high






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Coastal Management Zone: Hillarys to Kallaroo

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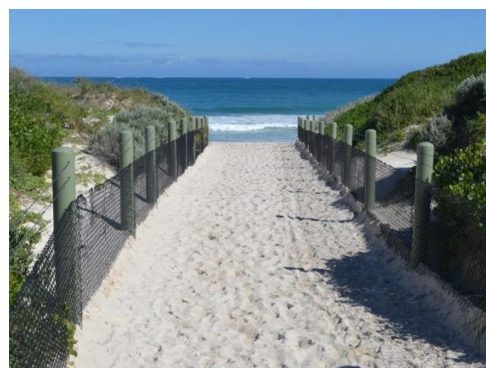
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Hillarys to Kallaroo Coastal Vulnerability


Coastal Management Zone 4: Mullaloo

		2015	2065	2115
Vulnerability to coastal erosion				
1	Beach	●	●	●
2	Coastal dunes and significant flora and fauna	●	●	●
3	Mullaloo Surf Life Saving Club	●	●	●
4	Beach access ways	●	●	●
5	Road – Oceanside Prm	●	●	●
6	Residences	●	●	●
7	Mullaloo Beach south toilets and changerooms	●	●	●
8	Road – Merryfield Pl	●	●	●
9	Carparks - West View Blvd and Oceanside Prm street parking	●	●	●
10	Residences	●	●	●
11	Roads – Korella St and Warren Wy	●	●	●
12	Mullaloo Beach carpark, north toilets and changerooms	●	●	●
13	Tom Simpson Park carpark	●	●	●
14	Tom Simpson Park	●	●	●

● Low ● Medium ● High ● Very high






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Coastal Management Zone: Mullaloo

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Mullaloo Coastal Vulnerability

Coastal Management Zone 5: Ocean Reef

	2015	2065	2115
Vulnerability to coastal erosion			
1 Whitfords Volunteer Sea Rescue Group buildings	●	●	●
2 Whitfords Volunteer Sea Rescue Group carpark	●	●	●
3 Ocean Reef Sea Sports Club park area	●	●	●
4 Road – Boat Harbour Qys	●	●	●
5 Beach	●	●	●
6 Coastal dunes and significant flora and fauna	●	●	●

● Low ● Medium ● High ● Very high





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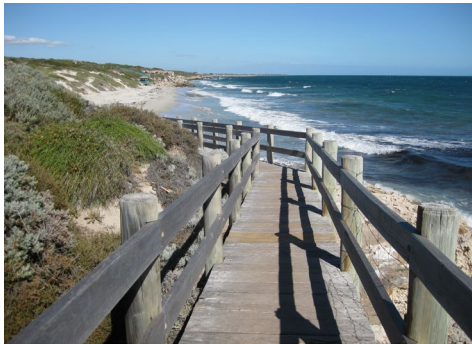
Coastal Management Zone: Ocean Reef		
Scale (A4): 1:12,000	Date: 9/03/2023	Compiled: A.Gilbert
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Ocean Reef Coastal Vulnerability

Coastal Management Zone 6: Iluka

	2015	2065	2115
Vulnerability to coastal erosion			
1 Coastal pathway	●	●	●
2 Beach access ways	●	●	●
3 Burns Beach carpark	●	●	●
4 Beach	●	●	●
5 Coastal dunes and significant flora and fauna	●	●	●
6 Iluka Beach foreshore park	●	●	●

● Low ● Medium ● High ● Very high





Note: the erosion hazard lines do not predict the future shoreline. These lines have been modelled to identify areas of risk and the potential extent of erosion into the future. These hazard lines highlight areas requiring future consideration for planning, monitoring and management.

Coastal Hazard Lines
from MP Rogers (2016)

- 2015 Erosion
- 2065 Erosion
- 2115 Erosion
- Rock
- Coastal Management Zone Boundary

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Coastal Management Zone: Iluka		
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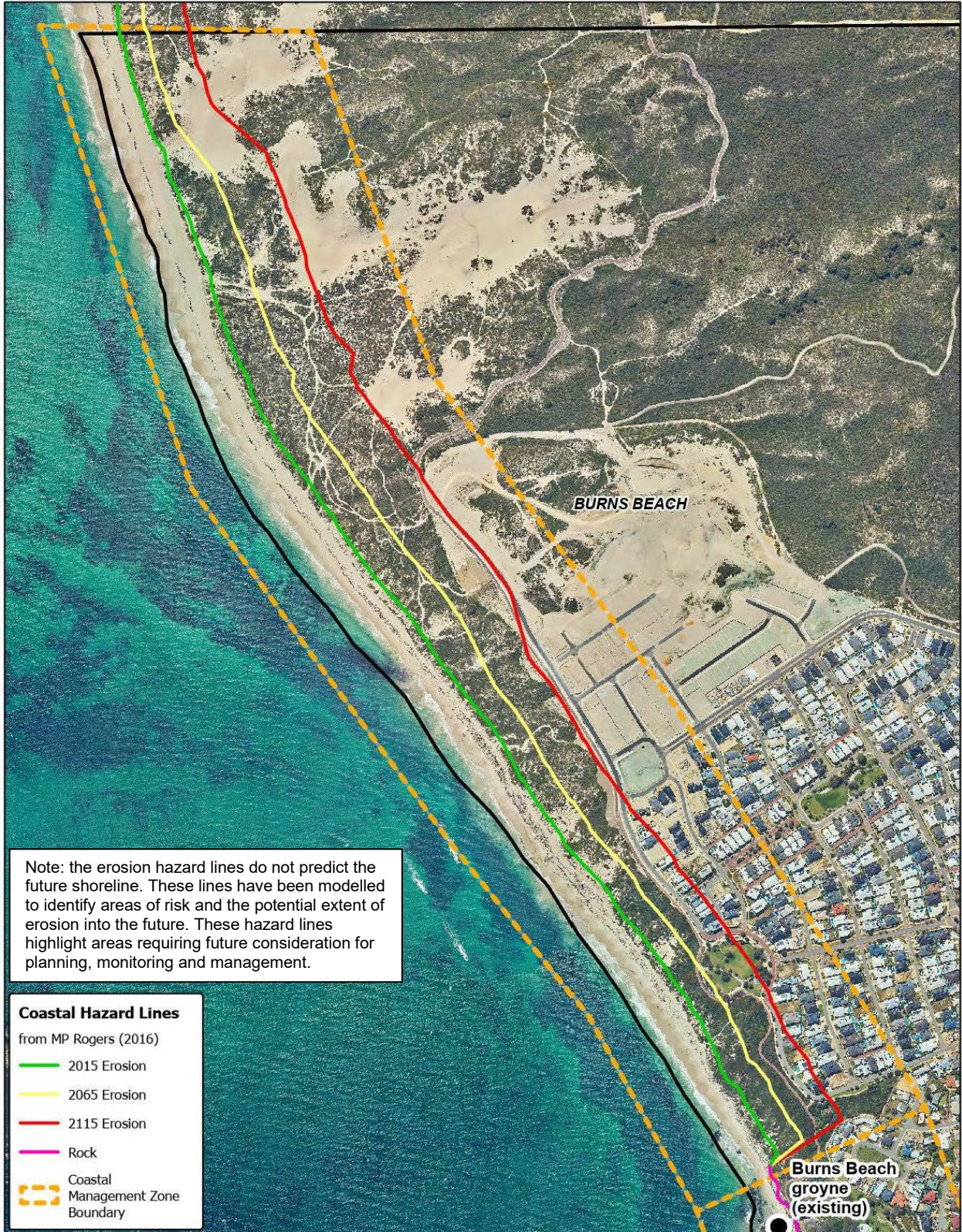
Iluka Coastal Vulnerability

Coastal Management Zone 7: Burns Beach

		2015	2065	2115
Vulnerability to coastal erosion				
1	Beach	●	●	●
2	Coastal dunes and significant flora and fauna	●	●	●
3	Beach access ways	●	●	●
4	Beachside Dve – road, street, car parks and pathways	●	●	●
5	Residences	●	●	●
6	Coastal pathway	●	●	●

● Low ● Medium ● High ● Very high





Note: the erosion hazard lines do not predict the future shoreline. These lines have been modelled to identify areas of risk and the potential extent of erosion into the future. These hazard lines highlight areas requiring future consideration for planning, monitoring and management.

