

# Capel to Leschenault CHRMAP

## City of Bunbury CHRMAP

Peron Naturaliste Partnership

4 December 2023





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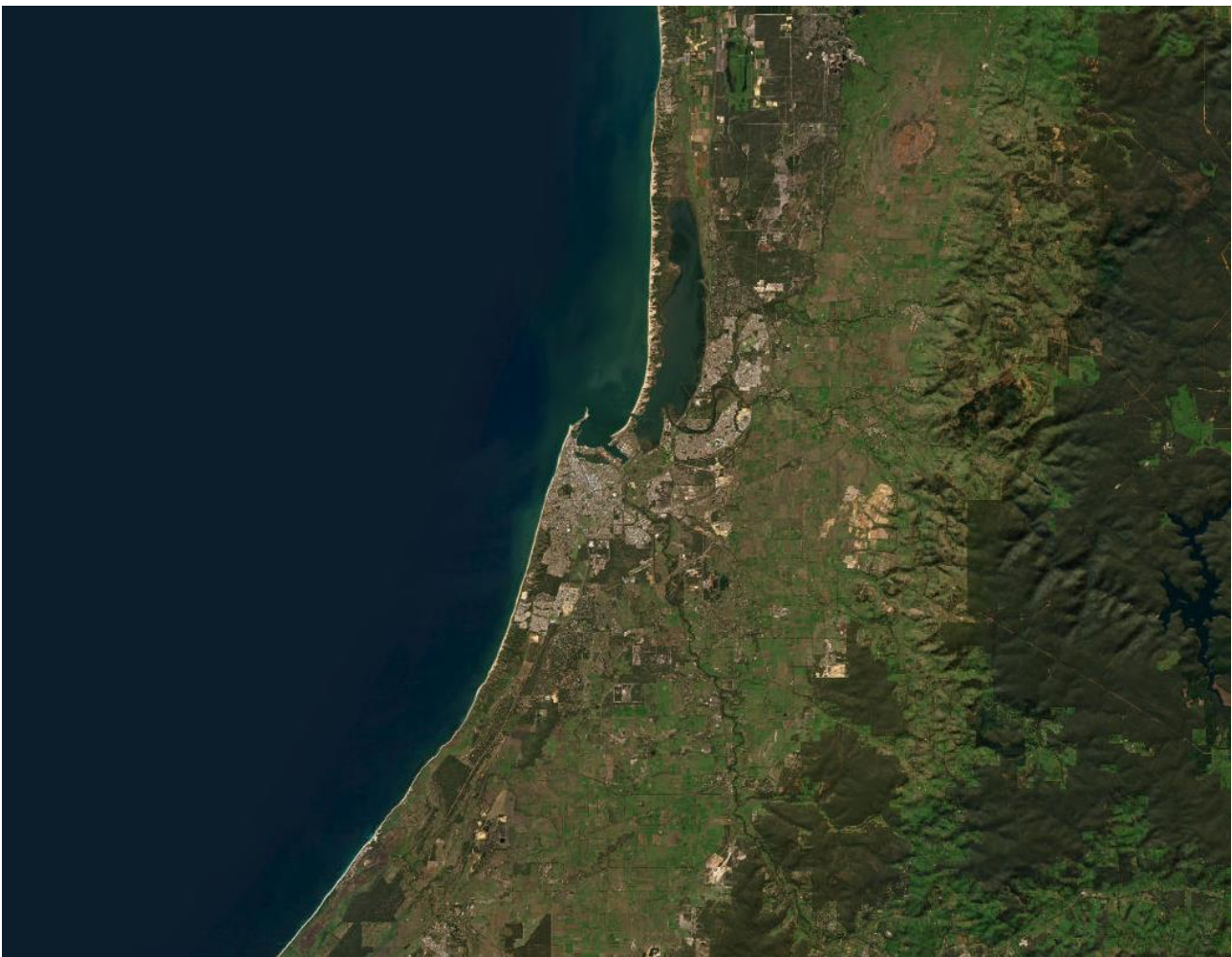
## ACKNOWLEDGEMENT OF COUNTRY

In the spirit of reconciliation, the Board, Directors and employees of Water Technology acknowledge and respect the Aboriginal and Torres Strait Islander Peoples as the Traditional Custodians of Country throughout Australia.

We acknowledge the Traditional Custodians of the land on which our offices reside and where we undertake our work. We specifically acknowledge the Wardandi Noongar people as the Traditional Custodians of the land our work relates to for this report.

We respect the knowledge, skills and lived experiences of Aboriginal and Torres Strait Islander Peoples and we will continue to strive to learn from them and work with them.

We also extend our respect to all First Nations Peoples, their cultures and to their Elders, past and present.



## EXECUTIVE SUMMARY

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is predicted to rise at an increasing rate in the future (IPCC 2014). Rising sea levels and intensifying storm activity will increase the risk of coastal inundation (temporary coastal flooding), storm erosion and long-term shoreline recession. State governments across Australia have introduced obligations that require local governments to consider and plan for these hazards. In Western Australia (WA), the governing policy is the



Western Australian Planning Commission's State Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013, herein referred to as "SPP2.6"). SPP2.6 recommends management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for land use or development that is vulnerable to coastal hazards. Specific guidelines have been developed to assist in this process (WAPC, 2019).

One of the key objectives of SPP2.6 is to establish coastal foreshore reserves including allowances for the protection, conservation and enhancement of coastal values across the state. Risk assessment processes are then utilised to identify risks that are intolerable to the community, and other stakeholders such as local governments, indigenous and cultural interests, and private enterprise. Adaptation measures are then developed according to the preferential adaptation hierarchy outlined in SPP2.6.

The Peron Naturaliste Partnership (PNP) comprises the membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for this CHRMAP. The project has investigated and planned for coastal hazards which are likely to affect these regions from Capel to Leschenault.

The project identifies the strategic direction for coastal adaptation scenarios and details an implementation plan describing risk management measures to be undertaken to achieve preferred risk treatments. The CHRMAP serves as a key reference for management, planning and policy making for the short-term (0-15 years), medium-term (15-30 years), and long-term (100 years).

The broader study area covers four Local Government Areas (LGAs) namely Shire of Harvey, City of Bunbury, Shire of Dardanup, and Shire of Capel. This report addresses coastal hazard vulnerabilities for the City of Bunbury.

The City shoreline can be divided into five primary management units:

- MU4 - Bunbury South
- MU5 - Bunbury (including Five Mile Brook district, Koombana Bay, Leschenault Inlet)
- MU6 - Bunbury Port (Inner Harbour)
- MU7 - The Cut
- MU8 – Bunbury East

A Coastal Hazard Assessment has identified the coastal hazards in the study area that need to be considered in the CHRMAP. Hazard maps were produced defining the erosion and inundation extents for present day, 2035, 2050, 2120. It is acknowledged that the hazard identification component of the present study was undertaken to provide a broad understanding of exposure that can support government planning at a regional level. The hazard identification may be superseded by future site-specific studies, particularly at the estuary/inlet and along the river courses. Results derived from this study should not be over-interpreted at a micro-scale due to the assumptions applied and the limitations in resolution.

Following the Hazard Assessment, a Coastal Assets Identification investigation was undertaken to identify the assets within the coastal hazard zone. All the assets in the coastal hazard zone were identified and classified into 9 categories as listed below. The quantity of each asset category by Management Unit, category and planning horizon are presented for each hazard.

- Roads
- Residential land
- Commercial land and assets



- Public and community assets not located in the foreshore reserve e.g., car parks, recreational facilities
- Developed foreshore reserve, including coastal, estuary and river foreshore areas
- Undeveloped foreshore reserve, including coastal, estuary and river foreshore areas
- Environmental
- Agricultural / rural lands
- Aboriginal heritage

Community and stakeholder involvement is a critical component of the CHRMAP process, as it defines what and how much value is placed on assets within the study area. As such, the project contained a high level of community and stakeholder engagement. Engagement outcomes have informed the adaptation planning process and ensured all needs are considered. This provides ownership of the CHRMAP with those that it affects, and acceptance of its outcomes. A Community Values assessment using various engagement methods was used to identify key values and concerns for the study area.

Key coastal, estuarine and riverine values identified by participants across the whole study area as follows:

- Beaches and estuarine areas for activities like walking, swimming, snorkelling, exercise, views, fishing, surfing, 4WDing
- Wetlands and environmental areas for their flora and fauna diversity which participants could appreciate
- Coastal views, walks and scenery
- Coastal vegetation and the natural environment generally

The values collated from the engagement to date have been used to generate the success criteria for the vulnerability and risk assessment component of the CHRMAP.

- Conserve, enhance and maintain the natural environment and character of the study area
- Facilitate and promote public usage and enjoyment of the natural environment, coast, estuaries and rivers
- Protection of the cultural values of the coastline
- Manage impacts to the existing residential areas from erosion and inundation
- Maintain critical infrastructure supporting the community (roads, utilities).
- Manage and maintain coastal infrastructure that provides access to the water and supports the lifestyle enjoyed by people in the region
- Retain the widest possible range of risk management options for future users of the coast

A Vulnerability Analysis, which constitutes the second stage of the risk identification process, was undertaken to develop likelihood, consequence, level of risk, adaptive capacity and vulnerability ratings for the nine asset categories.

All identified at-risk assets within the 11 management units are presented for the planning horizons of present day, 2035, 2050 and 2120, for each hazard. Extreme vulnerability has been identified from the present day onwards. Most of this extreme vulnerability is predicted to be from erosion, except for residential and commercial inundation.

The enormous number of at-risk assets, a total of approximately 48,000 in the broader study area, means grouping and summarising is the only meaningful method of assessing the risk at this stage of the planning process.



Recommended adaptation options to manage the coastal erosion and inundation risk in the City are presented to give direction for future investigations and funding opportunities. The recommendations are preliminary as they are based on currently available information. Future investigations are required to confirm they are suitable, including further consultation with stakeholders and the community. Subsequently a likely outcome is that a combination of options may be the preferred approach in some locations. The recommendations are based on the analysis presented in this report. Additional considerations may be incorporated into future analyses.

The proposed Options should be the subject of further investigations, surveys, policy review, impact investigations (environmental, visual and social), development approval and authorities endorsement, local stakeholder and community engagement, preliminary design, detailed design, costing and any other applicable preparation work required prior to be implemented. The Options should be optimised and modified following such additional investigations.

To address erosion for the City's coastline in the short-term a combination of Planned / Managed Retreat (MU4) and Protection with Groynes (MU5, MU6, M& and MU8) has been shown to be the preferred approach as a result of this analysis. To address inundation in the short-term it is recommended investigations are undertaken to plan for the Storm Surge Barrier to be replaced with an upgraded structure (MU5); and for confirmation of suitable levee design (MU6) as well as further design and investigations (MU7 and MU8)

A number of additional general investigations are recommended:

1. Prepare an Asset Management Plan for each Management Unit
2. Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat.
3. Sand source feasibility study
4. Rock source feasibility study
5. Emergency evacuation planning
6. Update Foreshore Management Plans (FMPs) - Updated foreshore management plans for the study areas may increase the protective capacity of the natural dune system.
7. Coastal Hazard Mapping Study

The CHRMAP is a strategic planning document that considers long timeframes. While the CHRMAP provides a rationale for coastal hazard management a substantial amount of preparatory work, detailed in the CHRMAP recommendations, is required before "on-the-ground implementation" can proceed. The next phase of research and studies would consider priority items in more detail, including:

- Community and stakeholder engagement
- Data collection and analysis
- Preliminary and detailed design investigations
- Environmental investigations to mitigate potential impacts
- Economic and budgeting analysis to determine accurate costs, once detailed designs are available





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# 1 INTRODUCTION

## 1.1 Background

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is predicted to rise at an increasing rate in the future (IPCC 2021). Rising sea levels and intensifying storm activity will increase the risk of coastal inundation (temporary coastal flooding), storm erosion and long-term shoreline recession. State governments across Australia have introduced obligations that require local governments to consider and plan for these hazards. In Western Australia (WA), the governing policy is the Western Australian Planning Commission's (WAPC) State Planning Policy No. 2.6: State Coastal Planning Policy (WAPC, 2013, herein referred to as "SPP2.6"). SPP2.6 recommends that management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for land use or development potentially vulnerable to coastal hazards. Specific guidelines have been developed to assist in this process (WAPC, 2019).

SPP2.6 requires adequate risk management planning is undertaken where the existing or proposed development is in an area at risk of being affected by coastal hazards over the 100-years planning timeframe. SPP2.6 and the CHRMAP Guidelines provide the risk assessment framework to be applied to identify risks that are intolerable to the community, and other stakeholders such as local governments, indigenous and cultural interests, and private enterprise. Risk management measures are then developed according to the adaptation hierarchy outlined in SPP2.6.

The Peron Naturaliste Partnership (PNP) comprises membership of nine local government authorities. The PNP's Coastal Adaptation Pathways Project identified the coastal areas of Capel, Leschenault and Greater Bunbury as being particularly exposed to coastal hazards and climate change, which triggered the need for this CHRMAP. Therefore, the present study aims to investigate the nature and severity of coastal hazards that are likely to affect these regions from metre over future planning horizons. Refer Figure 1-2 for locality, study area extent and management units. This report addresses coastal hazard vulnerabilities for the City of Bunbury (City).

This CHRMAP project aims to increase knowledge and understanding of coastal hazard risks and identify risk management and adaptation measures for implementation. The outcomes will be used to inform local and state government policies, strategies and plans, including (but not limited to), planning strategies, community strategic plans, drainage strategies, asset management plans, emergency management plans, and foreshore management plans. The project adheres to the WAPC (2019) guidelines with scope and deliverables consistent with the objectives identified by these guidelines and SPP2.6. In addition, the project determines the strategic direction for coastal adaptation scenarios from the present-day to 2120 (100 yrs. management time frame) and identifies an implementation plan to achieve this direction. Overall, this CHRMAP will serve as a key reference for management, planning and policymaking for the short-term (0-15 years), medium-term (15-30 years), and long-term (100 years).

Delivery of this project has occurred over 9 stages (as summarised in Figure 1-1), each of which represented a key hold point. The staged approach was developed according to the PNP's scope and is in line with the CHRMAP Guidelines (WAPC, 2019).

This report presents one of four Stage I Final CHRMAP Reports, which summarise the project and makes recommendations to address erosion and inundation vulnerabilities. The red bubble displayed in Figure 1-1, outlines Stage I in the context of the CHRMAP.



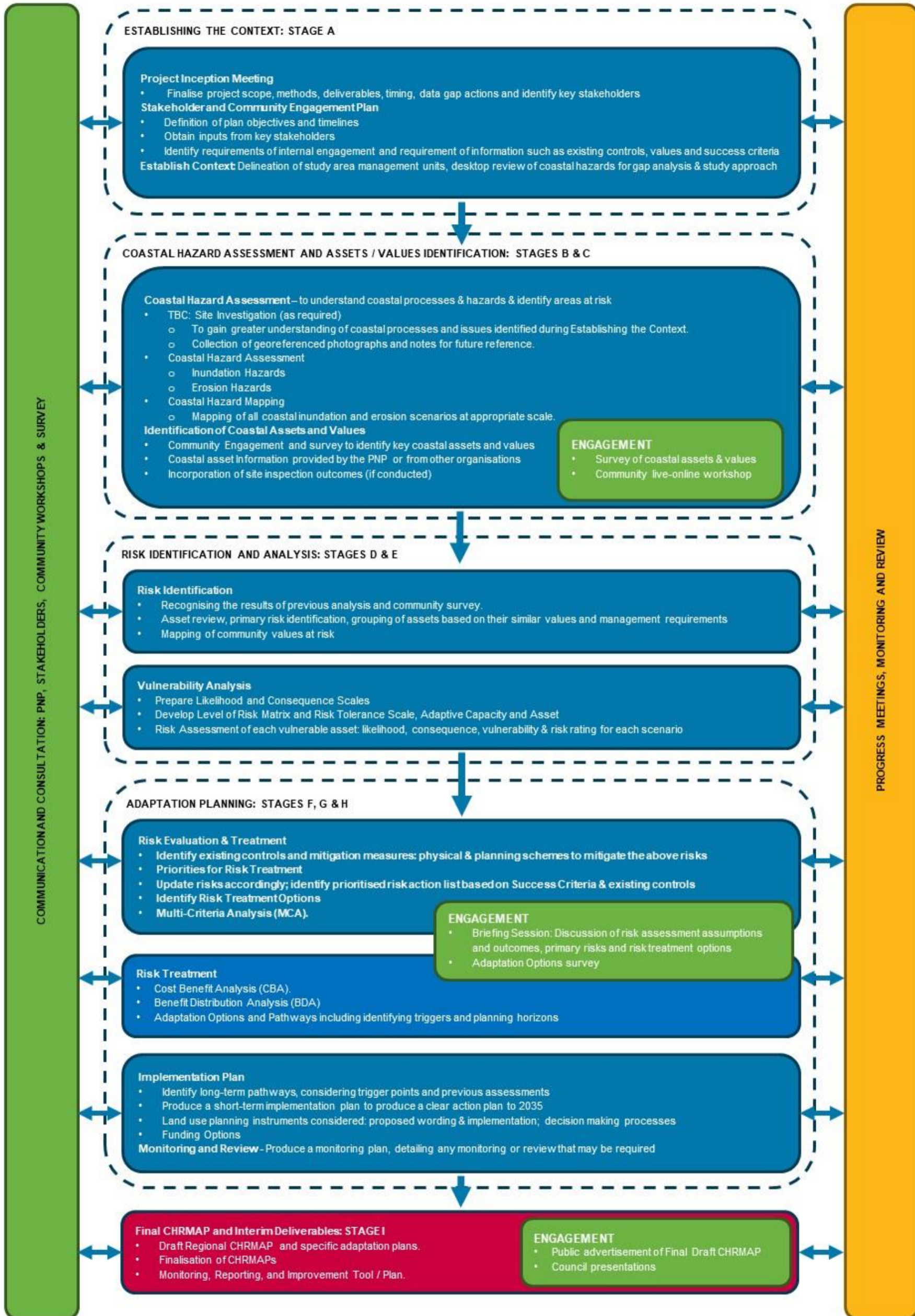


Figure 1-1 Methodology



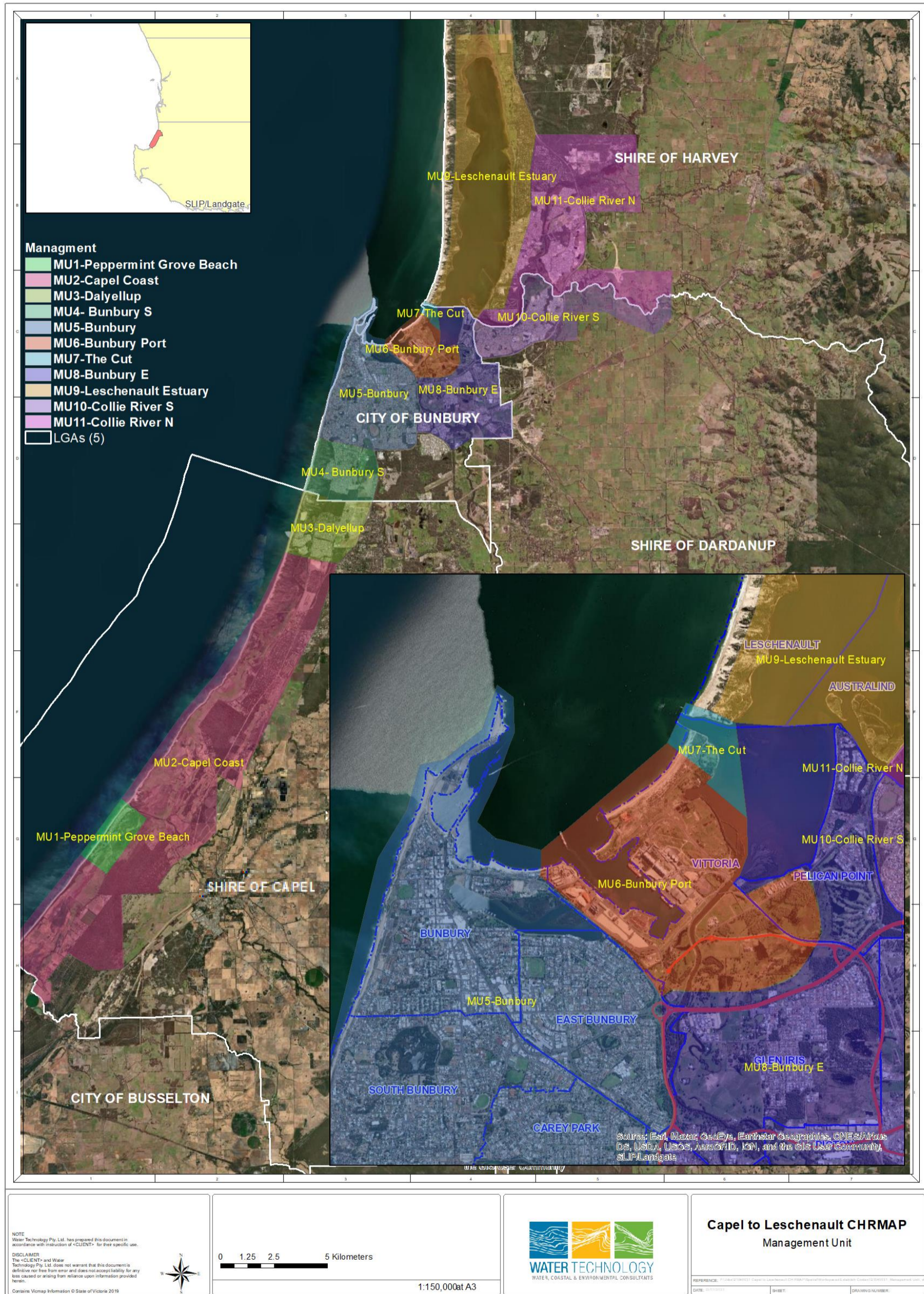


Figure 1-2 Study Area and Management Units





## 1.2 Structure of this report

This report is a summary document outlining the CHRMAP project and presenting content from the previous project stages and technical reports. It has been written to provide an overview that is more accessible to a wider audience. This report addresses coastal hazard vulnerabilities for the City and should be considered in combination with the more detailed technical reports which are provided as appendices. References are provided throughout this document and refer to the documents listed in the reference section of the relevant technical reports.

To facilitate the coastal hazard assessment and development of adaptation options, the study area was delineated into several management units which are determined according to a set of factors:

- Jurisdiction boundaries
- Presence of coastal assets and relevant stakeholders
- Coastal processes and potential hazard types.

The City shoreline can be divided into five primary management units:

- MU4 - Bunbury South
- MU5 - Bunbury (including Five Mile Brook district, Koombana Bay, Leschenault Inlet)
- MU6 - Bunbury Port (Inner Harbour)
- MU7 - The Cut
- MU8 – Bunbury East





## 2 STAGE A – ESTABLISH THE CONTEXT

An Establish the Context Chapter Report was prepared (Appendix A). This report outlines in detail the key management and adaptation issues that need to be considered in the CHRMAP, summarised below.

### 2.1 Purpose

The purpose of this project was for the PNP to work with the Steering Group and consultant(s) to develop a CHRMAP. The Steering Group included the City of Bunbury, the Shires of Capel, Dardanup and Harvey, WA Department of Biodiversity, Conservation and Attractions (DBCA), and the Southern Ports Authority (SPA), with support and technical advice from Department of Water Environment and Regulation (DWER), Department of Planning Lands and Heritage (DPLH), and Department of Transport (DoT).

The purpose of the CHRMAP was to provide strategic guidance for coordinated, integrated, and sustainable decision making for future coastal land use planning, including management of, and adaptation to, coastal hazard risks (coastal erosion and inundation). Management of risks to the study area's land adjacent to the ocean coast, estuaries and rivers is very important for the social, environmental, infrastructure and economic assets and values of the local communities. Although some work on coastal hazards had been undertaken across the study area in the past, a coordinated approach which identifies areas likely to be affected to erosion and/or inundation and requiring management and adaptation to mitigate the risks will provide increased resilience to these communities.

### 2.2 Objectives

The overall objectives of this CHRMAP were:

- Summarise the existing policies and planning controls, existing physical controls, and jurisdiction boundaries
- Improve understanding of existing coastal processes, features, and hazards within the study domain
- Identify coastal assets and values through stakeholder and community engagement
- Identify coastal hazard risks in terms of both coastal erosion and inundation, as well as potential vulnerability trigger points
- Improve understanding of asset risk and vulnerability to coastal hazards
- Determine the consequence, likelihood, and tolerance of assets to the identified risks
- Identify effective risk management measures through Multicriteria Analysis and Cost Benefit Analysis
- Identify short, medium, and long-term risk management actions
- Engage with stakeholders and the community to inform local values, adaptation pathway selection, and the implementation plan.

### 2.3 Scope

This CHRMAP identifies values and assets with intolerable risk levels to the coastal erosion and inundation hazards within the study area. Risk management measures were considered to reduce risks to tolerable levels. Tasks to implement the measures are summarised to provide strategic guidance on medium and longer-term risk management but provide more focus on short-term (<25 years) management measures. The CHRMAP has focussed on preserving assets and values which provide public benefit, although private at-risk assets are also identified.