Coastal Hazard Lines
from MP Rogers (2016)

- 2015 Erosion
- 2065 Erosion
- 2115 Erosion
- Rock
- Coastal Management Zone Boundary

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Coastal Management Zone: Burns Beach		
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Burns Beach Coastal Vulnerability

8 PLANNING FOR THE FUTURE

8.1 What are the adaptation options?

8.1.1 Adaptation hierarchy

SPP2.6 suggests selecting suitable adaptation options using the adaptation measures of avoid, retreat, accommodate and protect, on a sequential and preferential basis, where possible. Under this hierarchy, protect options are the least preferred.

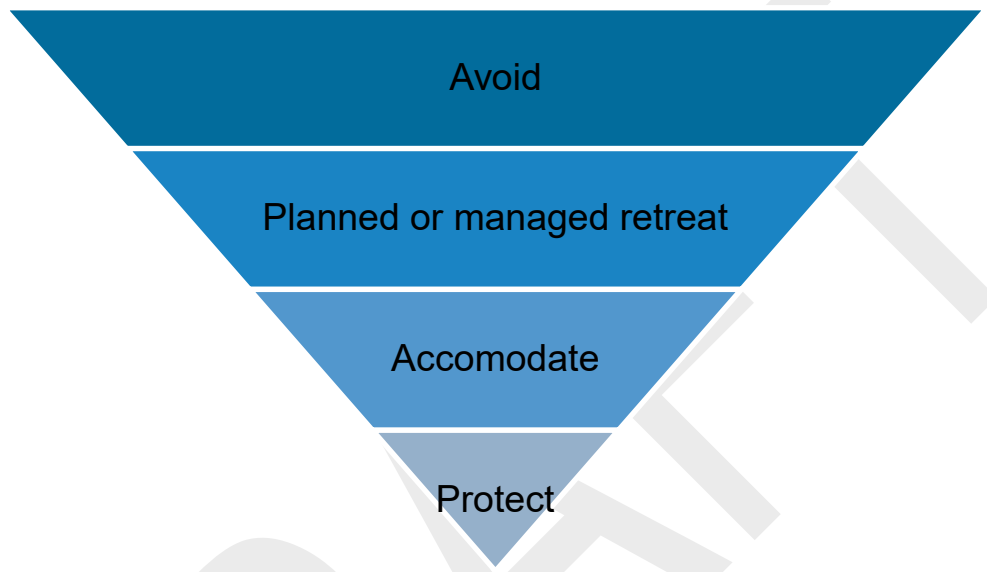


Figure 8-1 Adaptation hierarchy used when selecting adaptation options

Examples of adaptation options for the City using the adaptation hierarchy are presented below.

Do nothing: This option does not involve any new action. Where existing risk levels are low, accepting the risk may be appropriate. However, it may not be an appropriate option for high-risk locations and assets.

The City's Community Coastal Values Survey highlighted that the community is strongly opposed to 'doing nothing'.

Avoid: this option aims to avoid any new development occurring within coastal hazard vulnerability zones. Avoid is seen as the preferred option, however, is generally only applicable to undeveloped coastal land, or where new developments are proposed.

Avoid



Pros

- Relatively inexpensive solution for managing coastal risks
- Special Control Areas provide transparency to developers and landowners

Cons

- Doesn't mitigate the coastal hazard risks to existing assets and infrastructure

Planned or managed retreat: aims to remove assets from the coastal hazard zones and is the preferred option where there are built assets in the coastal hazards zone. The assets can be relocated in advance or when they are impacted.

Planned or managed retreat



Pros

- Removing assets from hazardous areas reduces ongoing protection requirements
- Can be cheaper to remove low value assets rather than protect them

Cons

- May be prohibitively expensive for high value assets, depending on the location and number of properties
- Can impact upon residential properties and commercial businesses

Accommodate: aims to redesign at-risk existing infrastructure to mitigate potential impacts and allow land for low-risk land uses. This option is rarely applicable to areas at risk of coastal erosion and the ability of existing, significant assets to be redesigned can be limited.

Accomodate



Pros

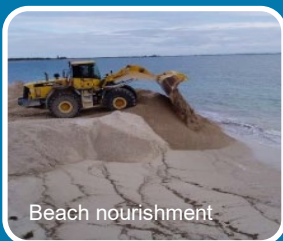
- Allows, in the short term, the continued use of the land

Cons

- High financial cost
- Some infrastructure may not be able to be adapted

Protect: when the asset within the hazard zone cannot be moved or adapted, the Protect option can be used. This includes **'soft' protection** options, such as beach nourishment and revegetation of the dunes, and **'hard' protection** options such as constructing groynes and seawalls. It should be noted however, that no protect option is considered permanent, and all have associated expense to implement, maintain and replace.

Protect



Beach nourishment

Soft protection - beach nourishment and dune stabilisation

Beach nourishment involves placing sand material along the beach to create a sufficient buffer against potential storm erosion. **Dune stabilisation** includes measures such as revegetating sand dunes to prevent erosion.

Pros

- Lower up front costs compared to hard protection options
- Does not require significant infrastructure
- Generally maintains beach amenity, aesthetics and access



Revegetation

Cons

- Offers only short term protection
- Doesn't provide guaranteed protection to any landward infrastructure
- Requires ongoing maintenance
- Limited sand supply available
- High and ongoing cost, which may escalate

Protect



Groyne

Hard protection - groynes or headlands

Groynes are rock structures that extend from the beach into the ocean, perpendicular to the beach. **Headlands** are rock structures that sit parallel to the beach.

Pros

- Can create beach compartments that maintain beach amenity on at least one side of each of the headlands or groynes
- Provides some level of shelter from wind and waves
- Can provide some protection to more critical infrastructure



Headlands

Cons

- Very expensive to build and require long term maintenance and funding
- Often requires beach nourishment works
- Disrupts swimming routes in the nearshore area
- Has the potential to trap seagrass wrack
- Can cause impacts to aesthetics and amenity values

Protect

Hard protection - seawalls



Seawalls are generally rubble mound structures designed to withstand severe storm conditions and protect assets.

Pros

- Protects landward infrastructure and assets
- Can be buried or vegetated to minimise visual impact

Cons

- Very expensive upfront costs, and requires ongoing maintenance and eventual replacement
- Can lead to narrower or entirely lost sandy beach in front of the seawall
- Can divert coastal erosion issues elsewhere

8.1.2 Responsibility and equity

It is predicted that the cost of managing the City's coastline into the future will increase significantly, as more assets become vulnerable. At some point in the future, the cost of management may become prohibitively expensive.

Responsibility for coastal planning lies with State and Local Governments. However, there are no laws requiring any level of government to protect private property from natural coastal hazards, or provide compensation when land is lost.

All coastal planning decisions need to consider²:

- **Access** – the coast and foreshore reserves are public assets which need to remain accessible by the public into the future. Adaptation options need to ensure that public access will not be compromised.
- **Enjoyment** – adaptation options need to ensure that community values are maintained including recreation, social and environmental values.
- **Beneficiaries** – coastal protection structures at private residences provide benefits to the private landowners, however, may cause increased erosion downstream which may disadvantage others.
- **Intergenerational equity** – the impact of decisions on future generations. Continuing to develop the coast without consideration of hazards may cause future expenses and issues for future generations. Additionally, investing in protecting existing assets may exacerbate longer-term management issues for future generations.

It is critical that planning and management is as transparent as possible through mediums such as a CHRMAP.

The adaptation options selected should ensure equal access and enjoyment of the coast for all. The WA Coastal Strategy and SPP2.6 recommend a "beneficiary pays" principle which means that whoever benefits from an adaptation strategy should contribute to funding the strategy.

8.2 Adaptation options

8.2.1 Multi-Criteria Analysis

Risk management and adaptation options were considered for each of the City's Coastal Management Zones¹¹. A Multi-Criteria Analysis (MCA) was used as a first step to identify suitable adaptation options for each management zone, as well as determining any adaptation options that were not feasible.

The City's MCA included assessing each potential adaptation option against the following criteria¹¹:

- Effectiveness
- Constructability
- Legal requirements
- Adaptability
- Community values (social)
- Environment impact
- Capital cost
- Operating / maintenance cost

This preliminary MCA was completed for all assets with a 'High' and 'Very high' vulnerabilities over the 100-year planning timeframe. This preliminary assessment identified feasible adaptation options for each Management Zone, and also identified options which were not feasible¹¹. Options that were feasible after the MCA are provided in Table 8-1. These options were then economically assessed using a Cost Benefit Analysis.

Table 8-1 Feasible options for further consideration after the Multi-Criteria Analysis¹¹

Coastal Management Zone	Adaptation options considered					
	Do nothing	Seawall	Managed retreat	Groynes	Headlands	Beach nourishment
Marmion	✓	✓	✓			
Sorrento	✓	✓	✓	✓	✓	
Hillarys to Kallaroo	✓	✓	✓	✓	✓	✓
Mullaloo	✓	✓	✓	✓	✓	✓
Ocean Reef	✓					
Iluka	✓		✓			✓
Burns Beach North	✓		✓			

8.2.2 Cost Benefit Analysis

A Cost Benefit Analysis (CBA) was used to assess the viability of each of the adaptation options proposed by the MCA, for each Coastal Management Zone¹¹. The CBA investigated the feasibility of these proposed options based on the likely ratio of social, economic and environmental costs and benefits for each option¹¹. These ratios were used together with the results of the MCA and the community values survey results to determine the recommended options for each coastal management zone. The outcome of this process was a list of prioritised adaptation options for each Coastal Management Zone¹¹.

Separate CBAs were completed for each of the Coastal Management Zones, with the 'do nothing' option included and used as a baseline against which the other options could be compared to. The costs and benefits of each option were determined in groups of five years. The analysis included¹¹:

- Adaptation capital costs
- Adaptation maintenance costs
- Economic cost
- Social and environmental cost
- Social and environmental benefits
- Discounted cash flow calculations

Once the costs and benefits for each five-year period had been calculated, the total costs and benefits over the 100-year planning timeframe were determined for each adaptation option. These values were used to determine the cost benefit ratio for each option, which was then used to rank the adaptation options for each Coastal Management Zone.

The results showing the preferred adaptation option for each Coastal Management Zone are provided in Table 8-2.

Table 8-2 Preferred adaptation option for each Coastal Management Zone, after MCA and CBA¹¹

Coastal Management Zone	Preferred adaptation option
Marmion	Beach nourishment
Sorrento	Groynes
Hillarys to Kallaroo	Groynes
Mullaloo	Groynes
Ocean Reef	Do nothing
Iluka	Beach nourishment
Burns Beach	Retreat (public only)

9 RECOMMENDATIONS AND ADAPTATION PATHWAYS

9.1 Recommended adaptation pathways

The City's coastline is located within the Perth metropolitan area where substantial development has occurred and there are limited options for 'Avoid' and 'Managed Retreat' measures. As such, the dominant adaptation measure proposed is 'Protect' and is aimed at being undertaken in stages when triggering events occur¹¹.

All the recommended adaptation pathways provided below are sourced from the MP Rogers and Associates technical CHRMAP (2022), incorporating community values, and the outcomes from the MCA and CBA. The recommended options presented below for each Coastal Management Zone will be investigated for their feasibility and community support.

The proposed adaptation pathways highlight the recommended adaptation option for that zone and the triggers specific to that zone that will identify when the adaptation option should commence. Figure 9-1 shows how each adaptation pathway will be monitored and how monitoring data and triggers will be used to instigate the proposed adaptation options.

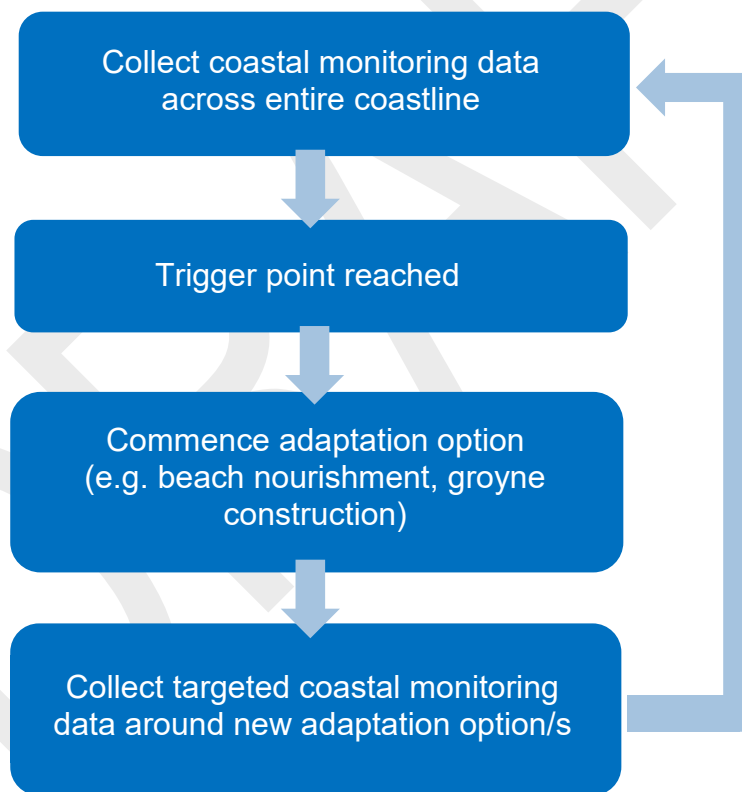


Figure 9-1 Adaptation pathway flowchart

Management Zone: Marmion

Adaptation pathway: Protect – beach nourishment

Assets at risk:

Sandy beach, Marmion Angling and Aquatic Club (MAAC), coastal and dune vegetation, coastal paths, beach accessways and stairs, public buildings

Key issues:

MAAC building and coastal foreshore reserves are vulnerable to coastal erosion risk. The MAAC area is identified as a coastal erosion hotspot priority area.

Priorities

Protect the MAAC and carpark and maintain beach amenity.

Advantages of this option

- Maintains the sandy beach
- Flexible and can be adjusted as required
- Sandy beaches are small, so the volume of sand required will likely be reasonably low
- Beach nourishment at Marmion is likely to lead to secondary nourishment further north at Sorrento

Disadvantages of this option

- Requires ongoing addition of sand to maintain beaches
- The volume of sand needed, and associated cost, will likely increase over time due to the impacts of sea level rise

Triggers for action

Commence beach nourishment when:

- the bank below the MAAC carpark has receded to 5 m or less and/or
- the beach in front of the MAAC carpark has reduced to 5 m or less over two consecutive monitoring periods

Timeline

Beach nourishment is likely to be needed every five years, starting in 2025

Estimated cost

\$5.0 million for a beach nourishment program completed approximately once every five years from 2025-2115

Note: this cost estimate does not include maintenance and replacement costs for the existing seawall at the MAAC as beach nourishment has been identified as the primary coastal protection activity for this management zone.