## 2.4 Local Context

*Goomburrup (Bunbury)* is located in the *Gnarla Karla Boodja* region of WA and the traditional owner of this land is the *Noongar nation*. The City is located approximately 180 km south of Perth covering about 65 km area of coast. The area was first established as Municipality of Bunbury in 1871. In 1961, it became the Town of Bunbury under the Local Government Act 1960 and assumed its current name in Oct 1979. The 2016 census figures indicate the City has an established population of almost 32,000.

The study area within the City comprises of many different sections of coastline with variable shore types and degrees of development (Figure 2-1). Low-lying land is present along Five Mile Brook (e.g., the Big Swamp Wetland), surrounding Leschenault Inlet, and along Preston River. These areas are susceptible to coastal inundation. The City is a regional hub and has undertaken numerous developments along its coast. Infrastructure located within Koombana Bay includes shops, restaurants, Koombana Beach foreshore playground, Bunbury Port, Koombana Bay Sailing Club, Casuarina Harbour, Dolphin Discovery Centre, breakwaters, jetties, groynes, seawalls, bridges, roads, the storm surge barrier, as well as foreshore reserves etc. Consideration of the coastal hazards and adaptation constraints of these assets will be crucial for successful risk management and implementation plans.

The current shoreline of Bunbury is a result of combined effects of coastal processes and human intervention. The City is subject to coastal erosion and inundation, despite the numerous physical controls that have been implemented.

- Koombana Beach (one of the erosion hotspots identified by DoT (2019) study) has experienced a westwards littoral drift and progressive erosion on the eastern end. The issue has been studied previously to develop a feasible adaptation option. A seawall structure has been constructed to prevent further erosion.
- A breach of the northern training wall occurred at the Cut channel into Leschenault Estuary (one of the erosion hotspots identified by DoT (2019) study) in 2012 causing erosion of a sand bar along the northern bank. Emergency remedial work (such as minor excavation of the sand bar, landward extension of the northern training wall, tie-in of the extension with existing training wall) was undertaken in 2014, however it was not built to specification due to erosion of the site access point.
- Bunbury Ocean Drive (on the watchlist of coastal erosion by DoT (2019) study). Rock outcrops are present north of Wellington St along Bunbury Ocean Drive and Baudin Terrace. These rocks in general have a low elevation backed by sandy soil. The shoreline further north is protected by the Outer Harbour breakwater and spur groyne.
- Shorelines within Koombana Bay are either modified by engineering controls e.g., breakwaters and seawall, or within the scope of large-scale developments (such as the Port). All beaches in Koombana Bay are heavily modified due to the construction of the Port's inner harbour and river diversion. Sandy beaches are also present inside the bay, e.g., within Casuarina Harbour, Koombana Beach, and near Turkey Point.
- Leschenault Inlet and surroundings have a low-lying nature and are vulnerable to present and future inundation hazards. A tidal gate (Bunbury storm surge barrier) was installed near the entrance to prevent coastal flooding.
- Five Mile Brook is one of the main drainage paths of the City. The surrounding areas, including the Big Swamp Reserve, have a low ground elevation. There is a physical control at the outfall location, but it is unclear how it will function during extreme ocean water levels. Water Technology recommend including this site in the (yet to be confirmed) site inspection.
- Flood plain along Preston River. Riverbank protections were built to restrict the spreading of river flood.



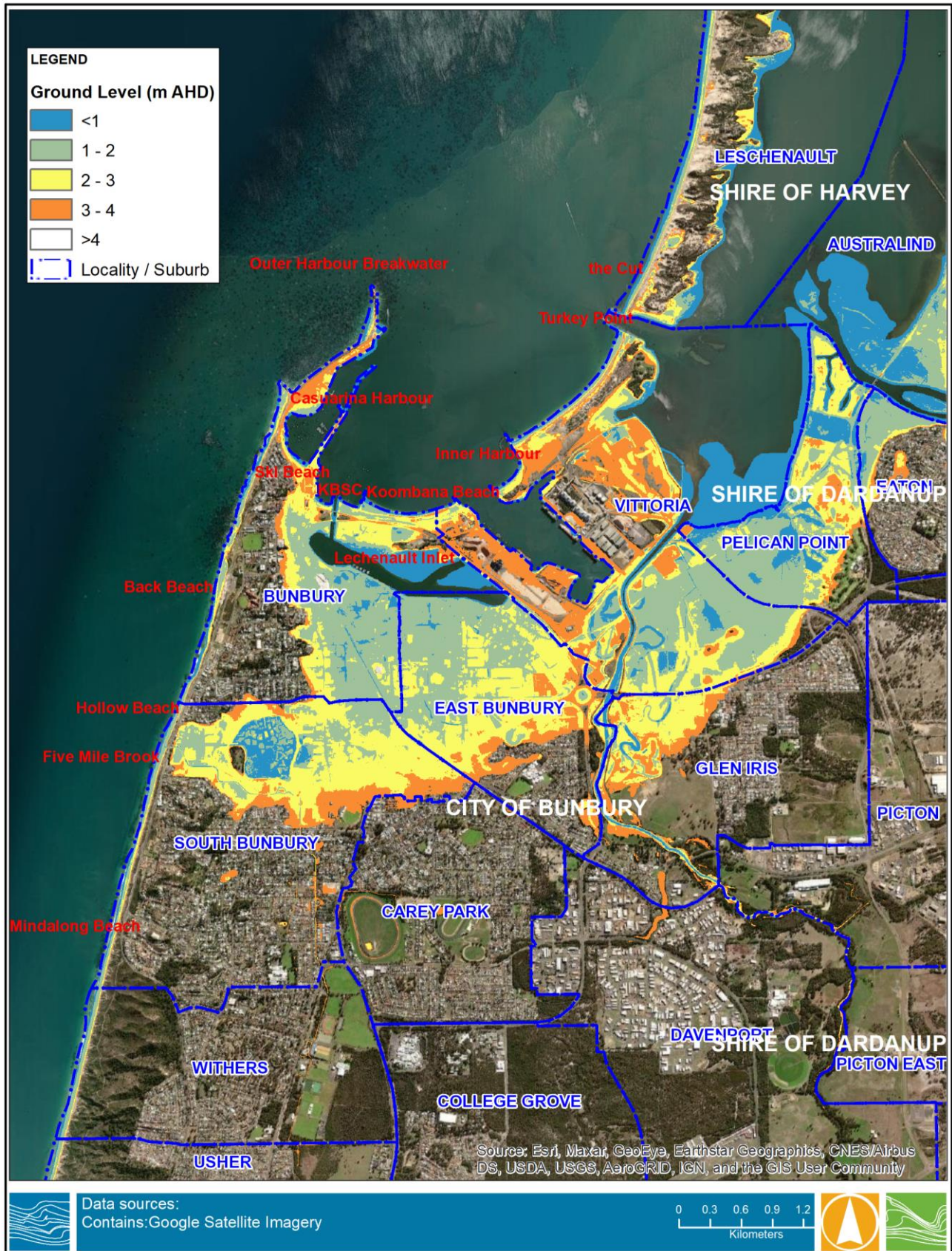


Figure 2-1 Bunbury Project Area (Overlaid are Suburbs & Roads)





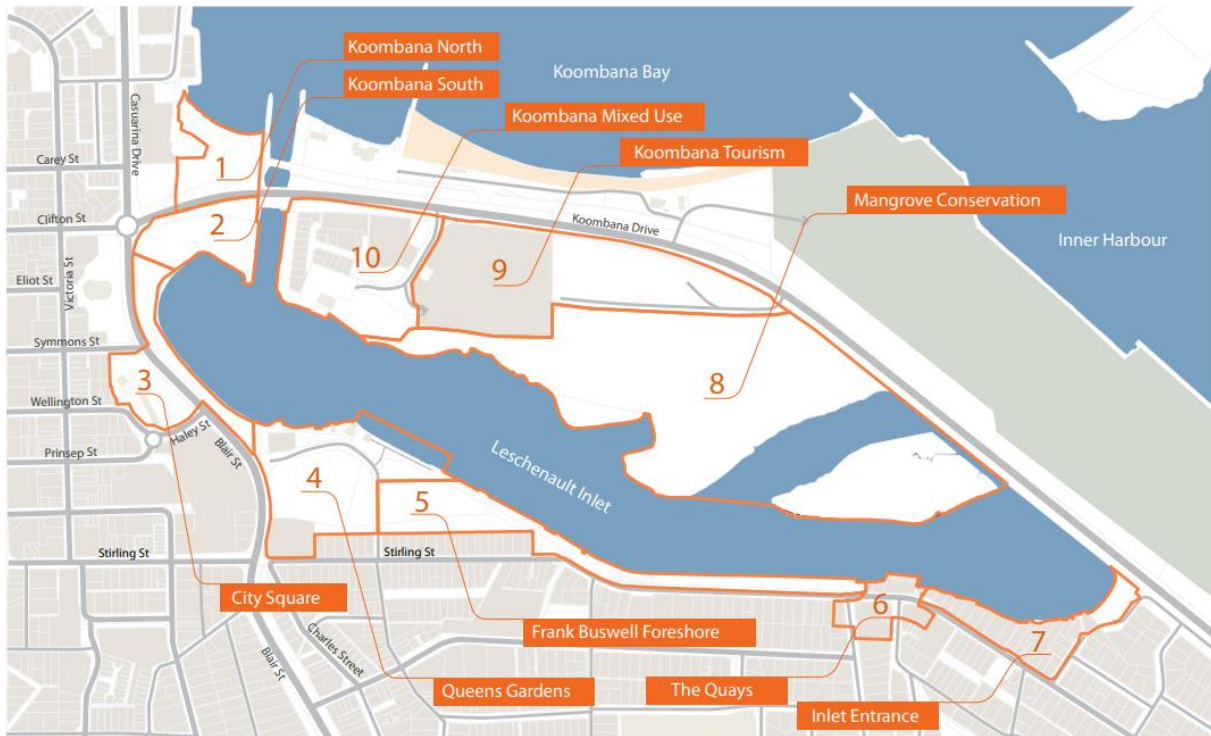


Figure 2-3 Bunbury Waterfront transformation - Marina Structures (Taken from RPS 2015)

## 2.4.2 Developments in Leschenault Inlet

Leschenault Inlet is a remnant of the lower section of the Leschenault Estuary, which was separated from the main water body by the construction of the Inner Harbour in the 1970s. The inlet has an area of approximately 70 hectares and is now one of Bunbury's most important recreational waterfronts. Since the 1980s, the inlet has undergone significant development including construction of foreshore protection (seawalls), boat ramps, jetties, boat clubs, discovery park, car parks, foreshore reserves, and boardwalks.

In 2013, the City prepared a Leschenault Inlet Master Plan to guide future development and planning for the area (Figure 2-4). The plan provided an overview of existing planning frameworks and land usage, and prioritised land developments for the future. Currently, the inlet comprises a mangrove reserve, and segments of engineered shoreline protecting the foreshore area. The foreshore is backed by paved roads and urban development and has limited setback for shoreline management or additional development beyond its present extent. In addition, the Bunbury storm surge barrier limits high ocean water levels impacting the inlet and surrounding lands.



**Figure 2-4 Leschenault Inlet Master Plan (City of Bunbury, 2013)**





## 2.5 Existing Planning Controls

Planning in Western Australia is guided and regulated by the State Planning Framework, which ranges from overarching strategic planning strategies, to specific planning policies and supportive guidelines. Figure 2-5 explains the framework, which includes planning at the state, regional, and local levels and demonstrates how strategic planning is implemented through statutory planning controls (e.g., local planning schemes) and local planning policies. This Framework sits within the Planning and Development Act 2005. The relationships of the various policies are presented in Figure 2-6.

The planning documents within this Framework were reviewed to determine which are relevant to coastal hazard planning in the project area. This review helped to: assess the adequacy of the existing planning documents for addressing coastal hazards; identify gaps that needed to be addressed through the CHRMAP process (such as planning controls that are required, or need amending to enable implementation of CHRMAP recommendations); identify any potential planning issues that may constrain the CHRMAP process; and ensured that the adaptation plan aligns with state, regional and local planning frameworks.

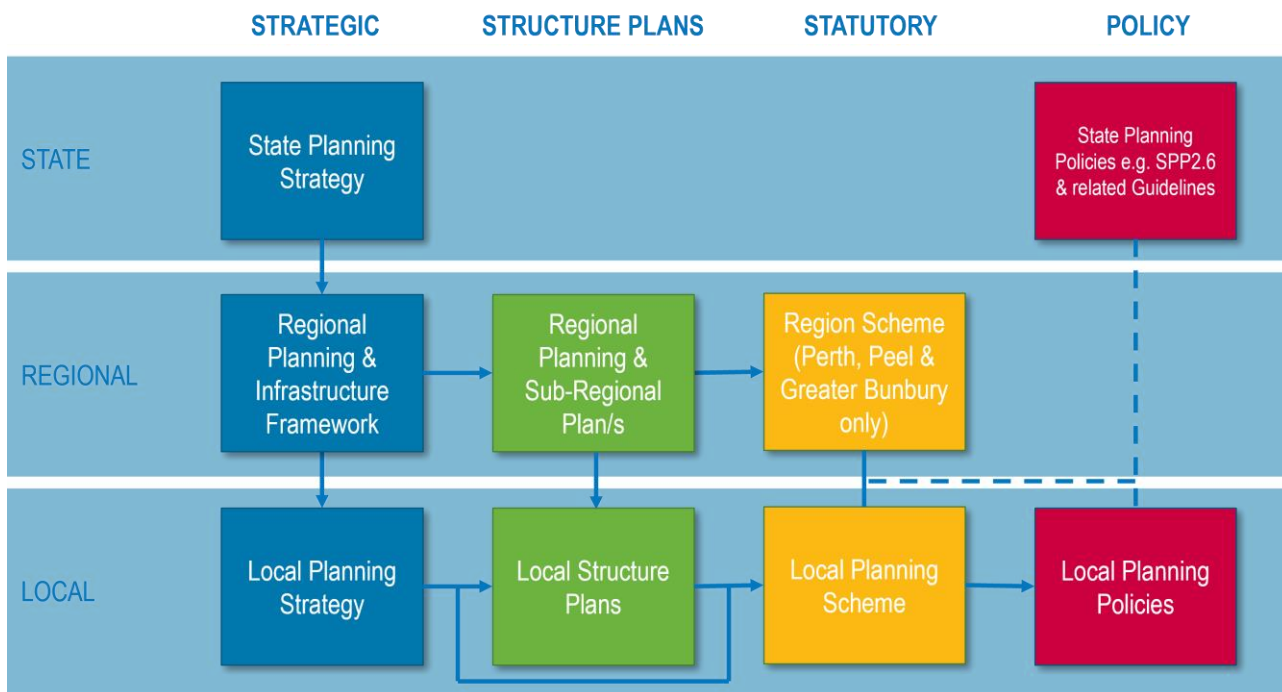


Figure 2-5 State Planning Framework for Western Australia

## 2.6 State Planning Policies and Strategies

The following state documents have been reviewed. Information relevant to the CHRMAP has been included below:

- State Planning Strategy 2050
- The WA Coastal Zone Strategy 2017
- State Planning Policy 2.6 – State Coastal Planning Policy, and associated Guidelines
- State Planning Policy 2.9 – Water Resources
- Coastal Hazard Risk Management and Adaptation Planning Guidelines 2019
- State Planning Policy 3.4: Natural Hazards and Disasters

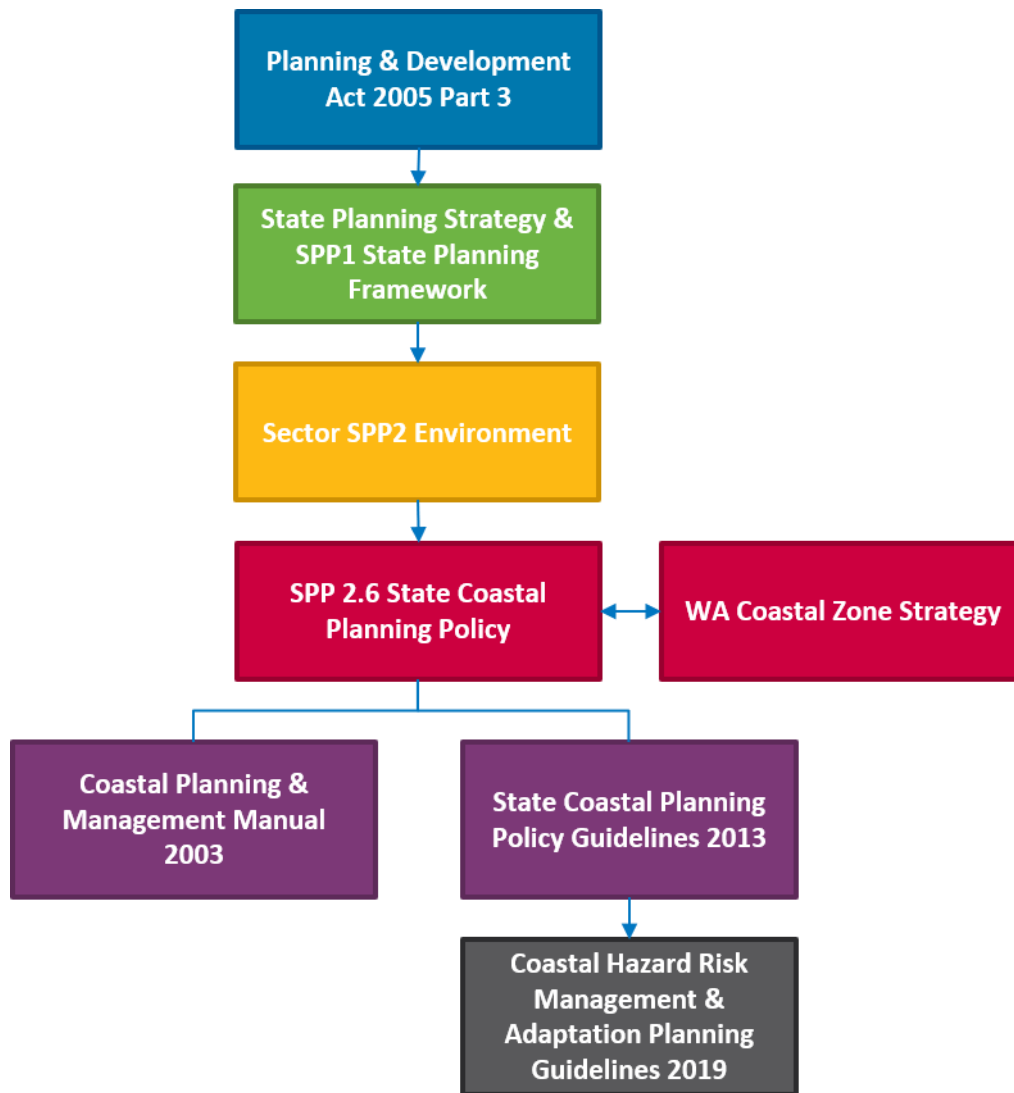


Figure 2-6 Policy Relationships

Regional and local planning documents were also reviewed for study area and discussed further in the Establish the Context Report.

## 2.7 Community and Stakeholder Engagement

Key to the success of the CHRMAP project was to ensure that the plan is underpinned by community and stakeholder values and knowledge. To this end, a Community and Stakeholder Engagement Plan was developed in order to identify relevant stakeholders and determine the structure and pathways for their engagement throughout the CHRMAP process. The plan was intended to be tailored, and commensurate with the size and scope of the CHRMAP –to avoid consultation fatigue within the community.

This plan was prepared in accordance with the requirements of, and for consistency with, the following documents:

- Capel to Leschenault Communications Framework (PNP, 2020)
- The International Association of Public Participation (IAP2) documentation

The overarching objectives of the community and stakeholder engagement plan for the CHRMAP are:



- Establish strong working relationships with community networks and stakeholders which are built on mutual trust and respect.
- To ensure all stakeholders have up to date information about the CHRMAP, and the broader coastal management framework that supports the project.
- To provide the community and relevant stakeholders the opportunity to have direct input into the development and delivery of the CHRMAP.
- To understand community goals and aspirations for the coastal zone and community views on values, assets, opportunities and priorities.
- To aid in identifying key issues and selecting site-specific CHRMAP management actions to address them. Stakeholders on the ground will have knowledge of the site developed over years of interaction. This provides invaluable information that can be applied to generate innovative CHRMAP measures.
- Increased community and stakeholder understanding of, and support for, actions and priorities in the CHRMAP.

The engagement plan activities undertaken for the CHRMAP are outlined below in Table 2-1.

**Table 2-1 Summary of Engagement Activities**

CHRMAP Stage	Engagement Activity	Description
Stage C: Coastal Assets and Community Values	Prepare for launch of project	Established Social Pinpoint mapping page for integration with PNP website portal - Social Pinpoint is a customisable community engagement platform which will be used to create a space to share information and keep the community engaged and informed. Provided tailored information for project communications (website content, media release, project information sheet, letter/email content, FAQs) Project launch – live project webpage, social media posts, launch of Coastal Assets and Values Survey to commence engagement phase of the project
Stage C: Coastal Assets and Community Values	Coastal Assets & Values Survey	Digital survey for PNP’s use, to provide the community, and stakeholders with the opportunity to identify areas / assets of value. Values will be categorised to aid the identification process.
Stage C: Coastal Assets and Community Values	Community live-online workshop	Confirmation local community’s values and perceptions of the key issues facing the study area. In this session, community members had an opportunity to provide information regarding: <ul style="list-style-type: none"> <li>▪ Community uses, and areas of high social, environment and cultural value; and/or</li> <li>▪ Community concerns regarding potential issues (including their priorities) to be addressed in the CHRMAP. This can also ascertain feedback regarding the current management plans and opportunities for improvement.</li> </ul>



<b>CHRMAP Stage</b>	<b>Engagement Activity</b>	<b>Description</b>
Stage F: Risk Treatment and Stage H: Implementation	Coastal Community Advisory Group	Two workshops with community members to calibrate the evaluation of options and consult on planned implementation measure.
Stage I: Draft CHRMAP	Public Advertisements of CHRMAP Reports	Draft CHRMAP will be placed on the CHRMAP website for public comment. The document will be emailed / mailed to stakeholders identified as not having access to the CHRMAP website.



## 3 STAGE B - COASTAL HAZARD ASSESSMENT

A Coastal Hazard Assessment Chapter Report (Appendix B) was prepared to identify the coastal hazards in the study area that need to be considered in the CHRMAP. Hazard maps are produced defining the erosion and inundation extents for present day, 2035, 2050, 2120.

The study area covers a complex shoreline with various types of coastal hazards present in this region. The presence of rivers, an estuary and inlet has increased the complexity of the broader study area, in particular the assessment of inundation hazards where river flood plays a more dominant role than the intrusion of ocean water. **It is acknowledged that the hazard identification component of the present study was undertaken to provide a broad understanding of exposure that can support government planning at a regional level - and will be superseded once site-specific studies become available, particularly at the estuary/inlet and along the river courses.** Results derived from this study should not be over-interpreted at a micro-scale due to the assumptions applied and the limitations in model resolution. More detailed risk assessments and analysis may be required for the development of detailed engineering measures for specific sites. No geophysical or geotechnical assessments have been undertaken across the study to date. Erosion response across the study area may differ in reality to the predictions of this study due to the lack of data. Further geophysical/geotechnical assessment will be a recommendation of this CHRMAP.

### 3.1 Erosion Hazard Assessment Method

#### 3.1.1 Summary

The erosion hazard study was carried out by the following steps:

- Simulate storm erosion for the 100 years ARI storm (S1).
- Evaluate historic shoreline movement trends based on DoT vegetation lines (S2).
- Evaluate sea level rise impacts for present day, 2035, 2050 and 2120 (S3).
- Apply corrections for controlled shoreline segments.
- Evaluate total erosion values for each coastal management zones and for four different planning periods i.e., present day, 2035 (short term), 2050 (medium term) and 2120 (long term).
- Establish an erosion matrix considering both exposure levels and planning periods.
- Mapping of erosion hazard lines.

#### 3.1.2 Method

A desktop review of available information was undertaken, including:

- Metocean conditions
- Coastal processes
- Existing coastal monitoring and management
- Existing coastal hazard information

The coastal hazard identification approach has been developed based on the following policies and guidelines:

- State Planning Policy 2.6 State Coastal Planning Policy (SPP2.6)
- Coastal Hazard Risk Management and Adaptation Planning Guidelines (CHRMAP Guidelines)
- State Planning Policy 2.9 Water Resources (SPP2.9)



SPP2.6 (WAPC, 2013) has provided a clear guideline for the evaluation of erosion hazards in tidal areas. It stipulates the following components be considered when evaluating the coastal erosion risk:

- Storm erosion in response to storm waves and loss of beach material.
- Historic shoreline movement that highlights the chronic/long-term evolution of the coast. This could be contributed by littoral drift processes, larger scale morphological movements, long-term water level/wave dynamic variations (~18.6 yrs. tidal cycle, interannual climate oscillations e.g., La Niña effects, Pacific Ocean decadal Oscillation etc.) and climate change impacts (SLR, more intense storms and rainfalls etc.).
- Direct response to future sea level rise.