The estimated value of the vulnerable assets (including private property) within the Marmion Coastal Management Zone is \$8.9 million*.

* Asset values are sourced from MP Rogers 2022

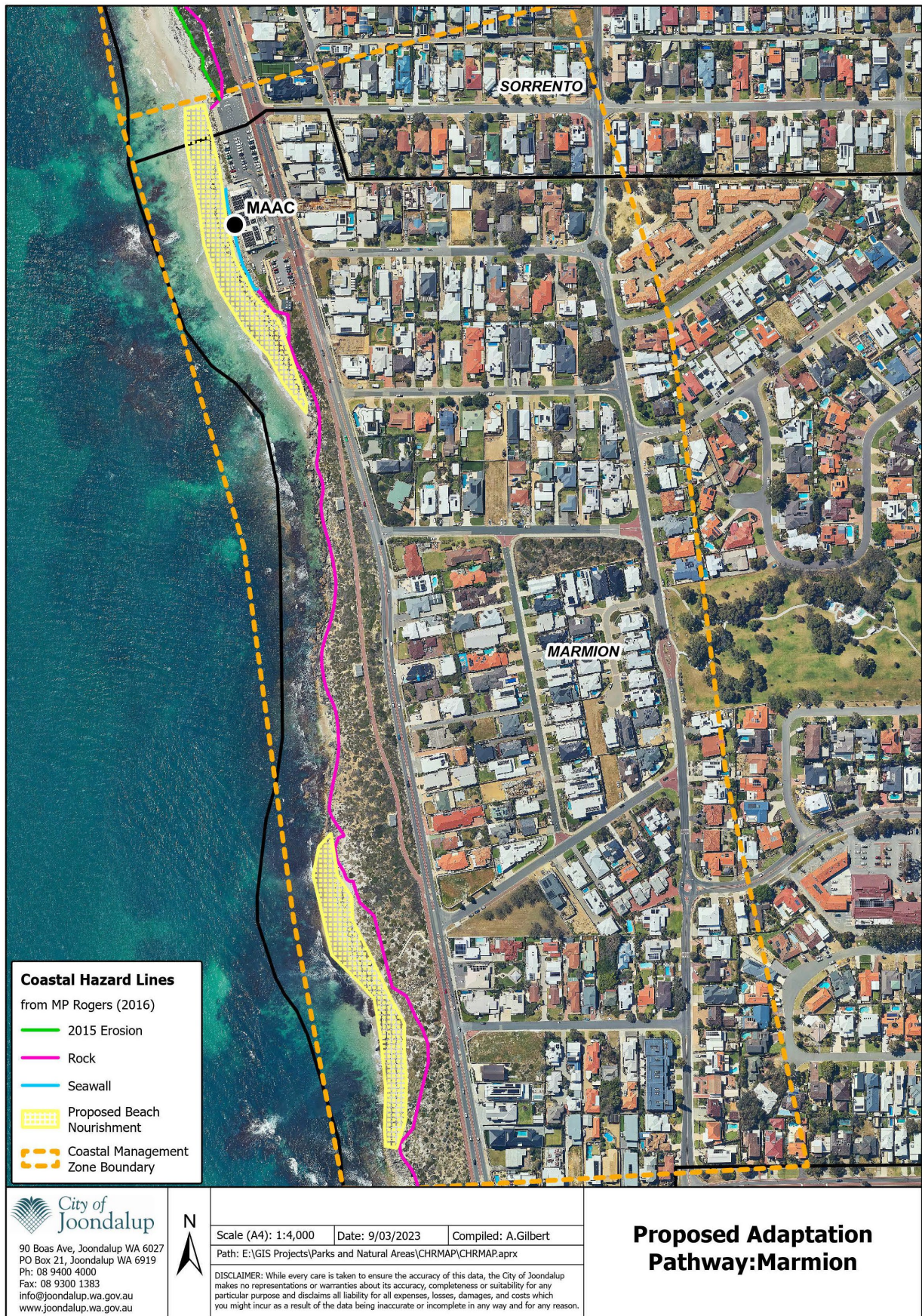


Figure 9-2 Marmion proposed beach nourishment locations (MP Rogers, 2022)

Management Zone: Sorrento

Adaptation pathway: Protect - replace/extend existing three groynes

Assets at risk:

Sandy and rocky beaches, coastal and dune vegetation, coastal paths, beach accessways, Sorrento SLSC, roads, and private residences

Key issues:

The coastal foreshore reserve, the Sorrento SLSC and private residences are vulnerable to coastal erosion risk

Priorities

Protect the Sorrento SLSC, foreshore park and carpark. Maintain beach amenity.

Advantages of this option

- Groynes are already present on this beach, reducing the potential cost
- Minimal short-term disturbance
- Maintains the sandy beach
- The existing groynes can be extended with limited impact

Disadvantages of this option

- Significant construction works will be required to maintain/rebuild the groynes, causing short term disturbances to beach usage

Triggers for action

The existing groynes reach the end of their design life in approximately 2030

Timeline

- 2030 – replace all three groynes, including beach nourishment
- Monitoring and groyne maintenance every 10-20 years, where required
- 2080 – replace three groynes, if required

Estimated cost

\$16.3 million to replace the existing three groynes in 2030 and 2080 and complete ongoing groyne maintenance between 2030-2115.

Note: this cost estimate does not include maintenance and replacement costs for the existing seawall at the Sorrento SLSC as groynes have been identified as the primary coastal protection assets for this management zone.

The estimated value of the vulnerable assets (including private property) within the Sorrento Coastal Management Zone is \$62.7 million*.

* Asset values are sourced from MP Rogers 2022



Figure 9-3 Sorrento proposed groyne locations (MP Rogers, 2022)

Management Zone: Hillarys to Kallaroo

Adaptation pathway: Protect - construct 11 groynes

Assets at risk:

Sandy beach, coastal and dune vegetation, coastal paths and beach accessways, roads, private residences

Key issues:

Coastal foreshore reserve and private residences are vulnerable to coastal erosion risk

Priorities

Protect public assets

Advantages of this option

- Maintains the sandy beach
- Works can be carried out in stages

Disadvantages of this option

- Significant construction works will be required to maintain/rebuild the groynes, causing short term disturbances to beach usage
- Periods of high capital cost when multiple groynes are built concurrently
- Possible reduction in sediment transport to Mullaloo
- Partial segmentation of the beach

Triggers for action

Groynes will be constructed when the shoreline has receded to within 20 m of a significant asset.

Timeline

11 groynes can be constructed in a staged approach:

- 2025 – construct groynes 1, 2, 5 and 7
- 2040 – construct groynes 4, 6, and 10
- 2060 – construct groynes 3, 8, 9 and 11
- 2075 – replace groynes 1, 2, 5 and 7, if required
- 2090 – replace groynes 4, 6 and 10, if required

Beach nourishment is likely to be included in groyne construction works.

Estimated cost

\$50.5 million to construct 11 groynes between 2025-2060 and replace groynes approximately 50 years after construction. This cost also includes beach nourishment and ongoing maintenance costs.

Note: this cost estimate does not include the annual existing beach nourishment program costs, where sand is moved from Sorrento Beach to Hillarys Beach.

The estimated value of the vulnerable assets (including private property) within the Hillarys to Kallaroo Coastal Management Zone is \$76 million*.

* Asset values are sourced from MP Rogers 2022

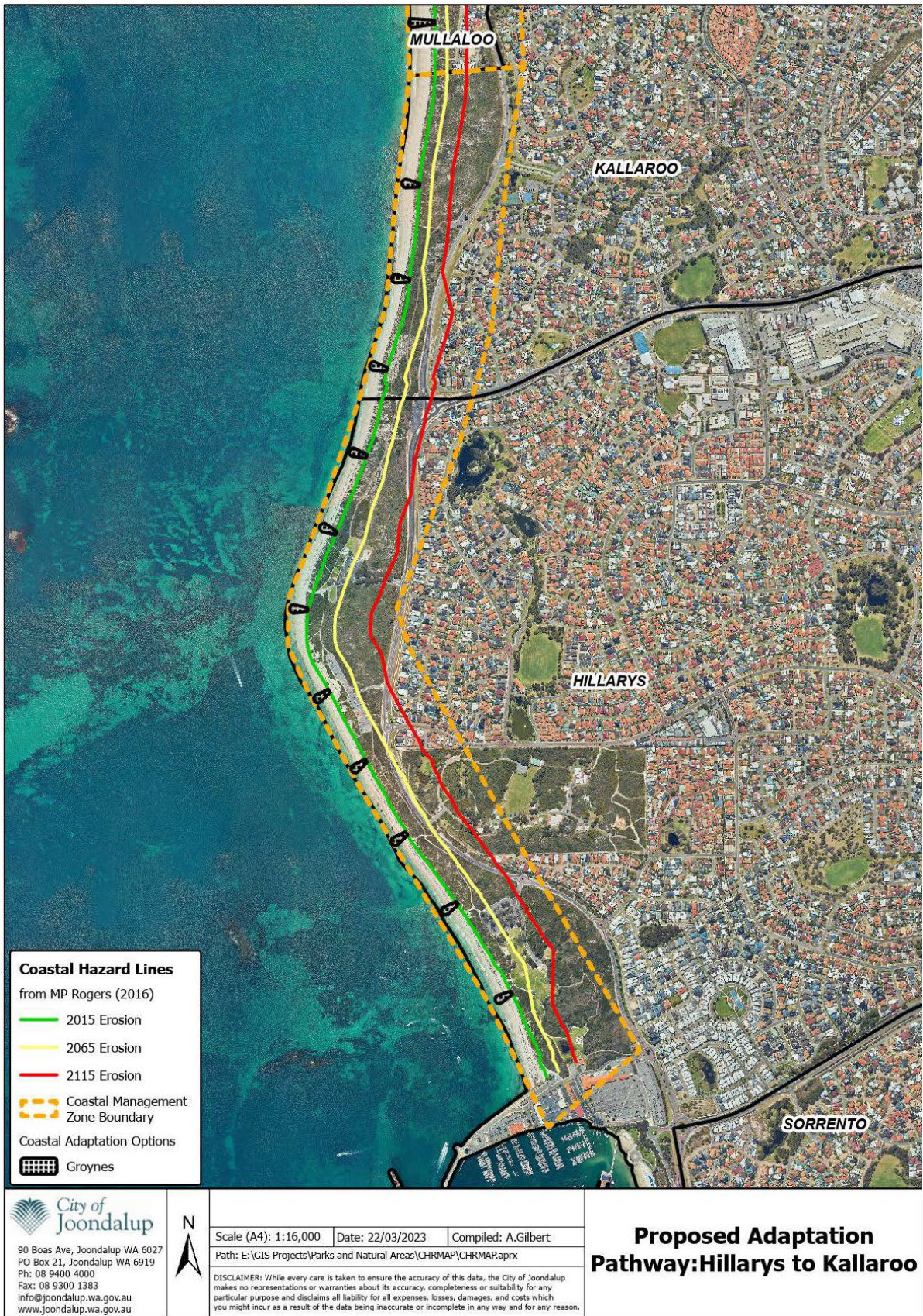


Figure 9-4 Hillarlys to Kallaroo proposed groyne locations (MP Rogers, 2022)

Management Zone: Mullaloo

Adaptation pathway option: Protect - construct 6 groynes

Assets at risk:

Foreshore reserve and public spaces, reserve infrastructure, sandy beach, private residences, Mullaloo SLSC

Key issues:

Coastal foreshore reserve, private residences and Mullaloo SLSC are vulnerable to coastal erosion risk

Priorities

Protect public assets.

Advantages of this option

- Maintains the sandy beach
- Works can be carried out in stages

Disadvantages of this option

- Significant construction work may disturb beach usage
- High capital cost
- Potential reduction of sediment transport north to Ocean Reef
- Potential segmentation of beach

Triggers for action

Commence constructing groynes when the shoreline has receded to within 20 m of a significant asset.

Timeline

Six groynes can be constructed in a staged approach:

- 2025 – construct groyne 2
- 2050 – construct groynes 3 and 6
- 2060 – construct groyne 1
- 2070 – construct groynes 4 and 5
- 2075 – replace groyne 2, if required
- 2100 – replace groynes 3 and 6, if required
- 2110 – replace groyne 1, if required

Beach nourishment is likely to be required during groyne development.

Estimated cost

\$21.0 million to construct six groynes between 2025-2070 and replace groynes approximately 50 years after construction. This cost also includes beach nourishment and ongoing maintenance costs.

Note: this cost estimate does not include maintenance and replacement costs for the existing seawall at the Mullaloo SLSC as groynes have been identified as the primary coastal protection assets for this management zone.

The estimated value of the vulnerable assets (including private property) within the Mullaloo Coastal Management Zone is \$49.1 million*.