SPP2.6 indicates the methods for determining the allowance for erosion for a sandy coast are derived principally for open coastlines. For erosion on tidal reaches of inland waters, allowance should be assessed in a site-specific context, with the methodology to be developed appropriately for each site.

The horizontal shoreline datum (HSD) is defined as the active limit of the shoreline under storm activity. It is the line from which the erosion hazard allowance will be applied from. In this assessment HSD has been determined by:

- Present day vegetation lines which often characterise the upper limit of seasonal storm impacts. The vegetation line can be difficult to establish within a reach where there are seasonal beach variations.
- Elevation of the 100-year ARI Peak Steady Water Level (about 1.7m AHD for 100-year ARI storm). A 2 m AHD elevation for open coast is generally appropriate to outline the potential unimpacted area for typical winter storms if vegetation lines are deemed too conservative for hazard mapping.
- For estuary environments with the presence of large tidal flats and vegetation growth, a conservative approach is used to define the HSD as the limit of storm inundation or riparian boundary as the HSD boundary.

The HSD line is included in the erosion hazard maps.

A summary of the erosion assessment approach is provided in Table 3-1.





**Table 3-1 Summary of Erosion Hazard Assessment Method**

Shoreline Type	Erosion Assessment
Open Coast	<p>Standard method as per SPP2.6. This considers erosion allowances relative to the present Horizontal Shoreline Datum.</p> <ul style="list-style-type: none"> <li>▪ HSD is defined by topographic contours, ground-truthed by vegetation lines.</li> <li>▪ Allowance for the current risk of storm erosion (S1) estimated by SBEACH model.</li> <li>▪ Allowance for historic shoreline movement trends (S2) estimated by analysis of historic vegetation lines.</li> <li>▪ Allowance for erosion caused by sea level rise (S3) through the application of Bruun Rule</li> <li>▪ Uncertainty allowance as per SPP2.6</li> <li>▪ Hazard lines are defined by <math>HSD+S1+S2+S3+uncertainty</math></li> </ul> <p>Consideration of erosion controls:</p> <ul style="list-style-type: none"> <li>▪ Physical controls such as Groynes, Port facilities, Outer breakwater and jetty road breakwater are considered as permanent structures assuming ongoing maintenance and management. These are key facilities that determines the overall landscape of Bunbury coast.</li> <li>▪ Seawall (erosion control works) that are designed with large armour rocks and proper toe protection are considered as effective for their design life e.g., buried seawalls along Ocean Drive, Ski Beach and Koombana Beach. The recorded extent of the existing seawalls along the ocean coast may be incomplete. During the CHRMAP the City identified that there are more seawalls in place along Ocean Drive than previously documented, with final details yet to be confirmed.</li> <li>▪ Temporary works, such as thin layers of revetment, are not considered as erosion controls.</li> </ul> <p>Consideration of landform stability in accordance with sediment cells and geomorphological features wherever appropriate.</p> <p>Rocky shoreline definition requires a continuous rocky surface extending above the reach of storm waves plus SLR. If the rocky surface is lower than the active limit of waves, the shoreline should be defined as a mixed or sandy type. Our analysis shows no continuous rock cliff above the reach of storm impact. Unless otherwise notified by geotechnical assessments, the shoreline within the study domain is categorised as 'sandy' (i.e. erodible) for the purpose of coastal planning and management.</p>
Estuary	<p>For shallow foreshore with/without riparian boundary, hazard lines defined by <math>HSD+S1+S2+S3+uncertainty</math> with fine scale adjustment to define the HSD:</p> <ul style="list-style-type: none"> <li>▪ HSD defined by the location of riparian boundary / inundation line (HAT level, 0.6m AHD, as boundary of tidal inundation) / physical controls.</li> <li>▪ Allowance for the current risk of storm erosion (S1). SBEACH model used to evaluate the extent of erosion generated by the strongest possible waves in the Estuary.</li> <li>▪ Allowance for historic shoreline movement trends (S2) estimated by review of historic vegetation lines/satellite images/historic reports.</li> <li>▪ A fixed allowance of 50 m is assumed as a response to SLR (or S3) by 2120, as per SPP2.9 recommendations.</li> </ul> <p>The estimated erosion hazard lines are compared against the permanent inundation extent (HAT water level +SLR) in 2121. Both are reported to facilitate erosion hazard assessment.</p> <p>Tidal flats and dynamic river deltas are excluded from current shoreline.</p>



Shoreline Type	Erosion Assessment
Leschenault Inlet	<p>Leschenault Inlet has a very limited impact from storm waves. Erosion of shoreline is largely contributed by increasing sea level and overflow of flood water.</p> <p>Shoreline movement is determined in context with tidal inundation from SLR and operation of the storm barrier.</p> <p>Total erosion allowance is estimated at 0.6m + SLR (e.g., 1.5 m AHD in 2120)</p>
Riverbank	<p>For riverbanks, methods derived for open coast by SPP2.6 are not applicable. SPP2.9 is used to guide the development of erosion hazard lines.</p> <ul style="list-style-type: none"> <li>▪ a 'foreshore reserve' width of 30 m by 2120 for main waterways (Preston, Collie River, Capel River)</li> <li>▪ a 'foreshore reserve' width of 15 m by 2120 for secondary channels (Branches of Collie River, Miller River, Henty River Brunswick River, Wellesley River etc.)</li> </ul> <p>We have noted several breaches through the coastal barrier near the Capel River mouth. This erosion is investigated at a broader scale by historic shoreline movement and also in the context of open coast erosion. Detailed analysis of breach activation is beyond the scope of current study.</p> <p>This study does not investigate riverine flooding through rainfall run-off within the river catchment, instead coastal flooding was assumed to be coincident with catchment flooding. Additionally, DWER has an existing Operational Policy 4.3, which requires a more comprehensive site-specific assessment based on biological and physical features.</p>

### 3.2 Inundation Hazard Method

Inundation is one of the primary coastal hazards of the region. Historical studies have identified multiple mechanisms contributing to the high-water levels along the coast and in the estuary and inlet of the broader study area.

SPP2.6 requires the allowance for inundation to be the maximum extent of inundation calculated as the sum of S4 Inundation plus the predicted extent of sea level rise. Being a coastal Policy, it does not apply to areas where inland processes dominate the inundation/flooding process.

A detailed numerical modelling approach has been used to assess coastal inundation with calibration to existing studies and information. Several MU's required case-by-case consideration and adjusted methodologies – please refer to the Coastal Hazard Assessment Chapter Report for a detailed description of the modelling tools utilised in this assessment.

The DHI MIKE storm surge model has been used to simulate the inundation extent in the study area coastal zone from Capel to Leschenault Estuary. The approach was proposed to account for the complexity of inundation processes in Leschenault Estuary, along river channels, and in the land depression of Capel which cannot be accurately assessed by a simple bathtub model approach, particularly with the inclusion of catchment flood impacts. A set of coincident ARI storm and cyclone events with river discharge events have been simulated to assess coastal inundation hazards.

Inundation along the open coast is evaluated by Water Technology's Danish Hydraulic Institute's MIKE storm tide model, calibrated to hindcast the storm tide conditions during TC Alby. The model simulates the combined effects of peak steady water level and wave setup through a coupled Hydrodynamic and Spectral Wave model.

For the 500-year ARI event, the inundation level is modelled through the simulation of a representative cyclone based on the existing TC Alby track, with adjustments to locate the cyclone eye near the Bunbury region (peak surge lasts for up to 4 hours). Overall, a physically realistic storm tide was modelled using this methodology.



### 3.3 Erosion Hazard Results

The total erosion hazard allowance for all MU's is presented in Table 3-2 to allow comparison. Detailed mapping of erosion extents is available in the Coastal Hazard Assessment Chapter Report. Summary mapping is provided in Section 3.5.

**Table 3-2 Erosion Hazard Allowance Summary**

Profiles	S1 m from HSD	S2 m/yr	S3 m/yr	Uncertainty m/yr	Erosion Allowance m from HSD			
					2020	2035	2050	2120
1 (MU2)	14.0	0	1	0.2	14	29	42	132
2 (MU2)	12.0	0	1	0.2	12	27	40	130
3 (MU2)	23.0	0	1	0.2	23	38	51	141
4 (MU1)	14.0	0	1	0.2	14	29	42	132
5 (MU2)	17.0	0	1	0.2	17	32	45	135
6 (MU2)	10.0	0	1	0.2	10	25	38	128
7 (MU2)	23.0	0	1	0.2	23	38	51	141
8 (MU2)	28.0	0.4	1	0.2	28	49	68	186
9 (MU3)	26.0	0.2	1	0.2	26	44	60	164
10 (MU3)	29.0	0.2	1	0.2	29	47	63	167
11 (MU3)	24.0	0.1	1	0.2	24	40.5	55	152
12 (MU4)	21.0	0	1	0.2	21	36	49	139
13 (MU5)	19.0	0	1	0.2	19	34	47	137
14 (MU5)	19.0	0	1	0.2	19	34	47	137
15 (MU5)	17.0	0	1	0.2	17	32	45	135
16 (MU5)	27.0	0	1	0.2	27	42	55	145
17 (MU5)	30.0	0	1	0.2	30	45	58	148
18 (MU5)	8.0	0	1	0.2	8	23	36	126
19 (MU5)	14.0	0	1	0.2	14	29	42	132
20 (MU5)	39.0	0	1	0.2	39	54	67	157
21 (MU5)	4.0	0	1	0.2	4	19	32	122
22 (MU5)	10.0	0.1	1	0.2	10	26.5	41	138
23 (MU5)	9.0	0.1	1	0.2	9	25.5	40	137
24 (MU5)	12.0	0.3	1	0.2	12	31.5	49	160
25 (MU6)	14.0	0	1	0.2	14	29	42	132
26 (MU6)	21.0	0	1	0.2	21	36	49	139
27 (MU6)	21.0	0	1	0.2	21	36	49	139
28 (MU7)	15.0	0	1	0.2	15	30	43	133



Profiles	S1 m from HSD	S2 m/yr	S3 m/yr	Uncertainty m/yr	Erosion Allowance m from HSD			
					2020	2035	2050	2120
29 (MU8)	3.0	0	0.5	0	3	10.5	18	53
30 (MU9)	5.0	0	0.5	0	5	12.5	20	55
31 (MU9)	3.0	0	0.5	0	3	10.5	18	53
32 (MU9)	3.0	0	0.5	0	3	10.5	18	53
33 (MU9)	3.0	0	0.5	0	3	10.5	18	53
34 (MU9)	5.0	0	0.5	0	5	12.5	20	55
35 (MU9)	5.0	0	0.5	0	5	12.5	20	55
Preston River	0.0	0	0.3	0	0	4.5	9	30
Collie River	0.0	0	0.3	0	0	4.5	9	30

### 3.4 Inundation Hazard Results

The modelled peak steady water levels are presented in Table 3-3. Detailed mapping of inundation extents is available in the Coastal Hazard Assessment Chapter Report. Summary mapping is provided in Section 3.5. The water level differences are smaller for 1-year, 10-year and 100-year storms as the duration of these storms were expanded to cover multiple tidal cycles. This represents the longer duration of winter storms compared to extratropical cyclones.



**Table 3-3 Modelled Peak Steady Water Level (m AHD)**

Locations	Peak Steady Water Level (m AHD), various ARIs (years)															
	Present				2035				2050				2120			
	1	10	100	500	1	10	100	500	1	10	100	500	1	10	100	500
Leschenault Estuary	1.1	1.5	1.9	2.1	1.2	1.6	2.1	2.3	1.3	1.7	2.2	2.9	2.1	2.4	2.9	3.1
Koombana Bay	1.1	1.4	1.9	2.8	1.2	1.5	2.0	2.9	1.3	1.6	2.1	2.9	2.1	2.4	2.9	3.7
Leschenault Inlet				1.2				1.3				1.9		0.6	1.9	2.6
Open Coast (Bunbury)	1.1	1.4	1.9	3.0	1.2	1.6	2.0	3.1	1.3	1.7	2.1	2.8	2.1	2.4	2.8	3.9
Open Coast (Capel)	1.1	1.4	1.8	2.7	1.2	1.5	1.9	2.8	1.3	1.6	2.0	2.8	2.1	2.4	2.8	3.6
Land Depression	1.0	1.2	1.5	2.3	1.1	1.2	1.5	2.4	1.1	1.2	1.6	2.4	1.2	1.5	2.4	3.4





### 3.5 Summary of Coastal Hazard Assessment Outcomes

The outcomes of the coastal hazard assessment for each management unit are summarised and discussed in Table 3-4 below.

**Table 3-4 Summary of Coastal Hazards for each Management Unit**

Management Unit	Erosion & Inundation Hazard	Summary
MU4 – Bunbury South		<ul style="list-style-type: none"> <li>▪ Inundation is not a high risk in this management unit.</li> <li>▪ Erosion is predicted to impact natural assets only within this management unit.</li> </ul>



Management Unit	Erosion & Inundation Hazard	Summary
<p>MU5 – Bunbury - including open coast, Koombana Bay and Leschenault Inlet</p>		<ul style="list-style-type: none"> <li>▪ Inundation is a significant risk across much of this management unit. The inundation risk is predicted to increase from present day to 2120. By 2120, the 100-year ARI is predicted to inundate a significant residential and commercial area.</li> <li>▪ The Storm barrier plays a key role in inundation control. The risk of coastal inundation would be much greater if the storm barrier was not in operation.</li> <li>▪ Much of the CBD is predicted to be under water during a 100-year and 500-year ARI storm in 2120. The crest of current storm barrier is about 2.1 m AHD, which is not predicted to be high enough to withstand these storms in 2120.</li> <li>▪ Erosion is a significant risk for buildings and natural assets along the western coast of the City.</li> <li>▪ Koombana Bay and Leschenault Inlet are heavily engineered. Erosion may still occur along shorelines not protected by structures.</li> <li>▪ Access to the outer harbour (Casuarina Drive) is at risk from 2035.</li> </ul>
<p>MU6 – Bunbury Port</p>		<ul style="list-style-type: none"> <li>▪ Inundation risk at the shipping yard and other lower ground areas.</li> <li>▪ Main port facilities are not affected as they are located at higher ground and are protected by controlled shorelines.</li> <li>▪ By 2120, the land near the entrance to the inner Port will be within the erosion hazard zone. Reinforcement may be required for shoreline segments not protected.</li> <li>▪ It is noted that a high-level study using policy setbacks provides no additional value to the planning and management of lands along the Preston River (at the back end of the port).             <ul style="list-style-type: none"> <li>– Water Corporation levees have not been considered in the development of these lines</li> </ul> </li> </ul>



Management Unit	Erosion & Inundation Hazard	Summary
<p>MU7 – the Cut</p>		<ul style="list-style-type: none"> <li>▪ The Cut entrance is at risk of erosion by 2120. Seawater may erode the sand dune behind the seawall if it is not designed and constructed to standards. Attention must be paid to the impact of overtopping and breaching of the sand dune behind the seawall.</li> <li>▪ Inundation is not a key risk in this management unit.</li> </ul>
<p>MU8 – Bunbury East - including Vittoria Bay, Pelican Point and Districts along Preston River</p>		<ul style="list-style-type: none"> <li>▪ The areas surrounding Preston River and the Estuary are at risk of inundation from the present day.</li> <li>▪ Foreshore Park and the commercial properties on Estuary Drive are predicted to be in the coastal erosion hazard zone by 2120.</li> <li>▪ It is assumed the canal infrastructure will be maintained; however, the canal properties are at risk from erosion along the river and estuary fronts by 2120. This prediction however only serves the purpose of government planning and should not be used for risk assessment of individual properties.</li> </ul>





## 4 STAGES C AND D – COASTAL ASSETS AND COMMUNITY VALUES IDENTIFICATION

A Coastal Values and Community Assets Chapter Report (Appendix C) was prepared which identifies the assets and community values within the coastal hazard zone. Community and stakeholder involvement is a critical component of the CHRMAP process, as it defines what and how much value is placed on assets within the study area. This informs the adaptation planning process and ensures all needs are considered. As such, the project contains a high level of community and stakeholder engagement. This provides ownership of the CHRMAP with those that it affects, and acceptance of its outcomes.

### 4.1 Asset Identification

Coastal assets (both natural and built) were identified in the following ways:

- Asset information was provided in excel and spatial file formats for use in this study by Steering Group members. These were imported into the GIS database developed for the project and used as the basis for the coastal asset identification.
- Landgate assets database, including for roads.
- The coastal values survey(s) and other engagement activities to identify additional assets of importance and value to the community.
- Site visit to investigate locations where information was not clear from the desktop assessment.
- Manual identification of further assets from aerial photography (e.g., developed areas of foreshore reserve)

### 4.2 Asset Classifications

At the time of identification, each asset was categorised into a classification. This streamlines the adaptation planning process in subsequent phases of the project. The study team grouped assets as follows:

- Roads
- Residential land, including both occupied and vacant land
- Commercial land and assets e.g., Bars, shops, markets etc.
- Public and community assets not located in the foreshore reserve e.g., car parks, recreational facilities
- Developed foreshore reserve, including coastal, estuary and river foreshore areas
  - Reserve containing public assets, e.g., car parks, public ablutions, playgrounds, walkways, access structures
- Undeveloped foreshore reserve, including coastal, estuary and river foreshore areas
- Environmental
  - Contaminated sites
  - DBCA data. This includes habitat areas potentially suitable for Matters of National Environmental Significance (such as Carnaby's Cockatoo's and Western Ringtail Possums), Threatened and Priority Ecological Communities, and known locations of threatened flora.
- Agricultural / rural lands
- Aboriginal heritage



One of the main challenges of this CHRMAP is the numerous assets and management zones. This asset classification was developed to address the main coastal adaptation issues and key locations and enable a simple yet effective method for adaptation planning.

### 4.3 Community Values Engagement Process

The engagement activities for this stage of the project included:

- Use of an interactive project tool (Social Pinpoint) to answer CHRMAP value survey questions and pin values and comments spatially on a project map
- Hard copy surveys mirroring the online component
- Community workshop held on 2<sup>nd</sup> September 2021 in each of the four LGAs and linked online to discuss coastal processes, map community values and understand issues and concerns of the community for the study area, attended by 28 members of the community
- Direct engagement with Traditional Owners and Indigenous representatives
- Stakeholder meetings

In the preliminary stage of engagement, stakeholders could visit an online project page with a mapping tool and survey to drop pins and comment on activities they value and their locational preferences for these activities on the map. Participants could also respond to a survey and provide any other feedback on how they use the different areas of the coastline. The survey was available online and in hard copy at the LGA administration centres. The survey and mapping tool was open from 26<sup>th</sup> July 2021 to 10<sup>th</sup> September 2021. In addition, people could provide survey responses in hard copy.

The project team received 84 CHRMAP values survey responses online, 97 hard copy survey responses (a total of 181 survey responses) and 56 'pins' were placed on the map. Whilst 'place of residence' was not included in the survey, more than 50% of respondents visited locations in the Shire of Capel most often, and approximately 30% of respondents visited beaches in the City of Bunbury most often.

Stakeholders were further engaged through the following:

- Social media posts
- Key briefings with the Steering Group, including administrative staff from PNP, the four LGAs, the Department of Planning, Lands and Heritage, Department of Water, Environment and Regulation, Southern Ports Authority and the Department of Transport
- Briefings to key staff members and Executive Management at the LGAs.

Overall, more than 150 participants contributed to this stage of engagement, with an approximate reach of more than 445 local community members and organisations.

### 4.4 Coastal Assets and Community Values

A summary and brief discussion of these assets is presented in Table 4-1 for the relevant MU's. Key coastal, estuarine and riverine values identified by participants across the whole study area as follows:

- Beaches and estuarine areas for activities like walking, swimming, snorkelling, exercise, views, fishing, surfing, 4WDing
- Wetlands and environmental areas for their flora and fauna diversity which participants could appreciate
- Coastal views, walks and scenery
- Coastal vegetation and the natural environment generally



- Opportunities for observing wildlife at various locations and protecting habitat for these communities and species

Key issues and concerns / risks to the coastal values:

- Beach erosion and its environmental, social and financial impacts
- Vegetation retention, revegetation and the need to do more to protect coastal areas from erosion came up multiple times in the different LGAs
- Environmental protection was generally very highly valued
- Sea level rise and climate change was also a key discussion point at the workshop, with participants wanting to see decision-makers actively addressing climate change impacts
- Contamination and pollution impacts on fauna and flora and the health of waterways from industrial activities along the coastline and river environment, including the port at Bunbury
- Protection of coastal wetlands that mitigate against impacts of extreme events and that are home to birds and wildlife
- Biodiversity and habitat loss
- Human impact on the coastal and estuarine natural assets and values to the community



Table 4-1 Summary of hazards to assets.

Management Unit	Summary	Snapshot of Assets at Risk
MU4 – Bunbury South	<ul style="list-style-type: none"> <li>Erosion is predicted to impact natural assets within this management unit.</li> <li>Inundation is not a high risk in this management unit.</li> </ul>	<ul style="list-style-type: none"> <li>By 2120, 12 environmental assets at risk from erosion; 7 by inundation</li> <li>Developed and undeveloped foreshore is at risk from erosion from the present day; public and community assets are by 2120</li> </ul>
MU5 – Bunbury - including open coast, Koombana Bay and Leschenault Inlet	<ul style="list-style-type: none"> <li>Erosion is a significant risk from the present day to both built and natural assets along the western coast of the City of Bunbury.</li> <li>Inundation is a significant risk across much of this management unit. The inundation risk is predicted to increase from present day to 2120. By 2120, the 1-year ARI is predicted to inundate a significant residential and commercial area.</li> <li>Environmental, public and community assets are also predicted to be significantly impacted by inundation</li> </ul>	<ul style="list-style-type: none"> <li>Approximately 340 roads at risk of inundation by 2120; 57 by erosion</li> <li>By 2120, 141 environmental assets at risk from erosion; 277 by inundation</li> <li>267 residential properties predicted to be impacted by erosion by 2120</li> <li>2106 residential properties predicted to be impacted by inundation by 2120</li> <li>By 2120, 8 commercial assets at risk of erosion, 500 from inundation</li> <li>4 Aboriginal Heritage assets in both hazard zones from the present day</li> <li>Developed and undeveloped foreshore, public and community assets are at risk from erosion and inundation from the present day</li> </ul>
MU6 – Bunbury Port	<ul style="list-style-type: none"> <li>By 2120, the land at the entrance to the inner Port is completely within the erosion hazard zone</li> <li>Inundation is the main risk in this management unit.</li> <li>It is noted that a high-level study using policy setbacks provides no additional value to the planning and management of lands along the Preston River.</li> </ul>	<ul style="list-style-type: none"> <li>Approximately 8 roads at risk of inundation by 2120; 3 by erosion</li> <li>By 2120, 90 environmental assets at risk from erosion; 78 by inundation</li> <li>2 agricultural / rural lots predicted to be impacted by erosion by 2120, 4 by inundation</li> <li>By 2120, 13 commercial assets at risk of erosion, 7 from inundation</li> <li>Developed and undeveloped foreshore, public and community assets are at risk from erosion from the present day</li> <li>Public and community, undeveloped foreshore at risk of inundation from the present day</li> </ul>
MU7 – the Cut	<ul style="list-style-type: none"> <li>The Cut entrance is at risk of erosion and inundation by 2120 (assuming seawalls are not maintained).</li> <li>Natural assets are at risk in this management unit</li> </ul>	<ul style="list-style-type: none"> <li>By 2120, 129 environmental assets at risk from erosion; 91 by inundation</li> <li>The undeveloped foreshore reserve is at risk of erosion and inundation from the present day</li> </ul>
MU8 – Bunbury East - including Vittoria Bay, Pelican Point and Districts along Preston River	<ul style="list-style-type: none"> <li>Inundation is the biggest risk for this management unit</li> <li>The areas surrounding Preston River and the Estuary are at risk of inundation from the present day.</li> <li>It is assumed the canal infrastructure will be maintained; however, the canal properties are at risk from erosion along the river and estuary fronts by 2120.</li> <li>Foreshore Park and the commercial properties on Estuary Drive are predicted to be in the coastal erosion hazard zone by 2120.</li> </ul>	<ul style="list-style-type: none"> <li>Approximately 19 roads at risk of erosion by 2120; 79 by inundation</li> <li>By 2120, 104 environmental assets at risk from erosion; 145 by inundation</li> <li>92 residential properties predicted to be impacted by erosion by 2120</li> <li>409 residential properties predicted to be impacted by inundation by 2120</li> <li>By 2120, 2 commercial assets at risk of erosion, 8 from inundation</li> <li>By 2120, 4 Aboriginal Heritage assets at risk of erosion, 7 by inundation</li> <li>Public and community, developed and undeveloped foreshore at risk of erosion and inundation from the present day</li> </ul>





## 4.5 Success Criteria

The values collated from the engagement were used to generate the success criteria for the vulnerability and risk assessment component of the CHRMAP. These are key to the whole CHRMAP as these criteria were used to drive the selection of adaptation options. The success criteria are reproduced in Table 4-2.