*Asset values are sourced from MP Rogers 2022

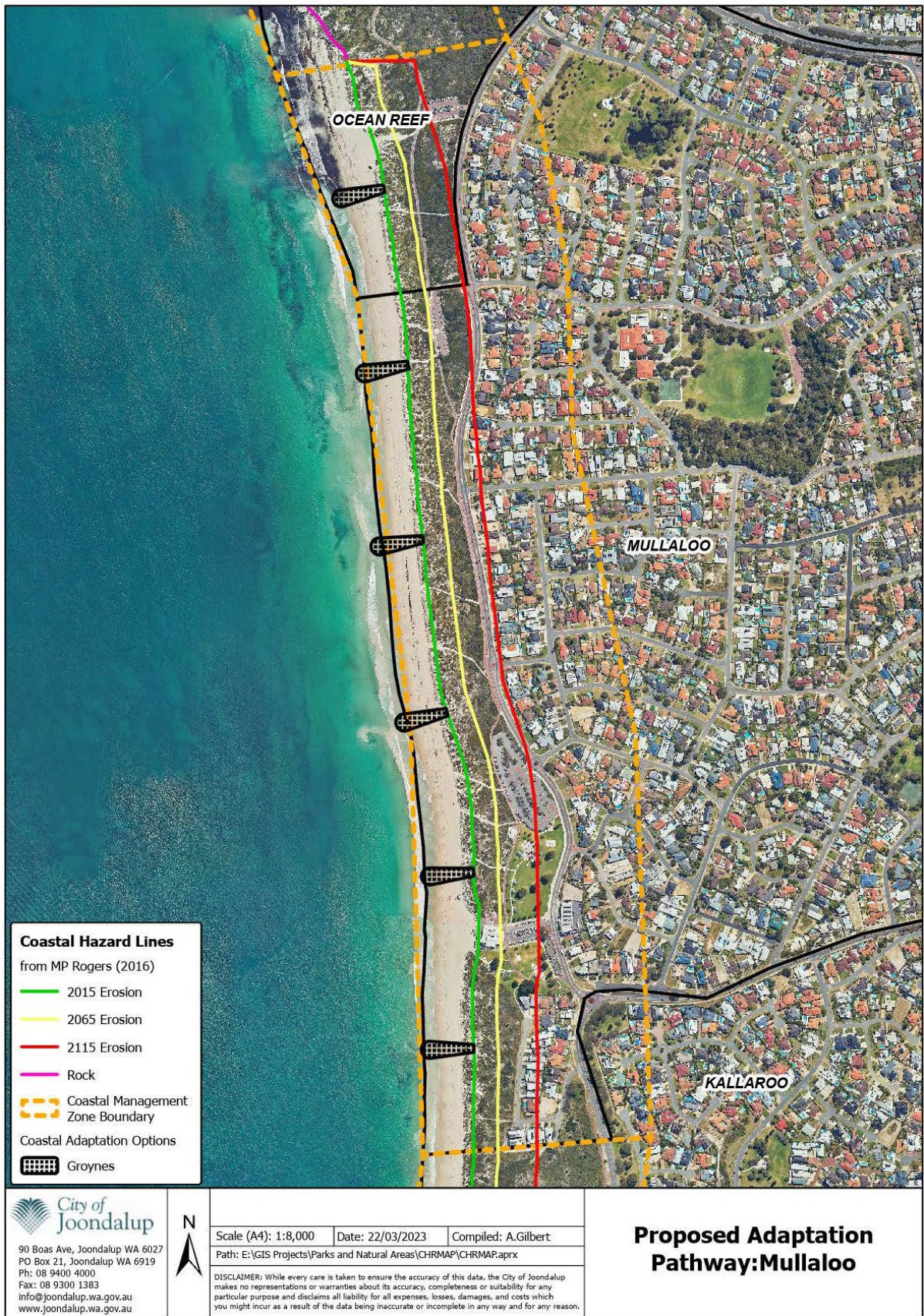


Figure 9-5 Mullaloo proposed groyne locations (MP Rogers, 2022)

Management Zone: Iluka

Adaptation pathway: Protect - beach nourishment

Assets at risk:

Sandy and rocky beaches, coastal and dune vegetation, coastal paths and beach accessways, parks, roads

Key issues:

Coastal foreshore reserves are vulnerable to coastal erosion risk

Priorities

Maintain beach amenity.

Advantages of this option

- Sandy beach is maintained
- Option is reasonably flexible and can be adjusted as required
- Due to the small size of the beaches, the nourishment volumes will likely be reasonably low
- Likely secondary nourishment of Burns Beach to the north

Disadvantages of this option

- Requires ongoing addition of sand to maintain the beach
- The volumes of sand, and associated cost will likely increase over time

Triggers for action

Commence nourishment when the beach is reduced to a width of 5 m or less, which is likely in 2025-2030.

Timeline

2025-2030 – beach nourishment likely to begin with works repeating around every five years.

Estimated cost

\$8.5 million to complete beach nourishment works approximately every five years from 2025-2030 until 2115.

The estimated value of the vulnerable assets (including private property) within the Iluka Coastal Management Zone is \$5.6 million*.

* Asset values are sourced from MP Rogers 2022



Figure 9-6 Iluka proposed beach nourishment locations (MP Rogers, 2022)

Management Zone: Burns Beach

Adaptation pathway: Managed retreat of public assets

Assets at risk:

Sandy beach, coastal and dune vegetation, coastal paths and beach accessways, public toilets and changerooms, roads, private residences, public park

Key issues:

Coastal foreshore reserve and private residences are vulnerable to coastal erosion risk

Priorities

Retreat public assets.

Triggers for action

Commence retreat when the shoreline has receded to within 20 m of a significant asset.

Advantages of this option

- Some beach areas will be retained
- Low initial cost
- Important assets and infrastructure retained.

Timeline

Commence planning for managed retreat of public infrastructure once the trigger is met.

Disadvantages of this option

- Comparatively high capital cost over the 100-year planning timeframe
- Minimising cost relies on preventing construction of any new assets in the hazard zones

Estimated cost

\$26.3 million to remove public infrastructure from within the vulnerable areas from 2015-2115.

Note: this cost estimate does not include maintenance and replacement costs for the existing Burns Beach groyne as managed retreat has been identified as the primary coastal protection activity for this management zone.

The estimated value of the vulnerable assets (including private property) within the Burns Beach Coastal Management Zone is \$19.3 million*.

* Asset values are sourced from MP Rogers 2022

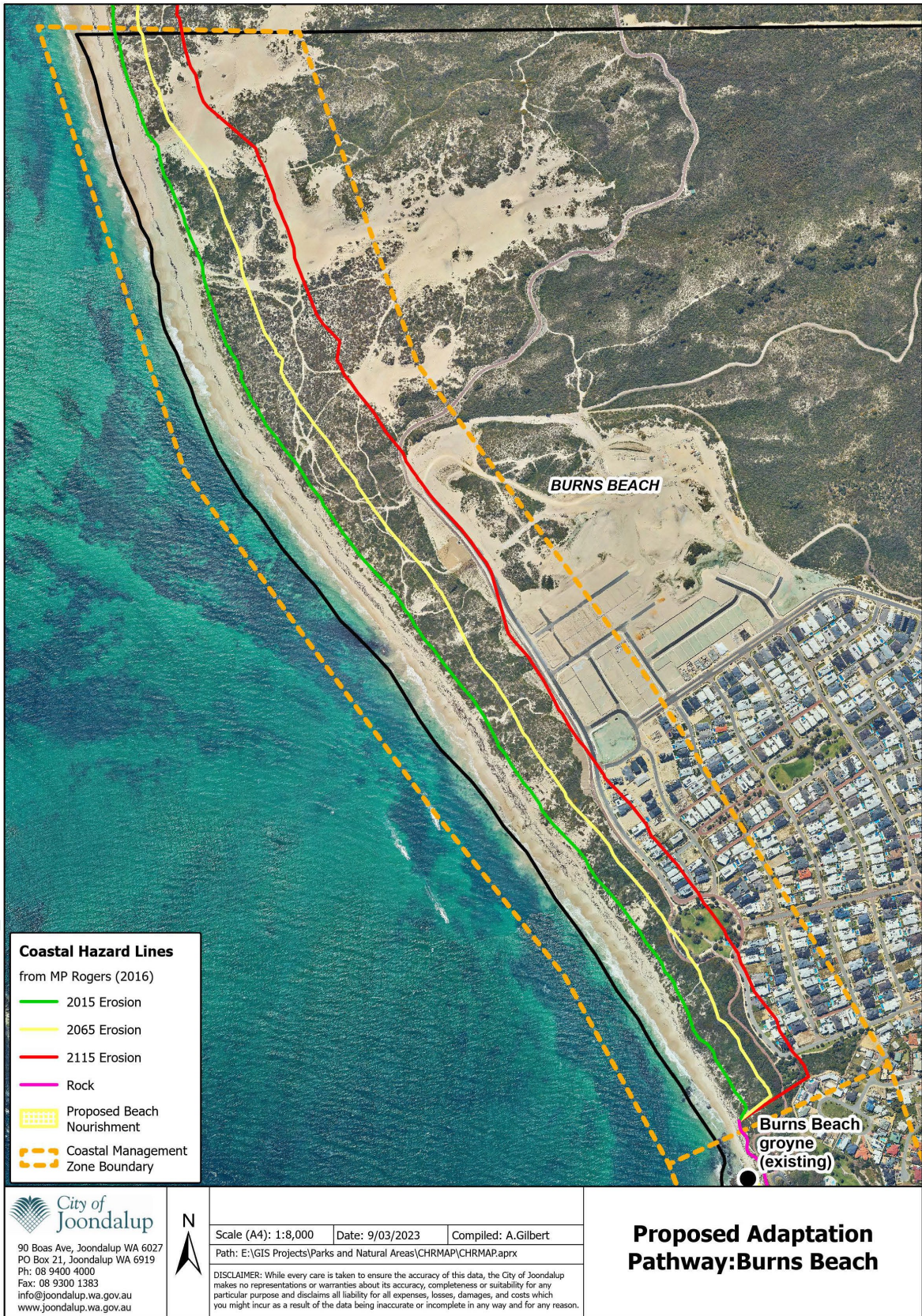


Figure 9-7 Burns Beach managed retreat option

9.2 Summary of recommended Coastal Management Zone adaptation pathways

The following table includes estimated direct costs of the proposed adaptation options. The proposed adaptation options in the draft CHRMAP are based on the Cost Benefit Analysis which comprises of two elements, the social/environmental benefits and the direct costs. The direct costs over a 100 year period in today's dollars are estimated at \$127.6 million, which equates to \$1.3 million per year. The direct costs relate to a real cost that would be incurred by one or more agencies for the one-off infrastructure, ongoing maintenance, and beach nourishment activities over a 100-year period in today's dollars.