**Table 4-2 Success criteria**

- Conserve, enhance and maintain the natural environment and character of the study area
- Facilitate and promote public usage and enjoyment of the natural environment, coast, estuaries and rivers
- Protection of the cultural values of the coastline
- Manage impacts to the existing residential areas from erosion and inundation
- Maintain critical infrastructure supporting the community (roads, utilities).
- Manage and maintain coastal infrastructure that provides access to the water and supports the lifestyle enjoyed by people in the region
- Retain the widest possible range of risk management options for future users of the coast



## 5 STAGE E – VULNERABILITY ANALYSIS

A Vulnerability Analysis Chapter Report (Appendix D) was prepared which constitutes the second stage of the risk identification process. Likelihood, consequence, level of risk, adaptive capacity and vulnerability scales were developed for the nine asset categories. All identified at-risk assets within the 11 management units were then assigned vulnerability ratings, according to the various scales. The vulnerability results are presented in full in the Vulnerability Analysis Chapter Report. A summary is presented below by management unit and asset category, for the planning horizons of present day, 2035, 2050 and 2120.

### 5.1 Method

A vulnerability assessment defines the degree of impact coastal hazards are likely to have on coastal assets over the planning timeframe. The vulnerability of coastal assets to coastal hazards is related to its exposure to the hazard, its sensitivity to that exposure, and the ability of the asset to be modified or adapted to manage this exposure. This is displayed diagrammatically in Figure 5-1; the input components are displayed in blue.

Inundation and erosion hazards are considered separately. Assets are grouped according to classification for ease of interpretation. Ratings were discussed with the Steering Group to ensure they reflect the community views.

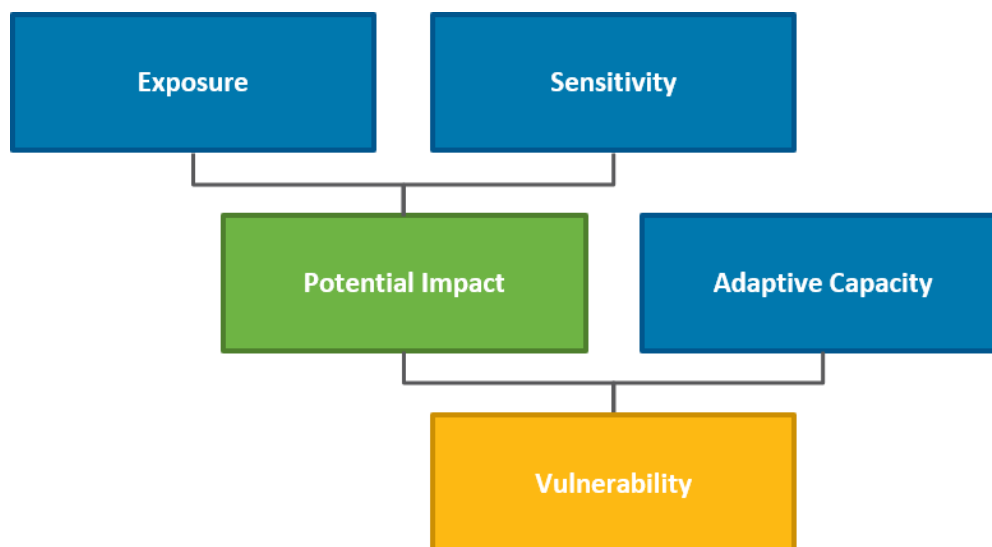


Figure 5-1 Vulnerability assessment components (reproduced from Allen Consulting, 2005)

### 5.2 Identification of Assets

One of the main challenges of this CHRMAP is the numerous assets and management zones. The asset classification presented in Section 4.2 was developed to address the main coastal adaptation issues and key locations and enable a simple yet effective method for adaptation planning across the broader study area.

### 5.3 Exposure / Likelihood

The **exposure / likelihood** of identified assets represents the likelihood of coastal hazards impacting on an asset. That is, the chance of erosion and / or storm surge inundation impacting on existing and future assets and their values (WAPC, 2019). The likelihood scale adopted for this study is presented in Table 5-1. Ratings have been allocated to asset categories for each hazard at each timeframe based on the interpretation of the hazard assessment results. The methods used are explained in detail in Vulnerability Analysis Chapter Report.



Table 5-1 Exposure/Likelihood Rating

Likelihood Rating	Description
<b>Almost Certain</b>	Expected to occur in most circumstances
<b>Likely</b>	Impact to asset shoreline for a given planning timeframe is likely
<b>Possible</b>	Impact to asset shoreline for a given planning timeframe is possible
<b>Unlikely</b>	Impact to asset shoreline for a given planning timeframe is unlikely
<b>Rare</b>	May occur in exceptional circumstances

#### 5.4 Sensitivity / Consequence

The **sensitivity / consequence** is an asset’s responsiveness to a coastal hazard. This could be a gradual or stepped change response to discrete events (WAPC, 2019). The sensitivity can be applied to the asset itself, or to the asset’s function and the criticality of the service it provides (CoastAdapt, 2017).

The consequence ranking presented in Table 5-2 constitutes the physical impact of the event to the asset, as well as that of the values attributed to it by the success criteria defined earlier in the study.

For each hazard, the consequence was assessed against the criteria qualitatively, based on experience of the impacts of coastal erosion and inundation, and the examples presented in the consequence scale. The purpose of assigning vulnerability is to identify and prioritise what requires adaptation.

Table 5-2 Sensitivity / Consequence ranking

Consequence Level	Physical, Financial	Environment	Community / Social & Cultural
<b>Insignificant</b>	No or minimal damage, perhaps requiring increased maintenance Financial loss less than \$20,000	Negligible to no impact to the environment	Minimal short-term inconvenience to the asset, services and function, <5% of community affected. Many alternatives exist
<b>Minor</b>	Minor damage to assets resulting in restrictions in capability, financial loss of \$20,000 to \$200,000	Short-term damage to environment. Recovery will be strong. Local or regional alternate habitat exists	Isolated but noticeable (short term) decline or disruption to asset, services and function, <10% of community affected. Alternative sites exist
<b>Moderate</b>	Damage to assets resulting in isolated loss of capability, financial loss of \$200,000 to \$2 million	Medium-term loss of environmental assets. Recovery is likely. Local or regional alternate habitats exist	Moderate (short to medium term) decline or disruption to assets, services and function, <25% of community affected. No convenient alternative exists



Consequence Level	Physical, Financial	Environment	Community / Social & Cultural
<b>Major</b>	Significant damage to many assets resulting in capability constraints, financial loss of \$2 million to \$5 million	Long-term damage to environmental assets. Limited chance of recovery. No local alternate habitat(s) exist. Regional habitats exist	Severe (medium-term) decline or disruption to asset, services and function, <50% of community affected. No convenient alternative exists
<b>Catastrophic</b>	Significant damage to most assets resulting in loss of capability, financial loss of over \$5 million	Permanent damage to environmental assets. No chance of recovery. No alternate habitat(s) exist.	Long-term or permanent loss of asset, services and function >75% of community affected. No alternative exists

Each asset category is assigned a sensitivity / consequence rating, for erosion and inundation respectively. A GIS-based approach to vulnerability analysis was used as it was practical for the study area size and complexity. This involved an “averaging” process, by applying blanket analysis on categories; suitable for delineation of vulnerabilities within a Management Unit, and comparisons between Management Units. A rating is assigned to each of the consequence columns, and then the overall rating is assigned as the worst of the ratings. This applies a conservative factor to this large-scale approach.

### 5.5 Potential Impact (Level of Risk)

Risk level, or **potential impact**, is calculated as the **product** of exposure and sensitivity (see Table 5-3). It provides a classification of the potential impact of coastal hazards on identified assets, which was determined for each project timeframe. Definitions are provided in Table 5-4.

**Table 5-3 Risk Level (Potential Impact) Matrix as Product of Sensitivity (Consequence) and Exposure (Likelihood)**

Sensitivity / Consequence	Exposure / Likelihood				
	Rare	Unlikely	Possible	Likely	Almost Certain
Catastrophic	Medium	High	Extreme	Extreme	Extreme
Major	Medium	Medium	High	Extreme	Extreme
Moderate	Low	Medium	Medium	High	High
Minor	Low	Low	Low	Medium	Medium
Insignificant	Low	Low	Low	Low	Low

**Table 5-4 Risk profile definition**

Risk Profile	Definition
Low	Tolerable risk. A level of risk that is low and manageable without intervention outside routine asset maintenance.
Medium	A level of risk that may require intervention to mitigate, such as changes to design standards or asset maintenance. Short to medium term action required.
High	A level of risk requiring significant intervention to mitigate in the immediate to short term.
Extreme	Immediate action required to reduce risk to acceptable levels





## 5.6 Adaptive Capacity

The **adaptive capacity** is the asset's ability to adjust/adapt to the identified hazard. It was determined based on the potential for the system to be modified to cope with the impacts from coastal hazards. Assets with high adaptive capacity can easily be adapted. For instance, beach and dune systems often have higher adaptive capacity than coastal infrastructure and residential land. The scale of adaptive capacity is provided in Table 5-5. Rating of adaptive capacity was determined by assets/asset groups as well as opinions from stakeholders and community.

Table 5-5 Adaptive Capacity

Adaptive Capacity	Description
No adaptation required	Potential impact has insignificant effect on asset. Controls are re-established naturally or with ease before more damage would likely occur.
Very High	Good adaptive capacity. Functionality restored easily. Adaptive systems restored at a relatively low cost or naturally over time.
High	Decent adaptive capacity. Functionality can be restored, although additional adaptive measures should still be considered. Natural adaptive capacity restored slowly over time under average conditions
Moderate	Small amount of adaptive capacity. Difficult but possible to restore functionality through repair and redesign.
Low	Little or no adaptive capacity. Potential impact would destroy all functionality. Redesign required.

## 5.7 Vulnerability Ratings

**Vulnerability** is calculated as the **product** of potential impact (risk level) and the adaptive capacity (Figure 5-2 and Table 5-6). As per WAPC (2019), four levels of vulnerability are considered in this study which should be assessed for each of the planning timeframes considered by this CHRMAP. **Vulnerability** ratings are EX (extreme), HI (High), ME (Medium) and LO (Low).

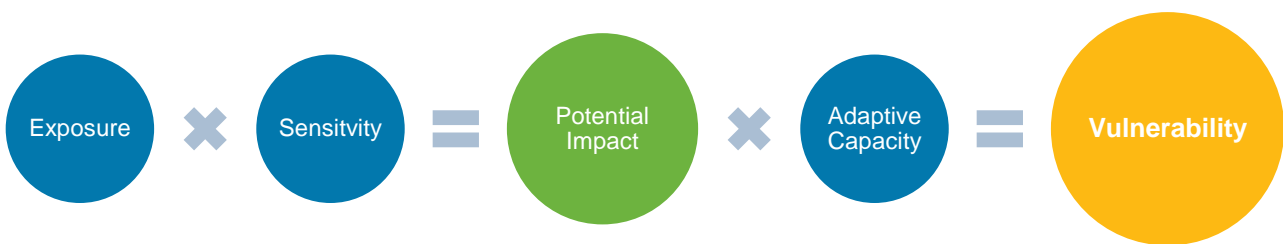


Figure 5-2 Vulnerability relationship

Table 5-6 Vulnerability Matrix as a Product of Risk Level and Adaptive Capacity

Risk Level	Adaptive Capacity			
	Low	Moderate	High	Very High
Extreme	Extreme	Extreme	High	Medium
High	Extreme	High	Medium	Medium
Medium	High	Medium	Medium	Low



Risk Level	Adaptive Capacity			
	Low	Moderate	High	Very High
Low	Medium	Medium	Low	Low

For each planning horizon, each category was then assigned an overall vulnerability rating. The most conservative rating for each category for each horizon was selected, except when there are less than 5 assets in the highest rating, with the majority in lower ratings. In those cases, the next highest rating has been selected, with the small number in brackets indicating the assets in the rating above.

The overall vulnerability ratings for each category within each management unit for each planning horizon is presented in Table 5-7 and Table 5-8 below for erosion and inundation respectively. Extreme vulnerability has been identified from the present day onwards. Most of this extreme vulnerability is predicted to be from erosion, with the exception of residential and commercial inundation.

The enormous number of at-risk assets, a total of approximately 48,000 across the broader study area, means grouping and summarising is the only meaningful method of assessing the risk at this stage of the planning process.



Table 5-7 Erosion vulnerability ratings, grouped by management unit & planning horizon

Management Unit	2020	2035	2050	2120	Summary
<b>MU4 - Bunbury South</b>					
Public and Community	High	High	High	Extreme	Erosion is a key risk for 4 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Foreshore - Developed	Medium	Medium	Medium	Medium	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	
<b>MU5 - Bunbury</b>					
Roads	Extreme	Extreme	Extreme	Extreme	Erosion is a key risk for 8 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Residential	High (4Ex)	Extreme	Extreme	Extreme	
Commercial	High (3Ex)	Extreme	Extreme	Extreme	
Public and Community	High (5Ex)	High (5Ex)	Extreme	Extreme	
Foreshore - Developed	Medium	Medium	Medium	Medium	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	
Aboriginal Heritage	Extreme	Extreme	Extreme	Extreme	
<b>MU6 - Bunbury Port</b>					
Roads	Extreme	Extreme	Extreme	Extreme	Erosion is a key risk for 6 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Commercial	Extreme	Extreme	Extreme	Extreme	
Public and Community	Extreme	Extreme	Extreme	Extreme	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	
Agricultural / Rural	Medium	Medium	Medium	Extreme	
<b>MU7 - The Cut</b>					
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	Erosion is a key risk for 2 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Environmental	Extreme	Extreme	Extreme	Extreme	
<b>MU8 - Bunbury East</b>					
Roads	Extreme	Extreme	Extreme	Extreme	Erosion is a key risk for 8 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Residential	High (3Ex)	Extreme	Extreme	Extreme	
Commercial	Extreme	Extreme	Extreme	Extreme	
Public and Community	Extreme	Extreme	Extreme	Extreme	
Foreshore - Developed	Medium	Medium	Medium	Medium	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	
Aboriginal Heritage	Extreme	Extreme	Extreme	Extreme	



Table 5-8 Inundation vulnerability ratings, grouped by management unit & planning horizon

Management Unit	2020	2035	2050	2120	Summary
<b>MU4 - Bunbury South</b>					
Foreshore - Developed	Medium	Medium	Medium	Medium	Inundation is a medium risk for 3 of the 9 categories within this management unit. Adaptation in some form may be required from the present day.
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	
Environmental	Medium	Medium	Medium	Medium	
<b>MU5 - Bunbury</b>					
Roads	Medium	Medium	Medium	Medium	<ul style="list-style-type: none"> <li>Inundation is a medium / high risk for 6 of the 9 categories within this management unit. Adaptation in some form may be required from the present day.</li> <li>Inundation is an extreme risk for residential and commercial assets. For these categories, adaptation in some form is required from the present day.</li> </ul>
Residential	Extreme	Extreme	Extreme	Extreme	
Commercial	Extreme	Extreme	Extreme	Extreme	
Public and Community	High	High	High	High	
Foreshore - Developed	Medium	Medium	Medium	Medium	
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	
Environmental	Medium	Medium	Medium	Medium	
Aboriginal Heritage	High	High	High	High	
<b>MU6 - Bunbury Port</b>					
Roads	Medium	Medium	Medium	Medium	<ul style="list-style-type: none"> <li>Inundation is a medium / high risk for 5 of the 9 categories within this management unit. Adaptation in some form may be required from the present day.</li> <li>Inundation is an extreme risk for commercial assets. For these categories, Adaptation in some form is required from the present day.</li> </ul>
Commercial	Extreme	Extreme	Extreme	Extreme	
Public and Community	Medium	Medium	Medium	High	
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	
Environmental	Medium	Medium	Medium	Medium	
Agricultural / Rural	Medium	Medium	Medium	Medium	
<b>MU7 - The Cut</b>					
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	Inundation is a medium risk for 2 of the 9 categories within this management unit. Adaptation in some form may be required from the present day.
Environmental	Medium	Medium	Medium	Medium	
<b>MU8 - Bunbury East</b>					
Roads	Medium	Medium	Medium	Medium	<ul style="list-style-type: none"> <li>Inundation is a medium / high risk for 7 of the 9 categories within this management unit. Adaptation in some form may be required from the present day.</li> <li>Inundation is an extreme risk for residential and commercial assets. For these categories, adaptation in some form is required from the present day.</li> </ul>
Residential	Extreme	Extreme	Extreme	Extreme	
Commercial	Extreme	Extreme	Extreme	Extreme	
Public and Community	High	High	High	High	
Foreshore - Developed	Medium	Medium	Medium	Medium	
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	
Environmental	Medium	Medium	Medium	Medium	
Agricultural / Rural	Low	Medium	Medium	Medium	
Aboriginal Heritage	High	High	High	High	





## 6 STAGE F - RISK EVALUATION AND TREATMENT

A Risk Evaluation and Treatment Chapter Report (Appendix E) was prepared, identifying risks and presenting and assessing treatment options using multi-criteria analysis. A summary is provided below.

### 6.1 Risk Evaluation - Priorities for Treatment

The erosion and inundation vulnerability ratings presented in Section 5 were considered for each MU as a whole by averaging the vulnerability ratings of individual asset categories; see Table 6-1 and Table 6-2. All MUs at all planning horizons have unacceptable levels of vulnerability for both erosion and inundation (medium or above) for one or more asset categories, and therefore need to be considered for risk treatment options. There are greater vulnerabilities to erosion in the study area compared to inundation.

**Table 6-1 Erosion vulnerability ratings by management unit & planning horizon**

Management Unit	2020	2035	2050	2120
MU4 – Bunbury South	High	High	High	Extreme
MU5 - Bunbury	High	Extreme	Extreme	Extreme
MU6 – Bunbury Port	Extreme	Extreme	Extreme	Extreme
MU7 – The Cut	Extreme	Extreme	Extreme	Extreme
MU8 – Bunbury East	Extreme	Extreme	Extreme	Extreme

**Table 6-2 Inundation vulnerability ratings by management unit & planning horizon**

Management Unit	2020	2035	2050	2120
MU4 – Bunbury South	Medium	Medium	Medium	Medium
MU5 - Bunbury	High	High	High	High
MU6 – Bunbury Port	Medium	Medium	Medium	High
MU7 – The Cut	Medium	Medium	Medium	Medium
MU8 – Bunbury East	High	High	High	High

### 6.2 Risk Management and Adaptation Hierarchy

SPP2.6 provides a hierarchy of adaptation pathways to guide decision-making in coastal areas to be used by planning authorities and development proponents when considering adaptation options to minimise coastal hazard risks at the local level. The hierarchy, presented in Figure 6-1, indicates a clear preference against the adoption of 'protect' as a long-term adaptation pathway. This preference is re-emphasised in SPP2.6, the policy guidelines, the CHRMAP Guidelines and the WA Coastal Zone Strategy. This hierarchy is discussed further below.

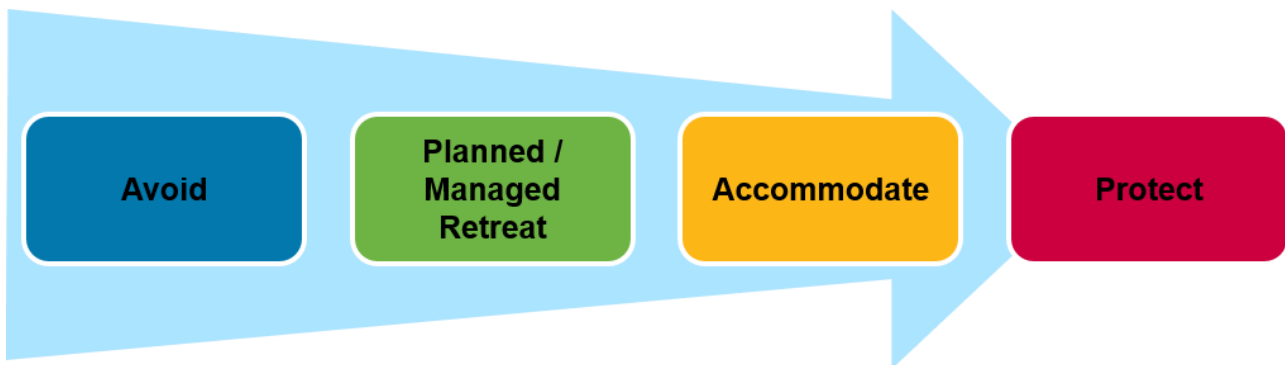


Figure 6-1 Coastal hazard risk management and adaptation planning hierarchy (adapted from WAPC, 2019)

Maintaining public access to the coast in developed areas is one of the main objectives of SPP2.6. The current State legislative framework means that where the shoreline recedes beyond private property boundaries, public access and trespass issues are likely to arise. This situation implies that public authorities have two main adaptation options available to them for preserving public coastal access:

- **Planned or Managed Retreat** i.e., maintaining a foreshore reserve through public acquisition of private property; or,
- **Protect** i.e., preventing the shoreline from receding beyond private property boundaries by stabilising the current shoreline position using various protection measures

Where public authorities cannot commit to either of these options over the long term, it is likely that public authorities will need to **Accommodate**, by modifying local planning frameworks to help ensure that new development is appropriately designed and located. Public authorities in this situation may also choose to consider the appropriateness of interim Protection measures to preserve public interests by delaying shoreline recession and minimising the effect of regular nuisance inundation events on existing development and infrastructure.

Table 6-3 presents a summary of the relevant information for adaptation. It is important to note that no law requires public authorities to protect private property from natural hazards nor compensation when land is lost due to coastal hazards. The CHRMAP process aims to minimise coastal hazard risks and maximise the beneficial use of the coast.



**Table 6-3 Adaptation consideration summary**

- Adaptation options should minimise coastal process interference and legacy issues
  - The adaptation hierarchy is presented in **Figure 6-1**.
- Coastal development must be sustainable in the long term, and must balance the community, economic, environmental and cultural needs
- Local Governments are responsible for managing risks to **public assets** and any assets they manage. They should also:
  - Develop local policies and regulations consistent with state legislation and policy
  - Facilitate building resilience and adaptive capacity within the local community
  - Work in partnership with the community to identify and manage risks / impacts
- Management strategies that preserve the natural coastline and move development away from the active coastal zone in an orderly manner are considered ideal. Of particular relevance to the CHRMAP process is the user pays principle, whereby those who benefit most from protection must provide the greatest financial contribution
- Adaptation options should maintain future flexibility, in order to build resilient coastal communities.
- A key adaptation option will be the use of planning instruments, including managed retreat.

### 6.3 Risk Treatment Options

Table 6-4 below presents a list of generally available adaptation options suitable for most coastal sites. These relate to both short-term and long-term adaptation to coastal hazards in general, not just in relation to planning for climate change impacts. The column on the right-hand side provides some discussion as to the possibility of its application for the study area.



Table 6-4 Risk treatment options from WAPC (2019)

Option Category	Option Name	Option Code	Description of how it will help
Avoid	Locating assets in areas that will not be vulnerable to coastal hazards	AV	Assets will not be vulnerable to risk arising from coastal hazards.
Planned / Managed Retreat	Leaving assets unprotected	PMR1	Accept loss following hazard event. Only implement repairs to maintain public safety. Allow for retreat that allows natural recession of the shoreline over the long-term.
	Demolition / removal / relocation of asset from inside hazard area.	PMR2	Relevant for assets of low value where it is impractical both technically and financially to design the asset to withstand the impact of the coastal hazards instead of relocating it.
	Prevention of further development / prohibit expansion of existing use rights	PMR3	This risk treatment option would enable existing development and use rights to continue without increasing them, until such time that risk arising from coastal hazards is intolerable. Specified in a local planning scheme.
	Voluntary acquisition	PMR4	This risk treatment option would require the acquisition of affected properties, on a voluntary basis.
Accommodate	Design assets to withstand impacts	AC1	Where avoiding or relocating an asset is not an option, design of assets to withstand the impact of inundation.
Protect	Beach nourishment or replenishment	PR1	Placement of sand within the beach profile and/or dunes to activate beach coastal processes and provide a sediment supply.
	Groyne	PR2	Construction of groynes to stop or restrict the movement of sand around the end of the structure, to provide protection to assets behind the beach/foreshore reserve. They are primarily effective where there is longshore sand supply or when partnered with sand nourishment.
	Seawall	PR3	Construction of a seawall usually along an entire section of shoreline. Where a beach is to be retained, this risk treatment option should generally be accompanied with beach nourishment or replenishment.
	Artificial reef	PR4	Construction of a submerged artificial reef offshore, to dissipate wave energy impacting the shore by causing waves to break on their seaward side and reducing wave energy on the leeward side. Artificial reefs do not block waves and during storm events water depths over the reef may be sufficient to allow waves to pass over the reef without breaking, reducing their effectiveness in protecting the beach from erosion.
	Offshore breakwater	PR5	Construction of an emergent offshore barrier (often referred to as an offshore breakwater). Offshore breakwaters effectively block wave energy by absorbing wave impact on their seaward side. They create a lower wave energy section of beach immediately in its lee, which is characterised by a salient where sand accretes in the low energy environment.
	Levee / Weir / Storm Surge Barrier	PR6	Inundation protection to minimise inundation on low-lying land. This could be a levee on the banks of a river, a storm surge barrier at the entrance to an inlet / estuary and so on. Details would be specific to the relevant conditions of each MU.
No Regrets	Monitoring	NR1	Involves long-term baseline monitoring and event-based monitoring following storm erosion events.
	Protection Structure Audit	NR2	Involves undertaking an audit of existing protection structures, to determine their current condition, effectiveness and future protection potential.
	Notification on title	NR3	Indicates to current and future landowners that an asset is likely to be affected by coastal erosion and/or inundation over the planning timeframe. Helps current and future owners make informed decisions about level of risk they are/may be willing to accept, and that risk management is likely to be required at some stage within the planning timeframe.
	Emergency evacuation plans	NR4	Where existing assets may be affected by inundation and are not already identified in an existing emergency evacuation management plan. Such plans are important in managing the safety of community and stakeholders.
Do Nothing	Do Nothing	DN1	Assumes all levels of risk are accepted and assumes that there is no change in existing planning controls, and no actions are implemented (i.e., no controls are implemented to treat known coastal risks).