Over 50% of the costs (circa \$72m) would be required in years 51 to 100, a further \$30m required in years 21 to 50 and circa \$25m required in years 1 to 20 if the adaptation options were implemented. This is a significant financial impost, and it is not proposed that the City accepts full responsibility for these costs. The estimated costs are subject to detailed design and further considerations such as coastal hazard information that may be available in the future. The City will advocate for external funding support for these costs.

Recommended adaptation pathway for each Coastal Management Zone				
Coastal Management Zone	Recommended adaptation option	Trigger point	Proposed timeline	Estimated cost to 2115
Marmion	Beach nourishment	The bank below the MAAC carpark has receded to 5m or less and/or the beach in front of the MAAC carpark has reduced to 5m or less over two consecutive monitoring periods	2025, with campaigns approximately every 5 years	\$5.0 million
Sorrento	Replace / maintain three existing groynes and beach nourishment	Existing groynes reach the end of their design life	<ul style="list-style-type: none"> • 2030 – replace all three groynes including beach nourishment • Monitoring and groyne maintenance every 10-20 years where required • 2080 – replace all 3 groynes, if required 	\$16.3 million

Recommended adaptation pathway for each Coastal Management Zone				
Hillarys to Kallaroo	Groynes (11) and beach nourishment	Shoreline has receded to within 20 m of a significant asset	Commence in 2025, with groynes built in stages over numerous years: <ul style="list-style-type: none"> • 2025 – construct 4 groynes • 2040 – construct 3 groynes • 2060 – construct 4 groynes Groynes are likely to be replaced after approximately 50 years: <ul style="list-style-type: none"> • 2075 – replace 4 groynes • 2090 – replace 3 groynes Beach nourishment is likely to be included in groyne construction works	\$50.5 million
Mullaloo	Groynes (6) and beach nourishment	Shoreline has receded to within 20 m of a significant asset	2025, with six groynes built in stages over numerous years: <ul style="list-style-type: none"> • 2025 – 1 groyne • 2050 – 2 groynes • 2060 – 1 groyne • 2070 – 2 groynes Groynes are likely to be replaced after approximately 50 years: <ul style="list-style-type: none"> • 2075 – replace 1 groyne • 2100 – replace 2 groynes • 2110 – replace 1 groyne 	\$21.0 million
Iluka	Beach nourishment	Beach has eroded to a width of 5 m or less	2025-2030, with campaigns approximately every 5 years	\$8.5 million
Burns Beach	Managed retreat	Shoreline has receded to within 20 m of a significant asset	When necessary, as determined by ongoing coastal monitoring	\$26.3 million
Total estimated cost to 2115				\$127.6 million

Source: MP Rogers 2022

Management recommendation

1. Implement the proposed adaptation pathways for each Coastal Management Zone, presented in Section 9.1, subject to detailed design, the latest coastal hazard information and community consultation in accordance with the City's Community Consultation Policy.

9.3 Recommendations applicable to all Coastal Management Zones

9.3.1 Monitoring and further investigation

Monitoring and further investigation is recommended to define coastal hazards and risk levels more clearly in the future, to determine the feasibility of proposed adaptation options and to monitor coastal changes against trigger points.

Coastal monitoring

The City implements an annual Coastal Monitoring Program which includes beach profile surveys, inspections and photo point beach monitoring, and shoreline mapping from aerial photos. The monitoring results will be used to inform management actions and identify the trigger points outlined in this CHRMAP to commence adaptation actions, such as sand nourishment works. The results will also be used to inform long-term coastal planning and future CHRMAP revisions.

Additional coastal monitoring is recommended following the implementation of the adaptation options. For Marmion and Iluka, where beach nourishment is recommended, additional topographic and bathymetric survey of the nourishment areas completed before, immediately following the nourishment campaign and around one year after the nourishment campaign should be completed. This allows for the effectiveness of the nourishment program to be determined, which will likely inform further nourishment campaigns.

The Sorrento, Hillarys to Kallaroo, and Mullaloo coastal management units are recommended to use a groynes adaptation option. For these coastal management units, it is recommended that additional coastal monitoring be completed through yearly profile monitoring of the areas following the construction of the groynes for a period of five years and five yearly following this. This will likely allow for the detection of any flow on effects from the construction of the groynes. This will also allow for revision to the groyne construction program likely limiting the impact of any of these potential issues upon the coastal management units.

Management recommendation

2. Continue to implement the existing annual Coastal Monitoring Program and increase coastal monitoring following the implementation of adaptation options, where required.

Coastal protection assets condition inspections

The City engaged coastal engineering consultants to conduct coastal protection assets condition inspections in 2017 and 2018 to assist in the ongoing management and maintenance planning for these assets. Monitoring of the condition of coastal protection assets, including detailed surveying, should be undertaken every 3-5 years and after significant storm events to identify changes in the condition of each structure and assess repair and maintenance works that might be required.

Management recommendation

3. Conduct coastal protection assets condition inspections every 3-5 years and after significant storm events to identify changes in the condition of structures and inform maintenance works.

Coastal hazard assessment

The City engaged coastal engineering consultants to conduct a Coastal Hazard Assessment in 2015 to identify coastal vulnerability lines over 100 years and inform the development of the CHRMAP. It is recommended that the Coastal Hazard Assessment be conducted every 10 to 15 years to capture any changes in the shoreline movement along the coast within a 100-year planning timeframe and incorporate relevant edits into the review of the CHRMAP.

It is also recommended that the Coastal Hazard Assessment is updated if the state government provide guidance which changes the determination of the required coastal hazard allowances as a result of new information becoming available. New information may be regarding climate change and projected sea level rise or information relating to the calculation of inundation allowances.

Management recommendation

4. Conduct a Coastal Hazard Assessment in 2025/26 and consider an update when the state government makes significant changes to coastal policies and processes.

Sand nourishment source investigation

Sand nourishment activities are recommended at several sites within the City, with sand nourishment required approximately every five years at several locations. The volume of sand required at each site is likely to increase over time due to sea level rise and climate change impacts causing increased coastal erosion rates. However, there is a finite amount of quality sand supply available and the City will need to identify suitable sand sources for use into the future.

Sand nourishment source investigations have been undertaken by other local governments in the Perth Metropolitan Area and this information may be able to be shared through the establishment of strategic partnerships. The state government has also commenced a comprehensive assessment of sand and rock supply and demand in the coastal regions of Western Australia with specific reference to that suitable for use in coastal protection works.

Management recommendation

5. Liaise with relevant local governments and state government to identify suitable sand sources for use in sand nourishment activities.

9.3.2 Planning controls

It is recommended that the City continues to implement the existing coastal hazard risk planning controls outlined in Section 3.7.1, including:

- Placing notifications about coastal hazard risks on certificates of title when undertaking development or subdivision on land that is subject to coastal hazard risk.
- Requiring that coastal hazard risk management and adaptation planning is undertaken by proponents prior to the development or subdivision of larger areas of land in coastal hazard risk areas.
- For land that is subject to a coastal hazard risk within the next 100 years, including this information on any Land Purchase Inquiry made in relation to that lot.
- Assessing structure plans and local development plans against the SPP2.6 requirements.