## 6.4 Multi-Criteria Analysis

Successful risk management and adaptation planning requires identification and diligent assessment of suitable options to ensure selection of the best strategy. The chosen option should mitigate risk to an acceptable level whilst maximising the values important to the stakeholders and community. For this CHRMAP the key assessment criteria were:

- Effectiveness
  - Ability for the option to mitigate the coastal hazard risk
- Environmental Impact
  - Impact on existing native vegetation / dunes / coastal processes
  - Includes consideration of:
    - Any construction / clearing impacts
    - Impact of maintenance on the environment
- Social Impact
  - This considers stakeholder and community impacts from previous CHRMAP chapters
  - Potential impacts on Aboriginal and European heritage sites and values are considered in this criterion.
- Aesthetic Impact
  - The visual appeal of the option
  - Consideration of option aesthetics tying into the wider town / Management Unit vision
- Cost
  - Upfront capital costs
  - Ongoing maintenance costs
  - Economic affects – such as loss of businesses, income, value
- Future Adaptability
  - Whether the option is easily adaptable in future, such as for updated sea level rise actuals or predictions
  - If the option limits the feasibility of selecting other options in future

Water Technology undertook an initial assessment of options against the criteria. The qualitative criteria (environmental, social and aesthetic) were then modified following review and confirmation by the Steering Group. **While ratings are somewhat subjective, these have been reviewed by the Steering Group to ensure the ratings are reflective of stakeholder knowledge and community feedback.**

A Coastal Community Advisory Group (CCAG) was formed, comprising community members from across the study area. Members attended a workshop to further review and calibrate the MCA scoring, focusing on the Environmental, Social and Aesthetic Impact categories. Several component category scores changed during this review process, but only one option in three MUs changed recommendations and only one of these was within the City:

- MU8 Bunbury East – PR5 Offshore Breakwater – changed from 'Suitability Unclear' to 'Not Recommended', so will be excluded from CBA process.

In most cases it is necessary to implement more than one option, and the options selected through the MCA may vary between management units and with implementation timeframes. Table 6-5 summarises the evaluated status of each option for each management unit. Options receiving a positive score are recommended for further consideration.



**Table 6-5 Multi-Criteria Analysis summary by MU. Green indicates recommended for further investigation; orange is unclear.**

Option	MU4	MU5	MU6	MU7	MU8
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	11	11	11	11	11
Leaving assets unprotected (PMR1)	2	2	2	2	2
Demolition / removal / relocation of asset from inside hazard area (PMR2)	7	7	7	7	7
Prevention of further development / prohibit expansion of existing use rights (PMR3)	10	6	6	N/A	6
Voluntary acquisition (PMR4)	N/A	5	5	N/A	5
Design assets to withstand impacts (AC1)	10	9	10	12	9
Beach nourishment or replenishment (PR1)	-7	3	4	4	2
Groynes (PR2)	-11	1	3	3	0
Seawalls (PR3)	-12	-2	0	0	0
Artificial reef (PR4)	-10	-3	-4	-4	-5
Offshore breakwater (PR5)	-12	0	-3	-4	-1
Levee / Weir / Storm Surge Barrier (PR6)	N/A	4	3	N/A	1
Monitoring (NR1)	7	7	7	7	7
Protection Structure Audit (NR2)	N/A	6	6	6	6
Notification on title (NR3)	7	7	7	7	6
Emergency evacuation plans (NR4)	N/A	6	6	N/A	7
Do nothing (DN1)	-8	-8	-8	-8	-8



## 7 STAGE G – RISK TREATMENT ANALYSIS

### 7.1 Cost Benefit Analysis

#### 7.1.1 Approach

The Cost-Benefit Analysis (CBA) aims to examine the selection of coastal adaptation options through economic analysis. This CBA includes coastal adaptation options requiring significant financial investment and scoring positively in the MCA. While the CBA process assists in contrasting options available “*at the time of the analysis*” and “*for a set of specific assumptions*”, it is not the Panacea for decision-making. For instance, changing scientific, environmental and macro-economic considerations can upset cost estimates in the future. Some of the CBA assumptions may not hold true for the long duration often considered in CBA analysis for major infrastructure (Covid pandemic, technological advances, etc.).

The CBA analysis allows selection of coastal adaptation options which are economically more defensible than other options which could require more effort to achieve a reduced outcome. However, to prepare a CBA some assumptions must be made, and changing these assumptions can significantly affect the valuation of economic benefits.

For instance, the CHRMAP CBA has only addressed valuing the loss of assets, managed retreat and physical protection options. This CBA does not consider indirect costs that another user might consider to be a loss. For example, the analysis did not include costs associated with Special Control Area (SCA) title notifications, emergency planning, and development restrictions. Also, options selected have been designed to provide similar level of beach and foreshore amenities to the present-day situation. This may not be practical. There may be further decisions about coastal amenities management (such as policies, planning decisions, legal proceedings, etc.), guided by community values, which may alter this assumption. Furthermore, in this CBA all coastal adaptation options are designed to provide beach and foreshore amenities into the future.

The cost-benefit of each coastal adaptation option is presented in net present value (NPV) terms. NPV is a standard economic analysis to compare options with time-variable costs and benefits. It allows for the adjustment of all future economic considerations to present-day dollars for a more direct comparison. This relates to the time-value of money, as planned expenses in the future are, in a sense, cheaper than equivalent costs today. The real discount rate chosen for this project was 4%, with sensitivity analyses at 7% and 2%. This decision was based on similar assessments the very long timeframe of analysis, and concerns about valuing future spending so low, which is at odds with resilient coastal planning principles.

The CBA has been performed over a 100-year period, to match the project planning timeframe and meet the requirements of the CHRMAP. It should be noted that the uncertainty around the CBA estimates and assumptions made grows with time. Cost estimates beyond 2040 should be viewed as indicative trends only. Long-term coastal adaptation pathways should be monitored and updated regularly.

#### 7.1.2 Options Suitable for Cost-Benefit Analysis

The CBA has only addressed options, including practical and economic actions across the planning timeframe. The economic base case used for comparison is calculated by valuing the loss of assets and values in an assumed scenario of inaction rather than “Business As Usual” (BAU). Total inaction is unrealistic in practical terms as emergency management works and obligations of other legislation would require LGAs and State Departments to act when projected coastal erosion and inundation occur. The economic inaction scenario is also different to the “Do-Nothing” adaptation option, which would assume that anyone over the planning timeframe undertakes no actions or management, and that hazards and resultant asset loss/damage occur exactly as the hazard analysis suggests. The adaptation options considered suitable for CBA are summarised in Table 6-4 – managed retreat and physical



protection options (e.g., nourishment, groynes, seawalls, artificial reefs, offshore breakwaters, levee/weir/storm-surge-barrier).

**Table 7-1 Risk treatment options from WAPC (2019) suitable for CBA. Note PR4 is greyed out as it did not progress through MCA for any MU's.**

Option Category	Option Name	Option Code
Planned / Managed Retreat	Voluntary acquisition	PMR4
Protect	Beach nourishment or replenishment	PR1
	Groyne	PR2
	Seawall	PR3
	Artificial reef	PR4
	Offshore breakwater	PR5
	Levee / Weir / Storm Surge Barrier	PR6

### 7.1.3 Other Options

The remaining adaptation options from WAPC (2019) are not considered suitable for CBA and have been costed using traditional budgeting techniques for MUs where they received a positive MCA score. Section 8 provides cost estimates and notes on any scoping details or assumptions.

### 7.1.4 Cost Benefit Analysis Methodology

The steps taken to complete the CBA are presented in detail in the relevant Chapter Report and summarised below:

1. Re-analysis of GIS vulnerability datasets to extract asset category data by area. This was undertaken where previous counts of assets were not considered to provide enough detail for economic analysis
2. Finalise quantities of assets at risk for all nine categories for both erosion and inundation hazards for each Management Unit (MU) at each timeframe
3. Determine an appropriate unit value for each category for both loss to erosion or damage by inundation
4. Valuing the loss of existing assets and values – this assumes the scenario of complete inaction over the next 100 years
5. Scoping and designing the adaptation options
6. Pricing the adaptation options
7. Reducing all costs to NPV
8. Conducting sensitivity analysis on NPV discount rate used in analysis
9. Presenting a summary of the inaction scenario and adaptation options in NPV for both erosion and inundation
10. Recommendation of options to proceed to for further consideration.

### 7.1.5 Recommended option(s) for further consideration for each MU

The CBA has been used as an additional tool to assist decision-making when assessing adaptation options with which to proceed. However, the reality that only some of the WAPC adaptation options are suitable for CBA, and the uncertainty in the effectiveness of those that are not suitable, means that the CBA results need to be used cautiously whilst considering the rest of the information identified during the CHRMAP project.





The review of the CBA results shows that the ranking of options for each MU by current NPV price depends on which discount rate is used. If options stayed in the same ranking for all three discount rates, there would be a stronger argument for selecting a single option with which to proceed. Options recommended to proceed are presented in Table 7-2 for erosion and Table 7-3 for inundation.

**Table 7-2 Recommended CBA options for erosion for each MU**

Management Unit	Recommended Option	Secondary Option (s)	Notes
MU4 – Bunbury South	Not applicable	Not applicable	<ul style="list-style-type: none"> <li>There are no CBA options for MU4.</li> </ul>
MU5 – Bunbury	PR2 - Groynes	PMR4 - Voluntary acquisition	<ul style="list-style-type: none"> <li>PR2 is best value for one discount rate (2%).</li> <li>PMR4 was best value for the other two discount rates (7% and 4%) but not by a significant amount.</li> <li>PMR4 has a lot more uncertainty around its implementation, given the large size of this MU and the large amount of values and built assets that are vulnerable including the Transforming Bunbury Waterfront project. Further investigation could consider more detailed analysis on subsections of this MU.</li> <li>PR1 may be suitable as an interim option in parts of this MU.</li> </ul>
MU6 – Bunbury Port	PR2 - Groynes	PR1 – Beach Nourishment	<ul style="list-style-type: none"> <li>PR2 is best value for one of the discount rates (2%).</li> <li>PR1 was best value for the other two discount rates (7% and 4%) and its risks around implementation and longevity are less of a concern within this more-sheltered MU. It may be suitable as an interim option.</li> </ul>
MU7 – the Cut	PR1 – Beach Nourishment	PR3 - Seawall	<ul style="list-style-type: none"> <li>PR1 is best value for two discount rates (7% and 4%).</li> <li>PR3 is not recommended as it would mean the loss of the beach. Should the objectives of this MU change in the future PR3 may be suitable long-term.</li> <li>PR1 could later be transitioned to PR3 if required.</li> </ul>



Management Unit	Recommended Option	Secondary Option (s)	Notes
MU8 – Bunbury E including Vittoria Bay, Pelican Point and Districts along Preston River	PR2 - Groynes	PR1 – Beach Nourishment	<ul style="list-style-type: none"> <li>PR2 is best value for two discount rates (4% and 2%) and almost equal best for the 7% rate.</li> </ul>

**Table 7-3 Recommended CBA options for inundation for each MU**

Management Unit	Recommended Option (s)	Notes
MU4 – Bunbury South	Not applicable	<ul style="list-style-type: none"> <li>There are no CBA options for MU4.</li> </ul>
MU5 – Bunbury	PR6 – Storm Surge Barrier	<ul style="list-style-type: none"> <li>PR6 is better value than the base case for all discount rates and no other options were recommended for CBA.</li> </ul>
MU6 – Bunbury Port Ocean frontage	PR6 - Levee	<ul style="list-style-type: none"> <li>PR6 is better value than the base case for all discount rates and no other options were recommended for CBA.</li> </ul>
MU6 – Bunbury Port Estuary frontage	Not applicable	<ul style="list-style-type: none"> <li>Further investigation is required as the broader PR6 option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate.</li> </ul>
MU7 – the Cut	Not applicable	<ul style="list-style-type: none"> <li>There are no CBA options for MU4.</li> </ul>
MU8, 9, 10, 11 Bunbury East, Leschenault Estuary, Collie River North and South	Not applicable	<ul style="list-style-type: none"> <li>Further investigation is required as the broader PR6 option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate. A feasibility analysis is recommended to assess its effectiveness with consideration of freshwater flooding events and further civil and maritime design considerations as to what scale of facility would be required.</li> </ul>



## 7.2 Benefit Distribution Analysis

### 7.2.1 Selection of Options for Benefit Distribution Analysis

After completing the CBA and reviewing the results, Water Technology discussed possible coastal adaptation options to proceed to Benefit Distribution Analysis (BDA). Following several discussions, considering projected vulnerable assets, nature of hazards, tenure of land projected to be vulnerable, the following three options were selected:

- MU 1 and 2 (in the Shire of Capel) - PR6 - Levees along the banks of the Capel River to minimise inundation. This option shall also consider inundation protection at Higgins Cut and the Minnipup Drain outlet near Tatton Place in Stratham.
- MU 3 (in the Shire of Capel) - PR2 - Groynes to manage beach erosion at Dalyellup, the Dalyellup Residual Waste Disposal Facility and the wastewater treatment plant to the north from erosion. Although this option has not scored positively in the CBA, its analysis in the BDA will still be valuable and provide further information about the selection of adaptation options.
- MU 5 Bunbury - PR2 - Groynes to protect Bunbury Back Beach and Koombana bay from erosion.

The BDA was undertaken by sub-consultant Marsden Jacobs and Associates, who have produced a stand-alone report on their BDA work, contained within the Risk Treatment BDA Chapter Report. Their work used the CBA results prepared by Water Technology as their inputs and is summarised below.

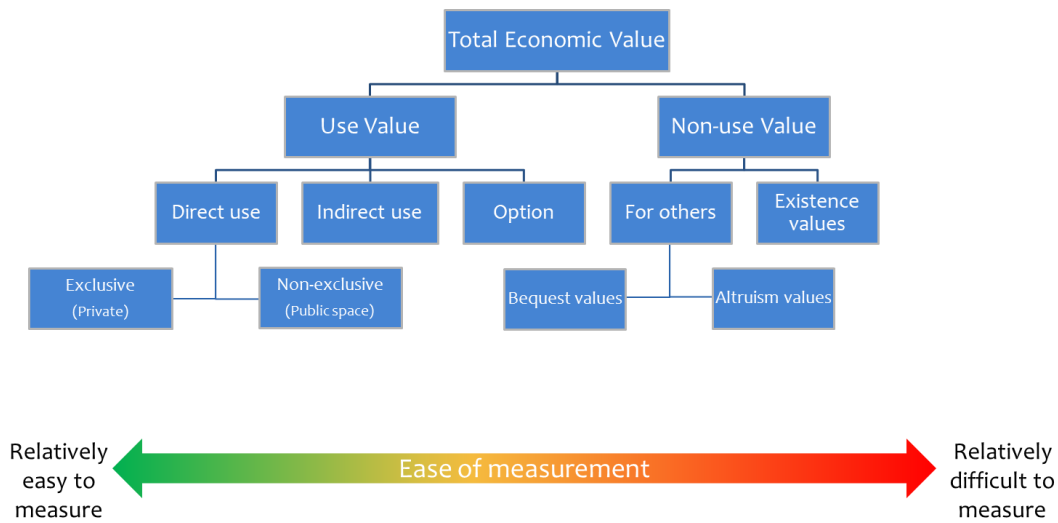
### 7.2.2 Method

A BDA is undertaken to allocate the derived benefits from the options identified to the relevant stakeholder. The relevant stakeholders are all those who are expected to benefit from the protection of the identified area. Key beneficiaries include:

- Private landholders
- Local community (Direct users of the area under threat)
- Broader community (Indirect users)

Identifying the beneficiaries and accurately evaluating their individual share of benefits is important. This paves the way for the next step in the BDA: identifying funding options and a funding model. CHRMAP follows a “beneficiary pay principle” and, thus, requires the accurate allocation of the proportion of benefits to the beneficiaries.

In order to identify the full range of benefits and beneficiaries that will arise from climate interventions, it is first important to identify the full range of uses and values. The concept of total economic value (TEV, Figure 7-1) is a well-established and useful framework for identifying the various values associated with protected areas. This framework is a useful tool for economic valuation, which measures market and non-market values that people hold for the study area and can be applied to value coastal areas and other natural resources such as wetlands, parks etc.



**Figure 7-1 Total Economic Value Framework**

The TEV framework provides a useful classification for the full range of community values. The framework's basic premise is that an area's total economic value is a function of its use and non-use values. The use values are made up of its direct use values, indirect use values, and option values. Non-use values typically include bequest and existence values.

The framework also helps avoid double counting of ecosystem functions, intermediate services, and final services.

TEV includes both use values, which measure the value of using assets that are protected, and non-use values, which refer to an individual's willingness to contribute to the cost of protecting public assets (such as beaches and estuaries), even if the individual will not use the areas themselves.

On the left-hand side of the TEV framework there are values for the exclusive direct use of assets – such as private land. The value the community places on these assets may be impacted by the market price paid for private land. There is no direct market value for the benefit obtained for all the other uses. These are often referred to as non-market values.

Applying the different types of values identified in the TEV framework, the 9 asset categories and their value type were assessed based on the TEV framework to determine an appropriate valuation method for each category, and their beneficiaries. The CBA base case results were used to determine the economic impact and apportion it to each asset category for each MU.





### 7.2.3 Results

Table 7-4 summarises the percentage of total benefits for each asset category for each MU. Results are highly variable across the different MU's.

**Table 7-4 Percentage of total benefits for each asset category at each MU**

Asset Category	MU 1 & 2	MU 3	MU 5
Roads	6%	0%	23%
Residential	3%	11%	2%
Commercial	1%	2%	1%
Public and Community	3%	6%	2%
Foreshore – Developed	0%	1%	45%
Foreshore – Undeveloped	0%	17%	17%
Environmental	68%	64%	11%
Agricultural / Rural	5%	0%	0%
Aboriginal Heritage	14%	0%	0%

Table 7-5 to Table 7-13 below summarise the financial contributions required from the custodians of each asset category to implement the preferred treatment options set out in the CBA. Note DBCA data largely informed the Environmental asset category. It includes habitat areas potentially suitable for Matters of National Environmental Significance (such as Carnaby's Cockatoo's and Western Ringtail Possums), Threatened and Priority Ecological Communities, and known locations of threatened flora.

For each of the stakeholders identified as a key beneficiary for each asset category, the financial contribution would be required as a singular payment and the annuity payment that would be required if the funds were collected over a 15-year period and at a 7% discount rate. 15 years is an arbitrary period – but it aligns with the duration between the first three assessment periods (2020, 2035, 2050). If funds started to be collected now, the projects would be largely funded ahead of the 2035 timeframe for implementation. Ahead of 2035, the risks and work required for 2050 could be reviewed, and then annuity payments could be required for 15 years to ensure any activities undertaken at that time were also funded ahead of work commencing.

#### 7.2.3.1 Peppermint Grove Beach and Capel Coast Inundation Risk - MU1 and MU2

**Table 7-5 Private asset categories – Annual funds to be collected per property for 15 years for each timeframe for number of properties protected.**

Asset Category	2020	2035	2050	2120
Residential	\$1,396	-	-	\$2
Commercial	\$1,047	-	-	-
Agricultural / Rural	\$52	\$19	\$7	\$1

**Table 7-6 Local community asset categories**

Asset Category	Total funds to be collected	Annuity (15 years)
Public and Community	\$79,026	\$8,677
Foreshore – Undeveloped	\$1,593	\$175



Asset Category	Total funds to be collected	Annuity (15 years)
Total	\$80,619	\$8,852

Table 7-7 Broader community asset categories

Asset Category	Total funds to be collected	Annuity (15 years)
Roads	\$163,542	\$17,956
Environmental	\$1,750,742	\$192,222
Aboriginal Heritage	\$362,624	\$39,814
Total	\$2,276,908	\$249,992

### 7.2.3.2 Dalyellup Erosion Risk - MU3

Table 7-8 Private asset categories – Annual funds to be collected per property for 15 years for each timeframe for number of properties protected.

Asset Category	2020	2035	2050	2120
Residential	-	\$31,124	-	\$99
Commercial	-	\$23,343	-	-
Agricultural / Rural	-	-	-	-

Table 7-9 Local community asset categories

Asset Category	Total funds to be collected	Annuity (15 years)
Public and Community	\$647,749	\$71,119
Foreshore – Undeveloped	\$68,076	\$7,474
Foreshore – Developed	\$1,926,599	\$211,530
Total	\$2,642,423	\$290,124

Table 7-10 Broader community asset categories

Asset Category	Total funds to be collected	Annuity (15 years)
Environmental	\$7,245,106	\$795,473.73

### 7.2.3.3 Bunbury Erosion Risk - MU5

Table 7-11 Private asset categories – Annual funds to be collected per property for 15 years for each timeframe for number of properties protected.

Asset Category	2020	2035	2050	2120
Residential	-	\$9,659	\$3,501	\$31
Commercial	\$19,987	-	\$2,626	\$23

Table 7-12 Local community asset categories

Asset Category	Total funds to be collected	Annuity (15 years)
Public and Community	\$1,133,001	\$124,397



Asset Category	Total funds to be collected	Annuity (15 years)
Foreshore – Undeveloped	\$32,206,592	\$3,536,111
Foreshore – Developed	\$12,268,686	\$1,347,036
Total	\$45,608,279	\$5,007,544

Table 7-13 Broader community asset categories

Asset Category	Total funds to be collected	Annuity (15 years)
Roads	\$16,766,838	\$1,840,909
Environmental	\$7,738,666	\$849,664
Aboriginal Heritage	\$1,119	\$123
Total	\$24,506,622	\$2,690,695

### 7.2.4 Discussion

The BDA has found that allocating beneficiaries when forecasting coastal management is a complicated process. The process provides information to assist decision-makers with information about the approximate proportion of beneficiaries between private and public parties. Table 7-14 defines potential funding sources and collection methods for each asset category.

Table 7-14 Potential funding sources and collection methods

Asset Category	Funding Source	Collection Method
Roads	WA Taxpayers	State Government grant
Residential	Property owners	Special levy on relevant properties - collected through rates
Commercial	Property owners	Special levy on relevant properties - collected through rates
Public and Community	Indirect users	Added to all rate payers
Foreshore - Developed	Direct users	Added to all rate payers
Foreshore - Undeveloped	Rate payers	Added to all rate payers
Environmental	WA Taxpayers	State Government grant
Agricultural / Rural	Property owners	Special levy on relevant properties - collected through rates
Aboriginal Heritage	WA Taxpayers	State Government grant

Table 7-15 summarises the annuity funds proposed to be collected from the local community via each relevant LGA, against the total expected rates revenue for 2022/23. Results are markedly different between the Shire of Capel and City of Bunbury.



Table 7-15 Comparison of required funds to LGA rate base

Management Unit	LGA	Annuity funds to be collected from the community	Total expected rates for 2022/23	Percentage proportion of annual rates
MU1 & 2	Shire of Capel	\$8,691	\$14,179,504	0.06%
MU3	Shire of Capel	\$285,677	\$14,179,504	2.01%
MU5	City of Bunbury	\$5,007,544	\$42,800,000	11.70%

While indicative funds appear to be relatively small compared to the value delivered and the overall cost, the costs are not insignificant and further work remains to detail each intervention (ie risk treatment option selected in the CHRMAP), their extents, design standard, program and costs through additional detailed technical studies. Also, the proposed interventions for MU3 do pass significant costs (e.g., \$31,000) onto a small number of private beneficiaries. While the costs are well below the value of the benefit delivered it may not be within the capacity of the property owners to pay for these costs. In these instances, further consultation may be necessary to establish a suitable approach to apportioning and collecting these funds.





## 8 STAGE H - IMPLEMENTATION

### 8.1 Land-Use Planning Instruments

There is a direct relationship between coastal hazard exposure and development. How buildings and assets are designed and located determines their exposure, ultimately impacting risk to people and property.

Therefore, the policy instruments that govern development are an important tool to reduce risk exposure. The following sections detail the relevant state and local measures that can be used to increase coastal resilience. In this section, the following land use planning instruments are described:

- Inclusion of coastal hazard exposure to be considered in **structure planning**
- Establishment of **Special Control Area/s** as an overlay to further regulate development in high-exposure areas
- Inclusion of coastal hazard information for buyers through **Notifications on Titles** to increase awareness of hazard exposure and risk
- Establishment of a program for **Compulsory Acquisition** of land where coastal hazard risk is deemed intolerable for habitation
- **Reservation of Land** to prevent intensification or inappropriate land use in areas exposed to coastal hazard
- **Other instruments** such as leaseback arrangements and land swaps, which are presently conceptual, may become feasible as further investigation is completed over time.

#### 8.1.1 General Land Use Planning Instruments

Western Australia has a well-established approach to coastal hazard planning via SPP 2.6 and CHRMAP Guideline, which refer to several planning instruments that can manage coastal hazards, as follows:

##### 8.1.1.1 Structure Planning

Structure Plans are prepared and approved prior to the subdivision or development of land in development areas identified within the Local Council Planning Scheme, or where required by WAPC.

In areas where further development or redevelopment of land is possible or anticipated, structure plans should incorporate the requirements of the CHRMAP. This would allow the formation of a coastal foreshore reserve to manage coastal erosion and to infill low-lying areas to manage coastal inundation. It is important to not increase the number of buildings and assets that are exposed to coastal hazards, so resources can be focused on managing the residual risk on existing development already at risk.

##### 8.1.1.2 Local Planning Scheme Amendments

###### 8.1.1.2.1 Special Control Area

###### What is an SCA?

A Local Government Authority (LGA) may declare a Special Control Area (SCA) over areas that are regarded as significant and where special provisions may need to apply.

To enable targeted planning measures to be applied to locations with the highest coastal hazard exposure, a local planning scheme (LPS) amendment can be progressed. This should be informed by SPP 2.6, to classify vulnerable areas as a Special Control Area (SCA).



An SCA overlay typically includes a mapped area that special development conditions apply to. The requirements of a SCA apply in addition to the underlying planning controls dictated by the planning scheme and state framework, such as zoning, building requirements and matters of significance.

### **Why implement a SCA?**

A coastal hazard SCA could be designed to address erosion or inundation separately or relate to combined coastal hazard risk. The effect of the SCA includes further development regulation to manage hazard exposure, which should be assessed on a case-by-case basis to control over the intensification of land where coastal risks are prominent. For example, a development that might otherwise be exempt from development approval would require a planning approval in addition to a building approval.

This may also include referencing a local planning policy to describe assessment procedures and development standards on land prone to coastal hazard, to provide government specific mechanisms for managing coastal risk in areas where it is most relevant.

### **Where would a coastal hazard SCA apply?**

An SCA can facilitate land use changes and development control within that area. The SCA can be determined by the position of either the 2120 coastal processes setback line, or the inundation extent of the 500-year ARI event in the year 2120, whichever is the more landward.

An SCA should be applied to relate specifically to land subject to coastal processes (as recommended in WAPC, 2019). The SCA is allocated a number and depicted on the Scheme Map (as an overlay map).

#### **8.1.1.2.2 Local Planning Policy (LPP)**

LPPs are prepared and adopted according to the provisions in Part 2 Division 2 of the Deemed Provisions of

A Special Control Area is suitable across the CHRMAP area. There may be some merit in consolidating the existing SCA for Flood Prone Areas in to the SCA for Coastal Hazard Planning. This will need to be investigated as the Flood Prone Areas SCA also sits within the Greater Bunbury Region Scheme.

the relevant local planning scheme. An LPP can be prepared in respect of any matter related to the planning and development of the Scheme area. The LPP may apply to a particular class or classes of matter specified in the policy and may apply to the whole of the Scheme area or to parts specified in the policy.

An LPP can provide more detail and guidance on what sort of development would be acceptable and will also assist the LGA in making planning decisions on coastal development requiring the exercise of discretion (e.g., it might specify appropriate design responses for individual development proposals; relocatable dwellings; prescribed setbacks; finished floor levels). The policy would further identify the Council's intention to require notifications on title as a condition of development approval.

A Local Planning Policy responsive to coastal hazard management is suitable across the CHRMAP area.

#### **8.1.1.2.3 Notifications on Titles**

Supported by a suitable SCA, there is an opportunity to require the provision of a Section 70A Notification on the Certificate of Title of land as a condition of any planning approval to alert prospective purchasers of the potential coastal hazard impacts on the lot, as required by SPP2.6. These Notifications can only be applied where triggered by a subdivision or development application. These can either be general alerts or more specific time-limited approvals (e.g., where the temporary use of land in hazard areas is allowed, where appropriate, until hazards materialise, while ensuring that the LGA maintains discretion over development in these areas).



The proponent may apply for an extension to the approval if the approval expires before hazards occur, whilst the LGA would be in a position to require demolition or removal of compromised structures if hazards occur ahead of the Notification timeframe. This option potentially supports landowners with larger risk appetites but may also be a source of future opportunities for conflicts, which will need ongoing management (funding, monitoring, reporting, etc.).

A Notice of Title planning instrument is suitable across the CHRMAP area and there may need to be some alignment with existing Notifications linked to the flood prone nature of some areas.

#### 8.1.1.2.4 Advice to Real Estate and Settlement Agents

Real estate agents and settlement agents are usually the first people that a prospective landowner will meet on their journey to buying into a town or region. Real estate agents have an obligation to provide information to prospective purchasers, whilst settlement agents are often in touch with the local government during settlement to ascertain the current monies owed or conditions applying to land. Although not a catch-all, providing information about the CHRMAP to these parties may help to alert prospective purchasers of the potential coastal hazard impacts on the lot, where a notification of the Certificate of Title has not yet been included.

This could include:

- Communication as soon as practical with all local real estate agents regarding identified hazards so that they will be obliged to share the vulnerability of land in the area.
- Implementation of an internal procedure to provide information regarding identified hazards to settlement agencies through the Orders and Requisitions request process linked to the sale of land to elevate the potential impact to the prospective purchaser (settlement agencies typically request these and they include details of rates paid, outstanding issues, approved development etc).

Advice could be provided to all known real estate agencies and settlement agencies operating in the area; recognising that some purchasers may use out of area services, as is their right, and would not get the benefit of this early advice.

#### 8.1.1.3 Compulsory Acquisition

Compulsory acquisition is an option where no other planning instrument has been able to suitably set aside land for coastal hazard processes, when hazards have advanced to a stage where land exceeds tolerable risk thresholds. This would require the reservation of land for public purposes via a scheme amendment. Options include:

- Purchase of the land by the LGA if the owner is willing to sell it by ordinary sale under Section 190 of the Planning and Development Act (2005) (PD Act)
- Compulsory taking by the LGA without agreement under Section 191 of the PD Act coupled with the Land Administration Act (1997).

If the land remains zoned (within an SCA overlay) then the above options are not available. This instrument should be carefully considered in relation to any protective structures being proposed.



#### 8.1.1.4 Reservation of Land

Subject to remaining consistent with the Greater Bunbury Region Scheme and associated Floodplain Management Policy, land within the local planning scheme may be reserved as 'Foreshore'. This is particularly the case for public assets, where such a reservation would give rise to improved asset management and planning of the foreshore, including information about when and how to relocate public assets such as public amenities, seating, shelter, playground etc when they reach end of life.

Reservation of land is suitable across the CHRMAP area.

#### 8.1.1.5 Other Instruments

Innovative planning instruments, such as 'leaseback of land' and 'land swaps' may be considered. While there is growing interest in these and much work interstate on these matters, these instruments have not been tested in the WA planning context and are not explicitly provided for or anticipated under the State's current planning framework. However, some research into these treatments may be suitable and palatable for the community for locations where "coastal retreat" is possible to adjacent location. In such a scenario, the nature of compensation may be limited to depreciating assets rather than the combination of land and structures.

Considerations of other instruments should be informed by research, implementation case studies from other locations, suitability to the local context, and receptiveness of decision-makers and the community.

## 8.2 Specific Land-Use Planning Instruments

The City and its partners have acknowledged coastal based hazard for many decades since the flooding experienced from Cyclone Alby in 1978. Planning conditions have been used to support an 'accommodate' option in the suburb of East Bunbury since that time, with flood-prone land noted via planning instruments in the Greater Bunbury Region Scheme and the City's Local Planning Scheme No. 8. A recent CHRMAP has also been prepared for Koombana Bay. The Koombana Bay, Casuarina Drive and Leschenault Inlet Master Plans refer to flooding and coastal vulnerability, as well as the importance of the waterfront environment.

However, few provisions exist within the City's planning instruments to directly respond to the broader coastal hazard challenge and there is a need to establish a response within the town planning legislative framework to best manage the challenge and make the associated risks more apparent / visible.

Structure planning may be effective in the coastal zone where some property development or redevelopment may be considered in low lying areas along the Leschenault Inlet and Koombana Bay (MU5), however, the whole of the City is generally built out and unlikely to experience this pathway.

Any changes to the land use planning framework to reflect the identified risks would be undertaken after detailed investigation into proposed coastal protection measures, as the specific coastal protection measure may alter the land use instrument required.

Recommended land use planning instruments, subject to detailed investigations, are detailed in Table 8-1.





**Table 8-1 Land use planning recommendations for the City of Bunbury**

Action	Description	Timing	Cost
LU1	<p>The City should prepare an amendment to the Local Planning Scheme No. 8 to include provisions relating to the coastal erosion and inundation hazard zones to 2120 as identified in this study.</p> <p>The amendment shall be inserted Schedule 7 and shall read: <i>Coastal Hazard Risk Area Special Control Area</i> and include the information provided in Table 8-2.</p>	Short - Medium	\$5,000
LU2	<p>The City should prepare an amendment to the Local Planning Scheme No. 8 to include a Foreshore Reserve encompassing public land within the coastal erosion and inundation hazard zones to 2120 as identified in this study.</p> <p>The amendment shall be inserted at Part II – Reserves, Clause 14 (3). A new Reserve name shall be included and shall read: 'Foreshore'</p> <p>The Objectives of the reserve shall read:</p> <ul style="list-style-type: none"> <li>▪ set aside areas for foreshore reserved abutting a body of water or water course</li> <li>▪ provide for the protection of natural values and processes, including a coastal retreat</li> </ul> <p>to accommodate a range of active and passive recreational uses that would be capable of relocation or rehabilitation</p>	Aligned with LU1	\$5,000
LU3	<p>The City should prepare a Local Planning Policy (LPP) to be linked to the SCA under Local Planning Scheme No. 8 and provide guidance for applicants and decision-makers in relation to assessment procedures and development standards on land prone to coastal hazards. This may include recommended finished floor levels where impacted by inundation or siting of development to the least vulnerable portion of a lot for both erosion and inundation where possible. The LPP may also specify appropriate design responses for individual development proposals e.g., relocatable dwellings, prescribed setbacks and revegetation responses.</p> <p>The preparation of the LPP should also comprise a review of design guidelines which are located within the same zone, such as the Grand Canals Design Guidelines, to ensure there is no misinterpretation of the role and power of each document. Consolidation is recommended where it can be achieved.</p>	Aligned with LU1	\$25,000
LU4	<p>In areas where further development or redevelopment of land is possible or anticipated, structure plans should incorporate the requirements of the CHRMAP, ensuring an appropriate coastal foreshore reserve is included and that any low-lying areas are adequately avoided or suitably filled to avoid inundation impacts. Existing and proposed structure plans should be reviewed to ensure they adhere to SPP2.6 and account for the risks identified in the CHRMAP.</p>	At application	N/A
LU5	<p>The City should notify landholders, real estate agents and settlement agents (operating in the local area) of land that may be affected by coastal hazards by 2120</p>	Aligned with LU1	\$5,000



Action	Description	Timing	Cost
	<p>Supported by a suitable SCA, there is an opportunity to require the provision of a Section 70A notification on the Title of land as a condition of any planning approval to alert landowners of the potential coastal hazard impacts on the lot, as required by SPP2.6. These notifications can only be applied where triggered by a subdivision (under Section 165 of the <i>Planning and Development Act 2005</i>) or development application (Section 70A of the <i>Transfer of Land Act 1893</i>). These can either be general alerts or more specific time limited approvals (e.g., where the temporary use of land in hazard areas is allowed, where appropriate, until hazards materialise, while ensuring that the City maintains discretion over development in these areas).</p> <p>The proponent may apply for an extension to the approval if the approval expires before hazards occur, whilst the City would be in a position to require demolition or removal of compromised structures if hazards occur ahead of predicted timeframe. This option potentially supports landowners with larger risk appetites. The LPP should include details of this potential framework.</p>		
LU6	<p>The City should notify prospective purchasers through the 'orders and requisitions' process with information relating to land that may be affected by coastal hazards by 2120 .</p> <p>Such advice should include the predictive nature of the investigations and provide advice on the ongoing investigations and monitoring that will result from the CHRMAP.</p>	Immediate	N/A
LU7	<p>The City should review existing leasehold facilities located within the hazard zone and notify the lessee of the CHRMAP. Leases should be reviewed at renewal timeframes to determine the suitability and/or length of future leases. The Foreshore Reservation in LU2 establishes the zone of interest.</p>	Aligned with LU1	N/A

**Table 8-2 Recommended content for City of Bunbury local planning scheme amendment appendix in accordance with LU1.**

Item	Recommended Text
Name of Area	Coastal Hazard Risk Area Special Control Area
Purpose	To provide guidance for land use and development within areas subject to coastal erosion and inundation
Objectives	<ul style="list-style-type: none"> <li>▪ To ensure land in the coastal zone is continuously provided for coastal foreshore management, public access, recreation and conservation.</li> <li>▪ To ensure public safety and reduce risk associated with coastal erosion and inundation.</li> <li>▪ To avoid inappropriate land use and development of land at risk from coastal erosion and inundation.</li> <li>▪ To ensure land use and development does not accelerate coastal erosion or inundation risks; or have a detrimental impact on the functions of public reserves.</li> <li>▪ To ensure that development addresses the Capel to Leschenault Coastal Hazard Risk Management and Adaptation Plan 2023 prepared in accordance with State Planning Policy No. 2.6 State Coastal Planning Policy (as amended) and any relevant local planning policy.</li> </ul>
Additional Provisions	1. All proposed development within the SCA requires approval



Item	Recommended Text
	<p>2. In considering proposed structure plans, subdivision or development applications due regard shall be given to –</p> <ol style="list-style-type: none"> <li>a) the Capel to Leschenault Coastal Hazard Risk Management and Adaptation Plan 2023.</li> <li>b) State Planning Policy 2.6 - State Coastal Planning Policy; and</li> <li>c) Relevant local planning policies.</li> </ol> <p>3. Where subdivision or development applications are received within SCA1, the local government shall require a notification pursuant to section 70A of the Transfer of Land Act 1983 to be placed on the Certificate(s) of Title of the subject land, at the cost of the landowner and to the satisfaction of the local government.</p> <p>The notification is to read as follows: <i>“Vulnerable Coastal Area – This lot is located in an area likely to be subject to coastal erosion and/or inundation over the next 100 years”</i></p> <p>4. Notwithstanding the provisions of above (1), (2) and (3) development approval is not required within SCA1 for the following development if such development is otherwise exempt from requiring development approval under the Scheme:</p> <ol style="list-style-type: none"> <li>a) temporary or non-permanent structures not used for human habitation.</li> <li>b) extensions to an existing single, grouped or multiple dwelling where the net floor area of the proposed extensions is no more than 50m<sup>2</sup>; and</li> <li>c) a change of use where no new structures are proposed.</li> </ol>
Advice Notes	<p>On the occasion of any development approval pursuant to the Additional Provisions of SCA 1, the following “Advice Notes” indicate suitable and tested advice to be provided to applicants:</p> <ul style="list-style-type: none"> <li>▪ The development subject of this approval may be impacted by coastal hazards in the short to medium term (likely by 2050). Should the development be affected by coastal hazards in the future as predicted, the development and any associated works are likely to require partial or complete relocation. The local government is under no obligation to assist or protect structures from coastal erosion/inundation threats and accepts no liability and will pay no costs associated with relocation or any protection from or damages caused by coastal processes.</li> <li>▪ The applicant is advised that the Horizontal Shoreline Datum means the active limit of the shoreline under storm activity, as defined in State Planning Policy 2.6 – State Coastal Planning Policy (2013).</li> <li>▪ The applicant is advised that the [x insert here] metre distance between the Horizontal Shoreline Datum and the most seaward part of the lot boundary is the S1 value for this location which is obtained from the Capel to Leschenault Coastal Hazard Risk Management Adaptation Plan 2023. S1 is the allowance for absorbing the current risk of storm erosion, as defined in State Planning Policy 2.6 – State Coastal Planning Policy (2013).</li> <li>▪ Should the development be affected by Coastal Hazards in the future the applicant will be responsible for relocating/removing the development and all costs associated. The local government is under no obligation to assist or protect structures from coastal erosion/inundation threats and accepts no liability and will pay no costs associated with any protection from or damages caused by coastal processes.</li> <li>▪ In relation to condition [x insert here], upon removal of the development the site is to be rehabilitated to pre-development condition which comprises of a bare earth lot, free of any buildings, demolition rubble or remnants of the approved development.</li> </ul>



## 8.3 Funding Options

This section identifies all revenue-raising mechanisms available for obtaining funds to assist implementation. Funding mechanisms considered include:

- Operating budget, general rates and coastal management fund
- Special area rates / differential rating
- Yearly budgeting
- Levies
- Lease land management
- State grants
- Federal grants
- Beneficiary pays

### 8.3.1 Operating Budget, General Rates and Coastal Management Fund

The individual land managers within the study area should consider establishing a coastal management fund that includes specific allowance for managing and adapting to the risk posed by coastal erosion and inundation. The purpose of this fund includes:

- To allocate a percentage of the organisation's operating budget for coastal management. The percentage and amounts will vary for each organisation but between 0.5% and 3.0% is proposed.
- To save funds routinely so that when triggers are met the established management actions can be implemented efficiently.
- Acknowledge coastal management costs are forecast to increase in line with sea level rise and the realisation of coastal hazard projections.

### 8.3.2 Specified Area Rate

Where adaptation options are designed to protect specific sections of coastal land and assets, such as private property, it is recommended that the City progress the establishment of a specified area rate. The rate can be applied to those beneficiaries within the 100-year hazard zone, and the amount raised should consider the estimated 100-year cost for each Option and the Benefit Distribution Analysis (BDA) report.

### 8.3.3 Levies

It is recommended the City investigate the feasibility of establishing a particular levy for coastal management that would be a transparent source of the coastal management fund discussed above.

### 8.3.4 Lease Land Management

Coastal land vested with coastal managers in the study area and leased to third parties represents a unique scenario whereby implementation of some Options may require specific lease clauses, but there is also potential to raise funds for coastal management. During considerations of lease renewal, coastal managers should consider the land use, vulnerability of the land, projected timeframe of unacceptable vulnerability, length of lease, recommended implementation Options and need for any specific clause around triggers or required management actions by the lessee. Increases in lease amounts may be able to raise funds to help offset the cost of management.





### 8.3.5 State Grants - CoastWA

CoastWA aims to implement a strategic response to the growing impacts of coastal hazards to ensure sustainable land use and development on the coast for the long-term. CoastWA has committed \$33.5 million of funding over five years from 2021-26. For further information visit <https://www.wa.gov.au/government/document-collections/coastwa-grants> It comprises the following grant programs:

- Coastal Adaptation and Protection grants
- Hotspot Coastal Adaptation and Protection Major Project Fund
- Coastwest grants
- Coastal Management Plan Assistance Program

There are also two other grant programs relevant to coastal hazard risk management in WA:

- Royalties for Regions
- Local Government Financial Assistance Grants

The Department of Transport administers the Coastal Adaptation and Protection (CAP) grants and the Hotspot Coastal Adaptation and Protection (H-CAP) Major Project Fund. CAP grants provide financial assistance for local projects that identify and manage coastal hazards. The program aims to build partnerships with local coastal managers, such as local governments and help them understand and adapt to coastal hazards. CAP Grants fund up to 50% of project costs. H-CAP supports projects which design and implement adaptation Options at coastal erosion hotspots identified by the DoT in recent years. Invitations to apply for H-CAP are sent directly to eligible coastal managers (those with a completed CHRMAP and an identified erosion hotspot) There are two identified erosion hotspots – The Cut in MU7 and Koombana Beach in MU5.

Coastwest grants support eligible coastal land managers and community organisations to undertake projects that manage and enhance WA's coastal environments through rehabilitation, restoration and preventative actions. Coastwest grants are administered by the Department of Planning, Lands and Heritage.

Coastal Management Plan Assistance Program (CMPAP) grants support eligible coastal land managers to develop adaptation and management plans and strategies for coastal areas that are, or are predicted to become, under pressure from a variety of challenges. CMPAP grants are administered by the Department of Planning, Lands and Heritage.

Other WA grant programs which may provide funding for coastal projects include Royalties for Regions and Local Government Financial Assistance Grants.

Royalties for Regions is facilitated by Department of Primary Industries and Regional Development and promotes and facilitates economic, business and social development in regional Western Australia for the benefit of all Western Australians. For further information visit: <http://www.drd.wa.gov.au/rfr/whatisrfr/Pages/default.aspx>

Local Government Financial Assistance Grants are administered by the Department of Local Government, Sport and Cultural Industries. They are grants funded by the Commonwealth Government and are distributed among 137 local governments in WA each year. The grants allow councils to spend the funds according to local priorities. For further information visit: <https://www.dlgsc.wa.gov.au/local-government/local-governments/financial-assistance-grants>



### 8.3.6 Federal Grants

Federal grants are variable and often unpredictable, but it is important for coastal managers to stay aware of any funding and grant programs available. Early planning and preparation will mean more-competitive applications can be prepared quickly when grants are announced.

On 13 February 2022 the Australian Government announced the \$50 million Coastal and Estuarine Risk Mitigation Program which is funded by the Emergency Response Fund. This program supports projects that reduce the impact of disasters on coastal communities. Successful applicants were announced on 4 November 2022. The Coastal and Estuarine Risk Mitigation Program will help drive long term resilience and sustainability by delivering priority projects that mitigate the impact of disasters on communities and economies.

Areas of focus for the Program include:

- Adaptation and resilience actions, including investment in grey infrastructure and green-blue infrastructure (which includes nature-based solutions)
- Planning, including local and regional risk assessments and mapping, business case development, preparation of community focused regional coastal management programs; and
- Investment in monitoring infrastructure and activities to understand the coastal and estuarine zone over time.

For more information visit <https://nema.gov.au/programs/emergency-response-fund/coastal-estuarine-risk-mitigation-program#Overview>

The Australian Government has also established the Disaster Ready Fund to provide up to one billion dollars over five years from 2023-24. The fund aims to decrease impacts of natural hazards, and eligible projects include direct investment in flood levees, seawalls, constructed wetlands and reefs. For more information visit <https://nema.gov.au/disaster-ready-fund>

### 8.3.7 Beneficiary Pays

'User Pays' principles essentially dictate that the beneficiaries of adaptation Options should pay for them. Mechanisms for fund raising may include:

- Specified Area Rates – as described above and considering the findings of the BDA.
- Mechanisms for visitors to the town, as user of the coastline, to contribute. This could be in the form of a levy applied to their accommodation, or paid parking at key tourist sites.
- Developer contributions where specific developments benefit from their coastal location

## 8.4 Short-term Implementation

The coastal adaptation pathway includes short-term, medium-term and long-term actions. Short-term actions are anticipated to be implemented by 2035, corresponding to a 10-15 year planning horizon; medium-term actions implementation would occur before 2050 (15-30); while long-term actions would be implemented beyond 2050, towards 2120.

### 8.4.1 Key assumptions

The timeframes envisaged in the coastal adaptation pathways are not absolute. These timeframes are related to the current state of local land planning, coastal processes knowledge and climate projections, as outlined in the CHRMAP. Therefore, the timeframes are typically not aligned on "worst-case" scenarios but instead consider risk-adjusted and/or consensus-based adjustments and quantifications. Other Options may be



envisaged, particularly if land planning practices, coastal processes knowledge or climate projections are changed. Therefore, the implementation pathway will evolve overtime.

The Options have been selected based on information gathered through all the previous CHRMAP project stages. Although the Multi-Criteria Analysis and Cost Benefit Analysis have been key gateway decision points for selecting many Options. The preparation of the MCA and CBA required interpretation and approximations, particularly regarding the criteria and cost quantifications, and have limitations. Also, the proposed Options have been developed only at a conceptual level to draw comparisons between several Options.

The CHRMAP proposed Options should be the subject of further investigations, surveys, policy review, impact investigations (environmental, visual and social), development approval and authorities endorsement, local stakeholder and community engagement, preliminary design, detailed design, costing and any other applicable preparation work required prior to be implemented. The Options should be optimised and modified following such additional investigations.

An example of this could be changes to Management Unit boundaries, to optimise Option effectiveness and to reduce costs. It may also be practical to develop a staged implementation approach to some of these management actions to test their effectiveness and to refine design of subsequent stages (e.g., staged installation of beach groynes). Some interim management Options may also be progressed, such as the development of emergency evacuation procedures and systems, until inundation protection measures can be fully implemented.

#### **8.4.2 Further Investigations**

Information gaps identified in the CHRMAP should be gathered early. Some of these gaps can be closed by the collection of data, as discussed further in Section 8.5. Other information gaps can be closed during the preliminary and/or detailed design phase when specific or detailed analysis of available data, information, modelling, and projections are carried out. The "governance/support" role currently undertaken by the PNP should continue with funding support for coordination of coastal management, planning, engineering and research in the study area.