It also recommended that the City investigates amending the Local Planning Scheme to create Special Control Areas that apply to coastal hazard zones. Doing so will allow greater control to be exercised over development which is likely to be affected by coastal hazards, and for suitable guidelines and development standards to be applied to permissible development.

Management recommendations

6. Continue to implement existing coastal hazard risk planning controls.

7. Investigate amending the Local Planning Scheme to create Special Control Areas that apply to coastal hazard zones.

9.3.3 Partnerships

The City participates in the Western Australian Local Government Association (WALGA) Local Government CHRMAP Forum which was formed to provide opportunities for officers working in Local Governments in the coastal zone to share information, challenges and experiences in relation to coastal hazard risk management adaptation planning and coastal adaptation in general. The Local Government CHRMAP Forum may also collaborate on projects of common interest, policy submissions and other advocacy activities.

The City could establish or join a strategic partnership with other local governments such as the City of Wanneroo and the City of Stirling to collaborate and coordinate coastal adaptation management actions such as Coastal Monitoring Programs, beach nourishment, sand nourishment source investigations and conducting a sediment transport analysis.

Management recommendations

8. Continue to participate in the WALGA Local Government CHRMAP Forum to keep informed about best practice approaches and share knowledge relating to coastal hazard risk management adaptation planning.

9. Investigate the establishment or joining of a strategic partnership with other local governments such as the City of Wanneroo and the City of Stirling to collaborate and coordinate coastal adaptation management actions.

9.3.4 Funding options

The total cost of implementing all the proposed long-term adaptation options is estimated to be approximately \$127.6 million to 2115, however this figure is an estimate based on several assumptions and is likely to change and potentially increase over time. This value is a substantial amount and significantly greater than what the City currently spends on coastal management.

A Business Case will be developed after the CHRMAP is endorsed by Council which will evaluate the options on funding the direct costs over the full 100-year period to deliver the proposed adaption pathways. The business case will also evaluate the options for funding the adaptation pathways in the next 10 to 20 years.

There are several potential revenue raising methods and funding sources which could be used to establish a cash reserve for coastal protection and adaptation works, including state and federal government grants and funding opportunities. It is recommended that these options are investigated, and appropriate methods are selected to provide the City with funding for proposed adaptation options.

Management recommendation

10. Investigate funding options for coastal protection and adaptation works.

9.3.5 Advocacy

There are opportunities for the City to advocate at state and federal government level for a sustainable and equitable framework for the funding of coastal adaptation and to undertake actions in support of coastal adaptation and protection works, in alignment with the City's Advocacy Framework. The City's Advocacy Framework states that a focus area is the "physical and digital infrastructure to enable the region's economic, environmental and community development goals."

The City can also support WALGA's advocacy work to state and federal government regarding equitable legislative, regulatory and policy changes that preserve public coastal access for current and future

generations and the provision of sustainable and adequate long-term funding for local governments to manage the impacts of coastal erosion and inundation, as per their Coastal Planning Advocacy Position.

Management recommendation

11. Undertake advocacy to state and federal government for a sustainable and equitable framework for the funding of coastal adaptation and to undertake actions in support of coastal adaptation and protection works.

9.3.6 Continue existing protection and management actions

As outlined in Section 3.7, the City already undertakes protection measures at several coastal locations, including:

- Monitoring and maintaining three seawalls at Sorrento SLSC, Mullaloo SLSC and the Marmion Angling and Aquatic Club (MAAC).
- Monitoring and maintaining groyne at Burns Beach.
- Undertaking annual sand bypassing program between Sorrento Beach and Hillarys Beach to address the recession identified at Hillarys Beach Park and Pinnaroo Point.
- Stabilisation of sand in coastal foreshore reserves by revegetating foreshore reserves and conducting weed control.

It is recommended that these existing protection and management measures are continued.

Management recommendations

12. Continue to monitor and maintain seawalls at Sorrento, Mullaloo and Marmion and groyne at Burns Beach.

13. Continue to undertake annual sand bypassing program between Sorrento Beach and Hillarys Beach to address the recession identified at Hillarys Beach Park and Pinnaroo Point.

14. Continue to stabilise sand in coastal foreshore reserves by conducting revegetation and weed control works as per coastal Natural Area Management Plans.

9.3.7 CHRMAP revision

The CHRMAP will be monitored annually, and minor revisions incorporated as required. The CHRMAP will undergo a major review at 5 years and 10 years. The major review and update will capture any new information such as movement of the shoreline which will be reflected in the revised CHRMAP recommendations. It is likely that the effects of sea level rise and significant storm events will become more apparent across the City's coast into the future and, as a result, there will be a greater focus on coastal management and protection.

Consideration will also be given to updating the CHRMAP following any state government guidance on the coastal hazard allowances, or when SPP2.6 is reviewed and updated.

Management recommendation

15. Undertake a major revision of the CHRMAP after 5 years and 10 years and consider a revision of the CHRMAP when SPP2.6 and the City's Coastal Hazard Assessment is updated.

9.4 Summary of management recommendations

No.	Action Type	Recommendation	Timeframe
1	Adaptation Pathways	Implement the proposed adaptation pathways for each Coastal Management Zone, presented in Section 9.1, subject to detailed design, the latest coastal hazard information and community consultation in accordance with the City's Community Consultation Policy.	2025-2115
2	Coastal Monitoring Program	Continue to implement the existing annual Coastal Monitoring Program and increase coastal monitoring following the implementation of adaptation options, where required.	Annually (ongoing)
3	Coastal protection assets condition inspections	Conduct coastal protection assets condition inspections every 3-5 years and after significant storm events to identify changes in the condition of structures and inform maintenance works.	2023 and every 3-5 years (ongoing)
4	Coastal Hazard Assessment	Conduct a Coastal Hazard Assessment in 2025/26 and consider an update when the state government makes significant changes to coastal policies and processes.	2025/26 and every 10-15 years (ongoing)
5	Sand nourishment source investigation	Liaise with relevant local governments and state government to identify suitable sand sources for use in sand nourishment activities.	2025-2030
6	Planning controls	Continue to implement existing coastal hazard risk planning controls.	Ongoing
7	Planning controls	Investigate amending the Local Planning Scheme (LPS) to create Special Control Areas that apply to coastal hazard zones.	Part of LPS review scheduled to commence in 2024-25
8	Partnerships	Continue to participate in the WALGA Local Government CHRMAP Forum to keep informed about best practice approaches and share knowledge relating to coastal hazard risk management adaptation planning.	Ongoing
9	Partnerships	Investigate the establishment or joining of a strategic partnership with other local governments such as the City of Wanneroo and the City of Stirling to collaborate and coordinate coastal adaptation management actions.	2024-2030
10	Funding options	Investigate funding options for coastal protection and adaptation works.	Ongoing
11	Advocacy	Undertake advocacy to state and federal government for a sustainable and equitable framework for the funding of coastal adaptation and to undertake actions in support of coastal adaptation and protection works.	Ongoing
12	Maintain existing seawalls and groyne	Continue to monitor and maintain existing seawalls at Sorrento, Mullaloo and Marmion and existing groyne at Burns Beach.	Ongoing
13	Sand bypassing program	Continue to undertake annual sand bypassing program between Sorrento Beach and Hillarys Beach to address the recession identified at Hillarys Beach Park and Pinnaroo Point.	Annually (ongoing)

No.	Action Type	Recommendation	Timeframe
14	Revegetation and weed control works	Continue to stabilise sand in coastal foreshore reserves by conducting revegetation and weed control works as per coastal Natural Area Management Plans.	Annually (going)
15	CHRMAP revision	Undertake a major revision of the CHRMAP after 5 years and 10 years and consider a revision of the CHRMAP when SPP2.6 and the City's Coastal Hazard Assessment is updated.	2028 (major revision) and 2033 (new CHRMAP)

DRAFT

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