A number of the recommended investigations may already exist in LGA technical or planning documents. The CHRMAP recommended investigations have been scoped specifically to meet coastal hazard planning elements introduced in the State Coastal Planning Policy 2.6.

The following investigations are recommended:

11. Prepare an Asset Management Plan, which identifies existing infrastructure and recreational facilities in the coastal erosion and inundation hazard zone and provides direction to:
  - a. Progressively relocate non-critical assets (PMR2) away from the coastal hazard zone once they reach the end of asset life or replace assets with suitably durable and/or sacrificial infrastructure. This may include vulnerable recreational car parks; recreational amenities such as public ablutions; barbeque/picnic/shade areas; playground and other recreational equipment; and access structures such as ramps, stairs and paths and fences, etc.
  - b. Plan for the relocation of critical service infrastructure outside of the coastal hazard zone once they reach the end of asset life, or at a minimum, modify the service infrastructure asset so that it does not run parallel to the coastline where possible and can be progressively removed when exposed to intolerable risk levels. This may include public safety infrastructure.
12. Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with landholders and whether opt-ins can be time constrained.



13. Sand source feasibility study – Several MU's have recommended Options which require sand nourishment, both for erosion management (such as beach groynes including sand nourishment) and inundation management (such as raising beach levels to improve coastal drainage). The availability of suitable sand for beach nourishment works is unfortunately not well understood in the study area. It is recommended that a sand source feasibility is undertaken for the PNP to determine the capacity and cost of local sand supplies. This study should consider both land-based and marine sand sources as well as evaluate potential environmental impacts and approvals required. Cost estimates in this CHRMAP have assumed that a reliable source of sand in reasonable proximity to the study area may be available. If this assumption is incorrect, costs may increase and affect the CHRMAP recommendations. The City's MU's would benefit from detailed consideration of sand available via Southern Ports maintenance dredging works.
14. Rock source feasibility study – Similar to the above but for armour rock suitable for building coastal management structures. Several MU's have recommended Options requiring armour rock which needs to be fit for purpose. An analysis of the availability of such rock suitable for marine works, with suitable density, quarry yields, close location and tolerable costs should be undertaken. Potential environmental impacts should be considered in the rock source feasibility study, as well as any approvals required. Cost estimates in this CHRMAP have assumed that a reliable source of rock can be found in the study area. If this assumption is incorrect, costs may increase and affect the CHRMAP recommendations.
15. Emergency evacuation planning – A review of emergency evacuation plans in the study area should be undertaken to assess if the evacuation plans are suitable for managing the projected coastal hazards. Existing documents may need to be updated or revised as required. Plans should detail emergency response to coastal erosion and flooding impacts, as well as storm damage causing infrastructure to collapse into the public foreshore or coastal environment. Evacuation planning for inundation should clearly identify appropriate evacuation routes, assess their suitability, and plan for upgrades required to meet future LGA developments. Scenario planning could also be undertaken to test the plans.
16. Foreshore Management Plans (FMPs) - Updated foreshore management plans for the study areas may increase the protective capacity of the natural dune system. Foreshore management plans should address:
  - a. The requirements of SPP2.6 and its supporting documentation
  - b. The findings of this CHRMAP
  - c. Potential environmental issues such as biodiversity and environmental impacts, and detail a weed management strategy for the coastline
  - d. Incorporate findings of Asset Management Plans as appropriate
  - e. Include recommendations for closing excess beach access points, ensuring appropriately fenced and signed paths, signage for dune repair and clear signage for 4-wheel drive access and permissibility
  - f. Develop an education strategy for coastal and environmental management. The strategy should work to inform the community about the CHRMAP and FMP and their findings and use suitable engagement methods such as infographics, FAQ's. The education strategy should also include appropriate on-ground signage and information for beach access, camping and 4-wheel driving, where applicable.
  - g. Monitor impacts of 4WD vehicles (where applicable) and general beach access on nesting habitats and migratory bird species in dune areas
  - h. Determine the need for a bush fire management plan for the dune and coastal areas
17. Coastal Hazard Mapping Study – the study partners should consider an advocacy program with the support of organisations such as the Western Australian Local Government Association (WALGA) and Local Government Planners Association (LGPA) to achieve a state-wide coastal mapping database similar





to the Fire and Emergency Services (FESA) mapping of bushfire prone areas recognised as a result of applying *State Planning Policy 3.7: Planning in Bushfire Prone Areas*. Such mapping could become a vital knowledge-building tool for communities across the state coming to terms with increasing coastal hazards. NB: it is recognised that only areas where a CHRMAP has been completed and endorsed could be mapped accurately, however, other identified coastal hazard hotspots could be included in this mapping with future studies determining the extent of the coastal hazard risk area. This undertaking would complement the local-scale education strategies.

## 8.5 Monitoring

### 8.5.1 Recommended Coastal Monitoring Activities

The monitoring activities described below are designed to identify the impacts of the recommended Options and to record the evolution of the coastal trigger points. Indicative costs for budgeting purposes are provided.

Should any Option be modified, or other coastal projects be undertaken (such as maritime, or recreation/tourism projects) where coastal hazard risk management is not the primary focus, they should be subject to the same CHRMAP principles and require their own monitoring program appropriate to their location, size and objectives. The following coastal monitoring activities are recommended:

1. Routine beach and dune surveys, in the form of beach profiles, , every 400m along the coast.
  - a. MU5 and MU6 should aim to have annual beach profiles at the end of winter while MU4 and MU7 could be undertaken every second year. More frequent profiles (every six months following summer and winter seasons) could be undertaken for areas of concern following collection and review of initial dataset.
  - b. Beach profiles may be spaced more closely where Options include trigger points monitoring and/or to support specific project requirements.
  - c. The beach survey may also be continuous along the coast using LiDAR or other appropriate techniques with a view to capture more accurately coastal processes, while allowing the compilation of beach profile data.
  - d. At the minimum, beach profiles should be carried out following winter every three years for MU5 and MU6 and every five years for MU4 and MU7.
  - e. Additionally, surveys can be undertaken immediately following severe storms producing significant beach erosion. These are useful for recording historical events, confirming the presence of bedrock, and calibrating models.
  - f. Beach profile datasets should include the location of the Horizontal Shoreline Datum (HSD). The beach profiles must extend from the edge of the coastal cadastral boundary down to the Lowest Astronomical Tide (LAT). The survey datasets should be centralised into a database, which includes previous historical beach profiles and quality control information such as survey date, datum, survey mark, beach material encountered (rock vs sand) and method used.
2. Corresponding monitoring photos should be taken at the same time as beach surveys – particularly for inundation events as it is often impractical to organise detailed survey at short notice.
3. Regular monitoring of the coastal management structures (Protection Structure Audit – NR2) – e.g., seawalls, groynes, breakwaters and storm surge barrier. These should be undertaken with consistent methodology to allow comparison between inspections. These can be commenced immediately, and the initial assessment would identify an appropriate review schedule for each structure, or if there is an issue with an asset. Such assessment would occur yearly to blend into the existing LGA asset management reporting systems.



4. Geotechnical investigations are proposed to determine the presence of bedrock below the beach. When bedrock is located relatively near the surface, it can provide some natural protection to erosion and reduce the scope of works. However, in low-lying areas, the presence of bedrock may not significantly mitigate the coastal hazards. Such investigation may be carried out by ground penetration radar, test pits or survey observations following beach erosion events. The priority for this investigation is MU5 and then the secondary priority is MU6.

### 8.5.2 Trigger Points

The CHRMAP considers four types of physical trigger points, as follows:

- **Proximity trigger:** Where the most landward part of the Horizontal Shoreline Datum (HSD) is within the Storm Erosion Allowance of the most seaward point of a public asset of interest or private property lot boundary. Due to the high value of the foreshore reserve, the foreshore reserve may be considered to be “the most seaward point”. If individual assets have a specific distance-based trigger relating to the HSD then the beach and dune survey activities described above should be used to collect topographic data that can be used to map the updated HSD position.
- **Access trigger:** Where a public road is considered no longer available or able to provide legal access to the property
- **Utilities trigger:** When water, sewage, communications or electricity to the lot is no longer available as they have been removed/decommissioned by the relevant authority due to coastal hazards.
- **Damage trigger:** Any property within the hazard zone and within a dedicated Special Control Area, that is damaged by a coastal hazard from an extreme weather event shall require LGA approval before being repaired. The review process should involve re-fit of minor or moderately damaged assets to accommodate coastal hazards in the future; or removal and redevelopment outside the hazard zone for damaged assets.

This list follows a sequential / prioritisation order. That is, a “proximity trigger” is recommended over a “damage trigger”.

### 8.5.3 CHRMAP Review

The CHRMAP should be updated at least every 10 years to maintain its currency and ensure it remains a “living document”. Also, the CHRMAP should be revisited when the triggers are reached to update the coastal hazard assessment.

There are several pitfalls to relying on triggers alone for coastal management. As described in Section 8.5.2, physical triggers provide limited flexibility, rely on monitoring, and assume that conflicting interests have been resolved. In addition, it is essential to recognise that environmental and societal considerations significantly affect the implementation of management actions. These external triggers would include:

- Environmental Triggers, such as:
  - Substantial storm events generating severe coastal hazards approaching or exceeding the CHRMAP projections
  - Environmental Impacts
- Societal Triggers, such as:
  - Change to governance, planning and/or laws, such as a significant change to State land-use planning or a major change in a Local Planning Scheme within the Greater Bunbury Region Scheme
  - New information becomes available that substantially affects the summary of local community values
  - Major societal events such as macro-economic context, public protests, etc.



Such unplanned external triggers will be determinant in actioning and timing some of the Options recommended in the CHRMAP. An earlier review of the CHRMAP may be considered when such an external trigger occurs. Therefore, it is essential to support coastal zone managers to be opportunistic and reactive to such external triggers rather than be only mandated to follow the CHRMAP actions.

To prepare a coherent CHRMAP update it may be necessary to update the Hazard modelling / assessment to include:

- Recent monitoring data
- Planning changes and changes to the CHRMAP success criteria and stakeholder feedback
- Updates in climate change science, specifically local sea level rise projections
- Updated coastal engineering science and methodologies

## 8.6 Medium and Long-term Implementation

Medium (15 – 30 years) and long-term (30 – 100 years) implementation provides a strategic consideration of how the PNP and its member organisations will adapt to long-term climate change impacts. Therefore, medium- and long-term implementation are not described in detail in the CHRMAP. Longer-term responses include:

- Actioning the revised planning instruments
- Managing coastal retreat
- Exhausting the SPP2.6 hierarchy of actions, high value assets may be protected where sustainable impacts and funding are identified/prioritised
- Providing temporary/interim hazard protection may also become more costly and a change in adaptation pathway could be required. For example, as sea level rise progresses, it is likely that Options using sand or rock resources to protect assets near the coast may become unsustainable.

The two primary coastal management actions mitigating erosion hazards are:

- Planned / Managed retreat (PMR4 – Voluntary Acquisition): Use the planning instruments and long-term plan to systematically move assets with low adaptive capacity out of the hazard zone
- Protect (PR2 - Groynes): Undertake the construction of groynes with beach renourishment as necessary to prevent erosion of natural and built assets

The three coastal management actions mitigating inundation hazards are:

- Planned / Managed retreat (PMR4 – Voluntary Acquisition): Use the planning instruments and long-term plan to systematically move assets with low adaptive capacity out of the hazard zone
- Accommodate (AC1 - Design Assets to Withstand Impacts): limit damage from inundation events through finished floor level requirements
- Protect (PR6 - Levee PR6): Undertake works as necessary to prevent or limit inundation of assets exposed along the coast



## 8.7 Recommendations

The following recommendations are based on currently available information. Recommendations that are included in this document are made based on the assumptions provided throughout this document, recognising the gaps in information that still need to be resolved, and a multi-criteria analysis based on technical, economic, social and environmental criteria.

Future investigations are required to confirm they are suitable, including further consultation with stakeholders and the community. The next step, following finalisation of this CHRMAP, is to develop a program of investigative works over the short to medium term, to help inform the timing and scope of future investigations. Subsequently a likely outcome is that a combination of options may be the preferred approach in some locations. The recommendations are based on the analysis presented in this report. Additional considerations may be incorporated into future analyses.

All recommendations still need further research. The CHRMAP provides the basis for which for the City may access grant funding to undertake this work; after which, recommendations may be updated, improved, or confirmed. This process requires ongoing engagement with affected communities.

Short, medium- and long-term recommendations are summarised in Table 8-3 to Table 8-7 below. In addition, long-term adaptation strategies/pathways have been recommended for erosion and inundation that will allow for the continuous function of local communities whilst accommodating the increasing burden of coastal hazards. The long-term strategy informs future planning instruments, supports monitoring, recommends planning reviews and underpins collaboration between coastal land managers, stakeholders and the community.



Table 8-3 MU4 Bunbury South Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
INVESTIGATION 1 Sand Source Feasibility Study	<ul style="list-style-type: none"> <li>Determine the capacity and cost of local sand supplies, including both land-based and marine sources</li> <li>Likely require repetition over Medium-term</li> <li>Focus for this MU is appropriate sand for ad hoc sand nourishment</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> <li>Can seek support from neighbouring LGA's, PNP, and state departments</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$30,000</li> <li>Assumes only undertaken for this MU in isolation, but synergies should be investigated.</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x		x	
INVESTIGATION 2 Update Foreshore Management Plans (FMPs)	<ul style="list-style-type: none"> <li>Prepare an updated Foreshore Management Plan</li> <li>An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$30,000</li> <li>Assumes only undertaken for this MU in isolation, but synergies should be investigated.</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>		x	x	x	x
INVESTIGATION 3 Audit of assets within 2035 erosion hazard zone	<ul style="list-style-type: none"> <li>Audit of assets within 2035 erosion hazard zone and identification of assets where damage would be unacceptable to determine between PMR1 and PMR2</li> <li>Investigation to determine acceptable foreshore amenity facilities within hazard zone</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>Included under component items below</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x	x		
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	<ul style="list-style-type: none"> <li>Item cost for investigations and management plans</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$150,000</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> </ul>	x	x			
Monitoring (NR1)	<ul style="list-style-type: none"> <li>Beach survey for storm behaviour and to track HSD and inundation levels</li> <li>Routine beach profiles every two years in Spring</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> <li>Can seek support and assistance from DoT</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> <li>Severe storm event(s)</li> </ul>	<ul style="list-style-type: none"> <li>\$5,000</li> <li>(Plus 10% annual maintenance of \$5,000)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x	x		
Notification on title (NR3)	<ul style="list-style-type: none"> <li>Item cost for investigations and implementation plans</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> <li>Can seek support and assistance from DPLH, WALGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$50,000</li> <li>(Plus 1% annual maintenance of \$500)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>		x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	<ul style="list-style-type: none"> <li>Item cost for investigations and management plans</li> <li>Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with landholders and whether opt-ins can be time constrained</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$50,000</li> <li>(Plus 1% annual maintenance of \$500)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>		x	x		





Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Demolition / removal / relocation of asset from inside hazard area (PMR2)	<ul style="list-style-type: none"> <li>Preparation of Asset Management Plan</li> <li>To 2035 for public-built assets</li> <li>Maintenance assumes ongoing allowance for foreshore reserve</li> <li>Removal / Relocation of assets as required</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Audit of assets within 2035 erosion hazard zone and identification of assets where damage would be unacceptable</li> </ul>	<ul style="list-style-type: none"> <li>\$129,000</li> <li>(Plus 1% annual maintenance of \$1,290)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x	x		
<b>Recommended Short-Term Option to address Erosion is Planned / managed Retreat combining Leaving Assets Unprotected (PMR1); Removal of Assets from Inside Hazard Area (PMR2), and Prevention of Further Development (PMR3)</b>	<ul style="list-style-type: none"> <li>Implementation of recommendation actions (PMR1-PMR3), following investigation.</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>Included under component items below</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x	x		
Leaving assets unprotected (PMR1)	<ul style="list-style-type: none"> <li>To 2035 for low-value public assets</li> <li>Assumes a clean-up rate following damage/loss</li> <li>No private land acquisition included</li> <li>Maintenance assumes ongoing allowance for foreshore reserve</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Storm damage</li> </ul>	<ul style="list-style-type: none"> <li>\$59,000</li> <li>(Plus 3% annual maintenance of \$1,770)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> </ul>	x	x	x		
<b>Recommended Medium and Long-term pathway to address Erosion is Planned / managed Retreat combining Leaving Assets Unprotected (PMR1); Removal of Assets from Inside Hazard Area (PMR2), and Prevention of Further Development (PMR3)</b>	<ul style="list-style-type: none"> <li>Implement when triggers are met</li> <li>See explanation in Land Use Planning Section of this report</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>HSD within 11m of low-value public assets, equivalent of approximately half of storm erosion allowance for this MU (21m)</li> </ul>	<ul style="list-style-type: none"> <li>Included under component items</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>				x	x



Table 8-4 MU5 Bunbury Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
INVESTIGATION 1 Detailed investigations to confirm assumptions used in the CHRMAP	<ul style="list-style-type: none"> <li>Determine program of investigative works</li> <li>Undertake detailed investigations to confirm assumptions used in the CHRMAP; and determine if rock groynes are most appropriate option</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$200,000</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> </ul>	x	x			
INVESTIGATION 2 Sand Source Feasibility Study	<ul style="list-style-type: none"> <li>Determine the capacity and cost of local sand supplies, including both land-based and marine sources</li> <li>Likely require repetition over Medium-term</li> <li>Focus for this MU is bulk sand nourishment for ocean coast, but should also consider the need for appropriate fill to raise height of land in the inundation hazard zone</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> <li>Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$60,000</li> <li>Assumes only undertaken for this MU in isolation, but synergies should be investigated.</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x		x	
INVESTIGATION 3 Rock Source Feasibility Study	<ul style="list-style-type: none"> <li>Analyse the availability of rock in terms of density, quarry yields, location and costs</li> <li>Likely require repetition over Medium-term</li> <li>Focus for this MU is armour and core rock of all sizes</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> <li>Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$60,000</li> <li>Assumes only undertaken for this MU in isolation, but synergies should be investigated.</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x		x	
INVESTIGATION 4 Update Foreshore Management Plans (FMPs)	<ul style="list-style-type: none"> <li>Prepare an updated Foreshore Management Plan</li> <li>An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$30,000</li> <li>Assumes only undertaken for this MU in isolation, but synergies should be investigated.</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>		x	x	x	x
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	<ul style="list-style-type: none"> <li>Item cost for investigations and management plans</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$150,000</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> </ul>	x	x			
Monitoring (NR1)	<ul style="list-style-type: none"> <li>Beach survey for storm behaviour and to track HSD and inundation levels</li> <li>Routine beach profiles every year in Spring</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> <li>Can seek support and assistance from DoT</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> <li>Severe storm event(s)</li> </ul>	<ul style="list-style-type: none"> <li>\$10,000</li> <li>(Plus 10% annual maintenance of \$1,000)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x	x		
Notification on title (NR3)	<ul style="list-style-type: none"> <li>Item cost for investigations and implementation plans</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> <li>Can seek support and assistance from DPLH, WALGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$250,000</li> <li>(Plus 1% annual maintenance of \$2,500)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>		x	x		
Protection Structure Audit (NR2)	<ul style="list-style-type: none"> <li>Item cost to inspect asset condition, influence on sediment transport and inundation and remaining design life on all coastal management structures</li> <li>Includes ocean coast seawalls Outer Harbour breakwater and spur groynes, Casuarina Harbour breakwaters and causeway, Koombana Bay groynes and Dolphin Discovery Centre buried seawall</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> <li>DoT</li> <li>Koombana Sailing Club</li> <li>Southern Ports, Bunbury</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$75,000</li> <li>(Plus 2% annual maintenance of \$1,500)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>		x	x		



Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Emergency evacuation plans (NR4)	<ul style="list-style-type: none"> <li>Item cost for investigations and evacuation plans</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$250,000</li> <li>(Plus 1% annual maintenance of \$2,500)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x			
Demolition / removal / relocation of asset from inside hazard area (PMR2)	<ul style="list-style-type: none"> <li>Preparation of Asset Management Plan</li> <li>To 2035 for public-built assets</li> <li>Maintenance assumes ongoing allowance for foreshore reserve</li> <li>Removal / Relocation of assets as required</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable</li> </ul>	<ul style="list-style-type: none"> <li>\$4,506,000</li> <li>(Plus 1% annual maintenance of \$45,060)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	<ul style="list-style-type: none"> <li>Item cost for investigations and management plans</li> <li>Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with landholders and whether opt-ins can be time constrained</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$100,000</li> <li>(Plus 1% annual maintenance of \$1,000)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>		x	x		
Design assets to withstand impacts (AC1)	<ul style="list-style-type: none"> <li>Item cost for investigations and management plans – primarily any case-by-case work needed for public assets</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$500,000</li> <li>(Plus 1% annual maintenance of \$5,000)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x			
<b>Recommended Short-Term Option to address Erosion is to investigate and prepare for Protection with Groynes (PR2)</b>	<ul style="list-style-type: none"> <li>CHRMAP analysis has found that the Protection Pathway is appropriate for this MU with provision of a sandy beach</li> <li>Currently the option assumes the following: <ul style="list-style-type: none"> <li>15 rock groynes 100m long, 400m apart (13 on ocean coast and 2 in Koombana Bay)</li> <li>Present day Implementation</li> <li>Interim management may use Beach Renourishment as temporary protection while implementation of primary option is organised</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> <li>Completed detailed investigations</li> <li>Monitoring</li> <li>Confirmation of design, costs and funding</li> <li>Construction likely to be staged</li> </ul>	<ul style="list-style-type: none"> <li>\$83.5M at NPV 4% for a 100-year timeframe</li> <li>Detailed design and costings estimated at \$250,000</li> <li>BDA analysis estimates a fair and reasonable breakdown of % costs to different benefiting parties is: <ul style="list-style-type: none"> <li>Private Landholders at ~3%</li> <li>City at ~64%</li> <li>WA State Government at ~34%</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> <li>Specified Area Rate</li> <li>Levies</li> <li>User Pays</li> </ul>	x	x	x		
<b>Recommended Short-Term Option to address Inundation is to replace storm surge barrier (PR6)</b>	<ul style="list-style-type: none"> <li>Replacement of storm surge barrier at the Leschenault Inlet</li> <li>2035 Implementation</li> </ul>	<ul style="list-style-type: none"> <li>State Government with DoT likely to be the lead agency with support by LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> <li>Monitoring</li> <li>Confirmation of design, costs and funding</li> <li>Confirmation of SLR in accordance with projections to 2035</li> </ul>	<ul style="list-style-type: none"> <li>\$17.9M at NPV 4%</li> <li>Detailed design and costings estimated at \$250,000</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> <li>Specified Area Rate</li> <li>Levies</li> <li>User Pays</li> </ul>		x	x	x	



Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Leaving assets unprotected (PMR1)	<ul style="list-style-type: none"> <li>To 2035 for low-value public assets</li> <li>Assumes a clean-up rate following damage/loss</li> <li>No private land acquisition included</li> <li>Maintenance assumes ongoing allowance for foreshore reserve</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Storm damage</li> <li>Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable</li> </ul>	<ul style="list-style-type: none"> <li>\$2,011,000</li> <li>(Plus 3% annual maintenance of \$60,330)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> </ul>	x	x	x		
<b>Recommended Medium and Long-term pathway to address Erosion is Protection with Groynes (PR2)</b>	<ul style="list-style-type: none"> <li>Monitoring will determine need for additional stages of groynes (or alternative protection method) in future and the eventual need for major refurbishment or replacement of the structures and associated beach renourishment</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring</li> <li>Updated CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>Annual maintenance estimate of approximately \$1.0M</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> <li>Specified Area Rate</li> <li>Levies</li> <li>User Pays</li> </ul>				x	x
<b>Recommended Medium and Long-term pathway to address Inundation is to replace storm surge barrier (PR6)</b>	<ul style="list-style-type: none"> <li>Monitoring and maintenance of infrastructure and design and performance reviews in accordance with new information and CHRMAP updates.</li> <li>Secondary components may include the need for additional levees and drainage improvements as sea level rise progresses</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring</li> <li>Updated CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>Annual maintenance estimate of approximately \$0.25M</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> <li>Specified Area Rate</li> <li>Levies</li> <li>User Pays</li> </ul>				x	x



Table 8-5 MU6 Bunbury Port Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
INVESTIGATION 1 Detailed investigations to confirm assumptions used in the CHRMAP	<ul style="list-style-type: none"> <li>Determine program of investigative works</li> <li>Undertake detailed investigations to confirm assumptions used in the CHRMAP; and determine if rock groynes are most appropriate option</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$200,000</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> </ul>	x	x			
INVESTIGATION 2 Sand Source Feasibility Study	<ul style="list-style-type: none"> <li>Determine the capacity and cost of local sand supplies, including both land-based and marine sources</li> <li>Likely require repetition over Medium-term</li> <li>Focus for this MU is sand nourishment for Southern Ports ocean and estuary frontage, but should also consider the need for appropriate fill to raise height of land in inundation hazard zone</li> </ul>	<ul style="list-style-type: none"> <li>Southern Ports, Bunbury</li> <li>Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$40,000</li> <li>Assumes only undertaken for this MU in isolation, but synergies should be investigated.</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x		x	
INVESTIGATION 3 Rock Source Feasibility Study	<ul style="list-style-type: none"> <li>Analyse the availability of rock in terms of density, quarry yields, location and costs</li> <li>Likely require repetition over Medium-term</li> <li>Focus for this MU is armour and core rock of all sizes</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> <li>Can seek support from neighbouring LGA's, PNP, and state departments</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$40,000</li> <li>Assumes only undertaken for this MU in isolation, but synergies should be investigated.</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x		x	
INVESTIGATION 4 Update Foreshore Management Plans (FMPs)	<ul style="list-style-type: none"> <li>Prepare an updated Foreshore Management Plan</li> <li>An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP</li> <li>For this MU controlled by Southern Ports Bunbury it is envisaged the work may incorporate appropriate clauses into operational and strategic planning and lease conditions as well as a joint approach with neighbouring LGA's.</li> </ul>	<ul style="list-style-type: none"> <li>Southern Ports, Bunbury</li> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$30,000</li> <li>Assumes only undertaken for this MU in isolation, but synergies should be investigated.</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>		x	x	x	x
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	<ul style="list-style-type: none"> <li>Item cost for investigations and management plans</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> <li>Southern Ports, Bunbury</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$50,000</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> </ul>	x	x			
Monitoring (NR1)	<ul style="list-style-type: none"> <li>Beach survey for storm behaviour and to track HSD and inundation levels</li> <li>Routine beach profiles every year in Spring</li> </ul>	<ul style="list-style-type: none"> <li>Southern Ports, Bunbury</li> <li>Can seek support and assistance from LGA, DoT</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> <li>Severe storm event(s)</li> </ul>	<ul style="list-style-type: none"> <li>\$5,000</li> <li>(Plus 10% annual maintenance of \$5,000)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x	x		





Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Notification on title (NR3)	<ul style="list-style-type: none"> <li>Item cost for investigations and implementation plans</li> <li>For this MU controlled by Southern Ports, Bunbury it is envisaged the work may incorporate appropriate clauses into operational and strategic planning and lease conditions.</li> </ul>	<ul style="list-style-type: none"> <li>Southern Ports, Bunbury</li> <li>Can seek support and assistance from LGA, DPLH, WALGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$50,000</li> <li>(Plus 1% annual maintenance of \$500)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>		x	x		
Protection Structure Audit (NR2)	<ul style="list-style-type: none"> <li>Item cost to inspect coastal asset condition, influence on sediment transport and inundation and remaining design life on all coastal management structures</li> <li>Includes Port seawall and Port Breakwaters for Inner Harbour</li> </ul>	<ul style="list-style-type: none"> <li>Southern Ports, Bunbury</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$50,000</li> <li>(Plus 2% annual maintenance of \$1,500)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>		x	x		
Emergency evacuation plans (NR4)	<ul style="list-style-type: none"> <li>Item cost for investigations and evacuation plans</li> </ul>	<ul style="list-style-type: none"> <li>Southern Ports, Bunbury</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$100,000</li> <li>(Plus 1% annual maintenance of \$1,000)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x			
Demolition / removal / relocation of asset from inside hazard area (PMR2)	<ul style="list-style-type: none"> <li>Preparation of Asset Management Plan</li> <li>To 2035 for public-built assets</li> <li>Maintenance assumes ongoing allowance for foreshore reserve</li> <li>Removal / Relocation of assets as required</li> </ul>	<ul style="list-style-type: none"> <li>Southern Ports, Bunbury</li> </ul>	<ul style="list-style-type: none"> <li>Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable</li> </ul>	<ul style="list-style-type: none"> <li>\$791,000</li> <li>(Plus 1% annual maintenance of \$7,910)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	<ul style="list-style-type: none"> <li>Item cost for investigations and management plans</li> <li>Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with landholders and whether opt-ins can be time constrained</li> <li>For this MU controlled by Southern Ports, Bunbury it is envisaged the work may incorporate appropriate clauses into operational and strategic planning and lease conditions.</li> </ul>	<ul style="list-style-type: none"> <li>Southern Ports, Bunbury</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$30,000</li> <li>(Plus 1% annual maintenance of \$3,000)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>		x	x		
Design assets to withstand impacts (AC1)	<ul style="list-style-type: none"> <li>Item cost for investigations and management plans – primarily any case-by-case work needed for public assets</li> </ul>	<ul style="list-style-type: none"> <li>Southern Ports, Bunbury</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$100,000</li> <li>(Plus 1% annual maintenance of \$1,000)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x			
<b>Recommended Short-Term Option to address Erosion is to investigate and prepare for Protection with Groynes (PR2)</b>	<ul style="list-style-type: none"> <li>CHRMAP analysis has found that the Protection Pathway is appropriate for this MU with provision of a sandy beach</li> </ul> <p>Currently the option assumes the following:</p> <ul style="list-style-type: none"> <li>5 rock groynes 75m long, 300m apart along ocean coast</li> <li>800m revetment seawall along estuary coast</li> <li>2035 Implementation</li> </ul>	<ul style="list-style-type: none"> <li>Southern Ports, Bunbury</li> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> <li>Completed detailed investigations</li> <li>Monitoring</li> <li>Confirmation of design, costs and funding</li> <li>Construction likely to be staged</li> </ul>	<ul style="list-style-type: none"> <li>\$8.8M at NPV 4% for a 100-year timeframe</li> <li>Detailed design and costings estimated at \$200,000</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x	x		



Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
<b>Recommended Short-Term Option to address Inundation is a Levee (PR6)</b>	<ul style="list-style-type: none"> <li>Assumes 700m levee to cover ocean frontage (400m east of port and 300m on west)</li> <li>Assumes present day implementation</li> <li>Does not address inundation risk from estuary frontage. Further investigation is required as the broader PR6 Option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate</li> </ul>	<ul style="list-style-type: none"> <li>Southern Ports, Bunbury</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> <li>Monitoring</li> <li>Confirmation of design, costs and funding</li> <li>Confirmation of SLR in accordance with projections to 2035</li> </ul>	<ul style="list-style-type: none"> <li>\$1.2M at NPV 4%</li> <li>Detailed design and costings estimated at \$150,000</li> <li>Further Investigation of Options for inundation that come from estuary frontage - \$150,000</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x	x		
Leaving assets unprotected (PMR1)	<ul style="list-style-type: none"> <li>To 2035 for low-value public assets</li> <li>Assumes a clean-up rate following damage/loss</li> <li>No private land acquisition included</li> <li>Maintenance assumes ongoing allowance for foreshore reserve</li> </ul>	<ul style="list-style-type: none"> <li>Southern Ports, Bunbury</li> </ul>	<ul style="list-style-type: none"> <li>Storm damage</li> <li>Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable</li> </ul>	<ul style="list-style-type: none"> <li>\$360,000</li> <li>(Plus 3% annual maintenance of \$10,800)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> </ul>	x	x	x		
<b>Recommended Medium and Long-term pathway to address Erosion is Protection with Groynes (PR2)</b>	<ul style="list-style-type: none"> <li>Monitoring will determine the need for additional stages of groynes (or alternative protection method) in future and the eventual need for major refurbishment or replacement of the structures and associated beach renourishment</li> </ul>	<ul style="list-style-type: none"> <li>Southern Ports, Bunbury</li> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring</li> <li>Updated CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>Annual maintenance estimate of approximately \$0.2M</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>				x	x
<b>Recommended Medium and Long-term pathway to address Inundation is a Levee (PR6)</b>	<ul style="list-style-type: none"> <li>Monitoring and maintenance of infrastructure and design and performance reviews in accordance with new information and CHRMAP updates.</li> <li>Secondary components may include the need for additional levees and drainage improvements as sea level rise progresses</li> </ul>	<ul style="list-style-type: none"> <li>Southern Ports, Bunbury</li> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring</li> <li>Updated CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>Annual maintenance estimate of approximately \$20,000</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>				x	x



Table 8-6 MU7 The Cut Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
INVESTIGATION 1 Detailed investigations to confirm assumptions used in the CHRMAP	<ul style="list-style-type: none"> <li>Determine program of investigative works</li> <li>Undertake detailed investigations to confirm assumptions used in the CHRMAP; and determine if rock groynes are most appropriate option</li> </ul>	LGA	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$200,000</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> </ul>	x	x			
INVESTIGATION 2 Sand Source Feasibility Study	<ul style="list-style-type: none"> <li>Determine the capacity and cost of local sand supplies, including both land-based and marine sources</li> <li>Likely require repetition over Medium-term</li> <li>Focus for this MU is sand nourishment for ocean and estuary frontage, but should also consider the need for appropriate fill to raise height of land in the inundation hazard zone</li> </ul>	To be confirmed between: <ul style="list-style-type: none"> <li>LGA's</li> <li>DoT</li> <li>DBCA</li> <li>Southern Ports, Bunbury</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$30,000</li> <li>Assumes only undertaken for this MU in isolation, but synergies should be investigated.</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x		x	
INVESTIGATION 3 Rock Source Feasibility Study	<ul style="list-style-type: none"> <li>Analyse the availability of rock in terms of density, quarry yields, location and costs</li> <li>Likely require repetition over Medium-term</li> <li>Focus for this MU is armour and core rock of all sizes</li> </ul>	To be confirmed between: <ul style="list-style-type: none"> <li>LGA's</li> <li>DoT</li> <li>DBCA</li> <li>Southern Ports, Bunbury</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$60,000</li> <li>Assumes only undertaken for this MU in isolation, but synergies should be investigated.</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x		x	
INVESTIGATION 4 Update Foreshore Management Plans (FMPs)	<ul style="list-style-type: none"> <li>Prepare an updated Foreshore Management Plan</li> <li>An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP</li> <li>For this MU a joint approach with Southern Ports Bunbury is recommended.</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> <li>Southern Ports, Bunbury</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$30,000</li> <li>Assumes only undertaken for this MU in isolation, but synergies should be investigated.</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>		x	x	x	x
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	<ul style="list-style-type: none"> <li>Item cost for investigations and management plans</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$50,000</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> </ul>	x	x			
Monitoring (NR1)	<ul style="list-style-type: none"> <li>Beach survey for storm behaviour and to track HSD and inundation levels</li> <li>Routine beach profiles every two years in Spring</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> <li>Can seek support and assistance from Southern Ports, Bunbury and DoT</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> <li>Severe storm event(s)</li> </ul>	<ul style="list-style-type: none"> <li>\$5,000</li> <li>(Plus 10% annual maintenance of \$5,000)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x	x		
Notification on title (NR3)	<ul style="list-style-type: none"> <li>Item cost for investigations and implementation plans</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> <li>Can seek support and assistance from DPLH, WALGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$50,000</li> <li>(Plus 1% annual maintenance of \$500)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>		x	x		



Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Protection Structure Audit (NR2)	<ul style="list-style-type: none"> <li>Item cost to inspect condition, influence on sediment transport and inundation and remaining design life on all coastal management structures</li> <li>Includes structures at The Cut</li> </ul>	To be confirmed between: <ul style="list-style-type: none"> <li>LGA's</li> <li>DoT</li> <li>DBCA</li> <li>Southern Ports, Bunbury</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$50,000</li> <li>(Plus 2% annual maintenance of \$1,500)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>		x	x		
Demolition / removal / relocation of asset from inside hazard area (PMR2)	<ul style="list-style-type: none"> <li>Preparation of Asset Management Plan</li> <li>To 2035 for public-built assets</li> <li>Maintenance assumes ongoing allowance for foreshore reserve</li> <li>Removal / Relocation of assets as required</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable</li> </ul>	<ul style="list-style-type: none"> <li>\$194,000</li> <li>(Plus 1% annual maintenance of \$1,940)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x	x		
Design assets to withstand impacts (AC1)	<ul style="list-style-type: none"> <li>Item cost for investigations and management plans – primarily any case-by-case work needed for public assets</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$50,000</li> <li>(Plus 1% annual maintenance of \$5,00)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> <li>Levies</li> </ul>	x	x	x		
<b>Recommended Short-Term Option to address Erosion is to investigate and prepare for Protection with Groynes (PR2)</b>	<ul style="list-style-type: none"> <li>CHRMAP analysis has found that the Protection Pathway is appropriate for this MU with provision of a sandy beach</li> <li>Currently the option assumes the following:               <ul style="list-style-type: none"> <li>2 rock groynes, 75m long on ocean-side beach,</li> <li>320m revetment seawall along estuary coast</li> <li>2050 Implementation</li> <li>Only monitoring and confirmation of concept design required in short-term</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> <li>Completed detailed investigations</li> <li>Monitoring</li> <li>Confirmation of design, costs and funding</li> <li>Construction likely to be staged</li> </ul>	<ul style="list-style-type: none"> <li>\$2.0M at NPV 4% for a 100-year timeframe</li> <li>Detailed design and costings estimated at \$200,000</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> <li>Levies</li> </ul>	x	x	x		
<b>Recommended Short-Term Option to address Inundation is Design assets to withstand impacts (AC1)</b>	<ul style="list-style-type: none"> <li>See AC1</li> </ul>	<ul style="list-style-type: none"> <li>See AC1</li> </ul>	<ul style="list-style-type: none"> <li>See AC1</li> </ul>	<ul style="list-style-type: none"> <li>See AC1</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> <li>Levies</li> </ul>	x	x	x		
Leaving assets unprotected (PMR1)	<ul style="list-style-type: none"> <li>To 2035 for low-value public assets</li> <li>Assumes a clean-up rate following damage/loss</li> <li>No private land acquisition included</li> <li>Maintenance assumes ongoing allowance for foreshore reserve</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Storm damage</li> <li>Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable</li> </ul>	<ul style="list-style-type: none"> <li>\$88,000</li> <li>(Plus 3% annual maintenance of \$2,640)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> </ul>	x	x	x		
<b>Recommended Medium and Long-term pathway to address Erosion is Protection with Groynes (PR2)</b>	<ul style="list-style-type: none"> <li>Monitoring will determine need for additional stages of groynes (or alternative protection method) in future and the eventual need for major refurbishment or replacement of the structures and associated beach renourishment</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring</li> <li>Updated CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>Annual maintenance estimate of approximately \$90,000</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> <li>Levies</li> </ul>				x	x
<b>Recommended Medium and Long-term pathway to address Inundation is Design assets to withstand impacts (AC1)</b>	<ul style="list-style-type: none"> <li>Monitoring</li> <li>Secondary components may include the need for additional levees and drainage improvements as sea level rise progresses</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring</li> <li>Updated CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>Included as part of Monitoring (NR1)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> <li>Levies</li> </ul>				x	x



Table 8-7 MU8 Bunbury East Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
INVESTIGATION 1 Detailed investigations to confirm assumptions used in the CHRMAP	<ul style="list-style-type: none"> <li>Determine program of investigative works</li> <li>Undertake detailed investigations to confirm assumptions used in the CHRMAP; and determine if rock groynes are most appropriate option</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$200,000</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> </ul>	x	x			
INVESTIGATION 2 Sand Source Feasibility Study	<ul style="list-style-type: none"> <li>Determine the capacity and cost of local sand supplies, including both land-based and marine sources</li> <li>Likely require repetition over Medium-term</li> <li>Focus for this MU is sand nourishment for estuary coast, but should also consider the need for appropriate fill to raise height of land in the inundation hazard zone</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> <li>Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$30,000</li> <li>Assumes only undertaken for this MU in isolation, but synergies should be investigated.</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x		x	
INVESTIGATION 3 Rock Source Feasibility Study	<ul style="list-style-type: none"> <li>Analyse the availability of rock in terms of density, quarry yields, location and costs</li> <li>Likely require repetition over Medium-term</li> <li>Focus for this MU is small to medium armour rock</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> <li>Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$30,000</li> <li>Assumes only undertaken for this MU in isolation, but synergies should be investigated.</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x		x	
INVESTIGATION 4 Update Foreshore Management Plans (FMPs)	<ul style="list-style-type: none"> <li>Prepare an updated Foreshore Management Plan</li> <li>An updated FMP could help increase the protective capacity of the natural dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$30,000</li> <li>Assumes only undertaken for this MU in isolation, but synergies should be investigated.</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>		x	x	x	x
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	<ul style="list-style-type: none"> <li>Item cost for investigations and management plans</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$100,000</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> </ul>	x	x			
Monitoring (NR1)	<ul style="list-style-type: none"> <li>Beach survey for storm behaviour and to track HSD and inundation levels</li> <li>Routine 6-monthly beach profiles following the summer and winter periods. Minimum every two years in Spring</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> <li>Can seek support and assistance from DoT</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> <li>Severe storm event(s)</li> </ul>	<ul style="list-style-type: none"> <li>\$10,000</li> <li>(Plus 10% annual maintenance of \$1,000)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x	x		
Notification on title (NR3)	<ul style="list-style-type: none"> <li>Item cost for investigations and implementation plans</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> <li>Can seek support and assistance from DPLH, WALGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$250,000</li> <li>(Plus 1% annual maintenance of \$2,500)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>		x	x		
Protection Structure Audit (NR2)	<ul style="list-style-type: none"> <li>Item cost to inspect condition, influence on sediment transport and inundation and remaining design life on all coastal management structures</li> <li>Includes walls along Collie R.</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$50,000</li> <li>(Plus 2% annual maintenance of \$1,000)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>		x	x		
Emergency evacuation plans (NR4)	<ul style="list-style-type: none"> <li>Item cost for investigations and evacuation plans</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$250,000</li> <li>(Plus 1% annual maintenance of \$2,500)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x			





Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Demolition / removal / relocation of asset from inside hazard area (PMR2)	<ul style="list-style-type: none"> <li>Preparation of Asset Management Plan</li> <li>To 2035 for public-built assets</li> <li>Maintenance assumes ongoing allowance for foreshore reserve</li> <li>Removal / Relocation of assets as required</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable</li> </ul>	<ul style="list-style-type: none"> <li>\$244,000</li> <li>(Plus 1% annual maintenance of \$2,440)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	<ul style="list-style-type: none"> <li>Item cost for investigations and management plans</li> <li>Investigate opportunities for leaseback of land and land swaps in the context of planned and managed retreat. Seek legal advice regarding the basis of agreements with landholders and whether opt-ins can be time constrained</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$100,000</li> <li>(Plus 1% annual maintenance of \$1,000)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>		x	x		
Design assets to withstand impacts (AC1)	<ul style="list-style-type: none"> <li>Item cost for investigations and management plans – primarily any case-by-case work needed for public assets</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>\$500,000</li> <li>(Plus 1% annual maintenance of \$5,000)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> </ul>	x	x			
<b>Recommended Short-Term Option to address Erosion is to investigate and prepare for Protection with Groynes (PR2)</b>	<ul style="list-style-type: none"> <li>CHRMAP analysis has found that the Protection Pathway is appropriate for this MU with provision of a sandy beach</li> <li>Currently the option assumes the following: <ul style="list-style-type: none"> <li>8 rock groynes, 30m long, 100m apart to cover estuary coast from Venezia Blvd north</li> <li>Assumes 6 groynes to cover section of river foreshore</li> <li>2035 Implementation</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> <li>Completed detailed investigations</li> <li>Monitoring</li> <li>Confirmation of design, costs and funding</li> <li>Construction likely to be staged</li> </ul>	<ul style="list-style-type: none"> <li>\$2.0M at NPV 4% for a 100-year timeframe</li> <li>Detailed design and costings estimated at \$250,000</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> <li>Specified Area Rate</li> <li>Levies</li> <li>User Pays</li> </ul>	x	x	x		
<b>Recommended Short-Term Option to address Inundation requires further investigation</b>	<ul style="list-style-type: none"> <li>Further investigation is required as the broader PR6 Option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate. A feasibility analysis is recommended to assess its effectiveness with consideration of freshwater flooding events and further civil and maritime design considerations as to what scale of facility would be required.</li> </ul>	<ul style="list-style-type: none"> <li>Jointly between State Government and LGA's</li> </ul>	<ul style="list-style-type: none"> <li>Completed CHRMAP</li> <li>Monitoring</li> <li>Investigation of Options, design, costs and funding</li> <li>Confirmation of SLR in accordance with projections to 2035</li> </ul>	<ul style="list-style-type: none"> <li>Further feasibility investigations estimated at \$200,000</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> <li>Specified Area Rate</li> <li>Levies</li> <li>User Pays</li> </ul>	x	x	x		
Leaving assets unprotected (PMR1)	<ul style="list-style-type: none"> <li>To 2035 for low-value public assets</li> <li>Assumes a clean-up rate following damage/loss</li> <li>No private land acquisition included</li> <li>Maintenance assumes ongoing allowance for foreshore reserve</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Storm damage</li> <li>Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable</li> </ul>	<ul style="list-style-type: none"> <li>\$111,000</li> <li>(Plus 3% annual maintenance of \$3,330)</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> </ul>	x	x	x		
<b>Recommended Medium and Long-term pathway to address Erosion is Protection with Groynes (PR2)</b>	<ul style="list-style-type: none"> <li>Monitoring will determine need for additional stages of groynes in future and the eventual need for major refurbishment or replacement of the structures and associated beach renourishment</li> </ul>	<ul style="list-style-type: none"> <li>LGA</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring</li> <li>Updated CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>Annual maintenance estimate of approximately \$50,000</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> <li>Specified Area Rate</li> <li>Levies</li> <li>User Pays</li> </ul>				x	x



Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
<b>Recommended Medium and Long-term pathway to address inundation requires further investigation</b>	<ul style="list-style-type: none"> <li>Further investigation is required as the broader PR6 Option comprising a new storm surge barrier at The Cut did not perform better than the base case for any discount rate. A feasibility analysis is recommended to assess its effectiveness with consideration of freshwater flooding events and further civil and maritime design considerations as to what scale of facility would be required.</li> </ul>	<ul style="list-style-type: none"> <li>Jointly between State Government and LGA's</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring</li> <li>Updated CHRMAP</li> </ul>	<ul style="list-style-type: none"> <li>To be determined following further investigations</li> </ul>	<ul style="list-style-type: none"> <li>Operational</li> <li>Grants</li> <li>Specified Area Rate</li> <li>Levies</li> <li>User Pays</li> </ul>				x	x



## 9 PUBLIC REVIEW AND COMMENT PERIOD

A draft version of this document was released for public review and comment for 12 weeks, up to the 16<sup>th</sup> of June 2023. Five comments were related to this document out of 58 public responses received. A summary of the written submissions received and associated responses are included as Appendix H, with contact details removed. Various edits have been made in this this document's Final version in response to the submissions received.

Several respondents were concerned that the recommendations were large scale and long term and would begin to be implemented quickly after the finalisation of this project. The CHRMAP is a strategic planning document that considers long timeframes. While the CHRMAP provides a rationale for coastal hazard management, a substantial amount of preparatory work, detailed in the CHRMAP recommendations, is required before "on-the-ground implementation" can proceed. The CHRMAP is a strategic planning document that considers long timeframes. The next phase of research and studies would consider priority items in more detail, including:

- Community and stakeholder engagement
- Data collection and analysis
- Preliminary and detailed design investigations
- Environmental investigations to mitigate potential impacts
- Economic and budgeting analysis to determine accurate costs, once detailed designs are available

The City held a public information drop-in session at the Bunbury Surf Life Saving Club during the review period, attended by City staff, Councillors, and more than 30 community members.

Concerns specific to the City, particularly at the Bunbury Back Beach area, were raised at the information session and in written submissions, primarily related to concern about the recommended use of groynes as the main protection option and the need for further detailed investigations. Other methods to implement protection, such as sand nourishment and different hard structures were proposed, which will continue to be considered as more detailed investigations, per the CHRMAP, provide greater levels of certainty.

The CHRMAP recommends protection for Bunbury Back Beach and Koombana Bay going forward. Groynes have been identified as the most cost-effective option to implement this pathway based on available information. High-level concept design work has been undertaken to allow budget estimates. Further consideration of the local coastal processes, design and costs is required before these recommendations can be progressed to seek funding, environmental impact assessment and approvals / endorsement. Composite protection options may be effective for Bunbury Back Beach, including sections of sand nourishment in combination with seawalls and offshore breakwaters instead of groynes. Further localised engagement is recommended through this process, including with the Bunbury Surf Life Saving Club. Surf Life Saving Clubs are recognised as a unique development requiring strategic planning within SPP2.6. Local monitoring of coastal processes, as recommended, combined with targeted engagement for this section of coast will allow for more detailed consideration of options.



# APPENDIX A ESTABLISH THE CONTEXT CHAPTER REPORT





# APPENDIX B COASTAL HAZARD ASSESSMENT CHAPTER REPORT







APPENDIX C  
COASTAL ASSETS AND COMMUNITY VALUES  
CHAPTER REPORT





# APPENDIX D VULNERABILITY ANALYSIS CHAPTER REPORT





# APPENDIX E RISK EVALUATION AND TREATMENT CHAPTER REPORT





# APPENDIX F RISK TREATMENT – BENEFIT DISTRIBUTION ANALYSIS CHAPTER REPORT





# APPENDIX G IMPLEMENTATION CHAPTER REPORT







# APPENDIX H PUBLIC REVIEW COMMENTS FOR THE CITY OF BUNBURY





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