

Capel to Leschenault CHRMAP

Final CHRMAP – Shire of Harvey

Peron Naturaliste Partnership

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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 Shire of Harvey. The Shire shoreline can be subdivided into two primary management units:

- MU9 - Leschenault Estuary
- MU11 - Collie River North, consisting of lands on the northern side of Collie River

Open ocean coast within Shire of Harvey is excluded from the scope of this CHRMAP as it has been considered previously in another project.

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. 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 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, with the exception of 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 Shire are presented.



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Appendix C	Coastal Assets and Community Values Chapter Report
Appendix D	Vulnerability Analysis Chapter Report
Appendix E	Risk Evaluation and Treatment Chapter Report
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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 Shire of Harvey (Shire).

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.

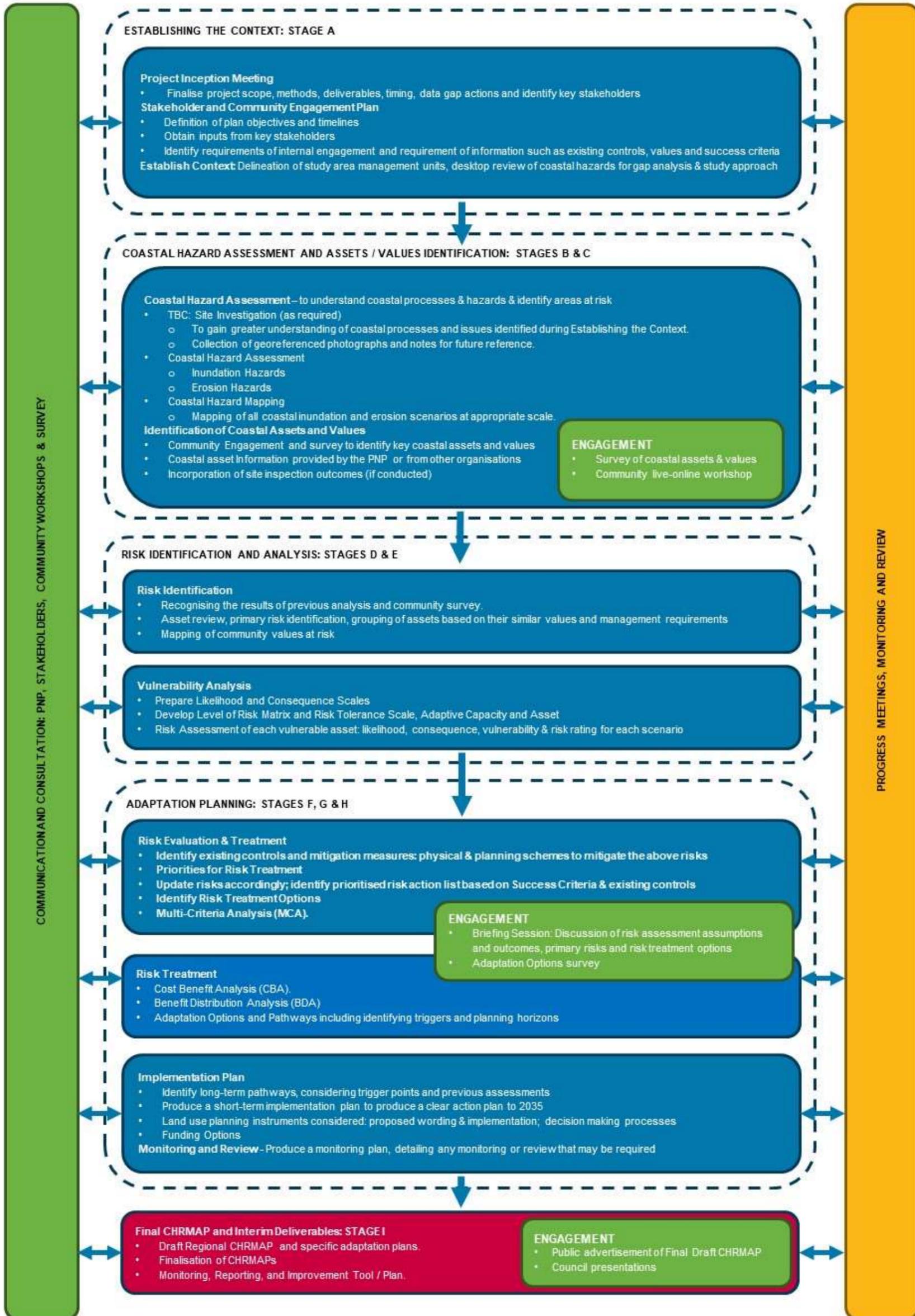


Figure 1-1 Methodology

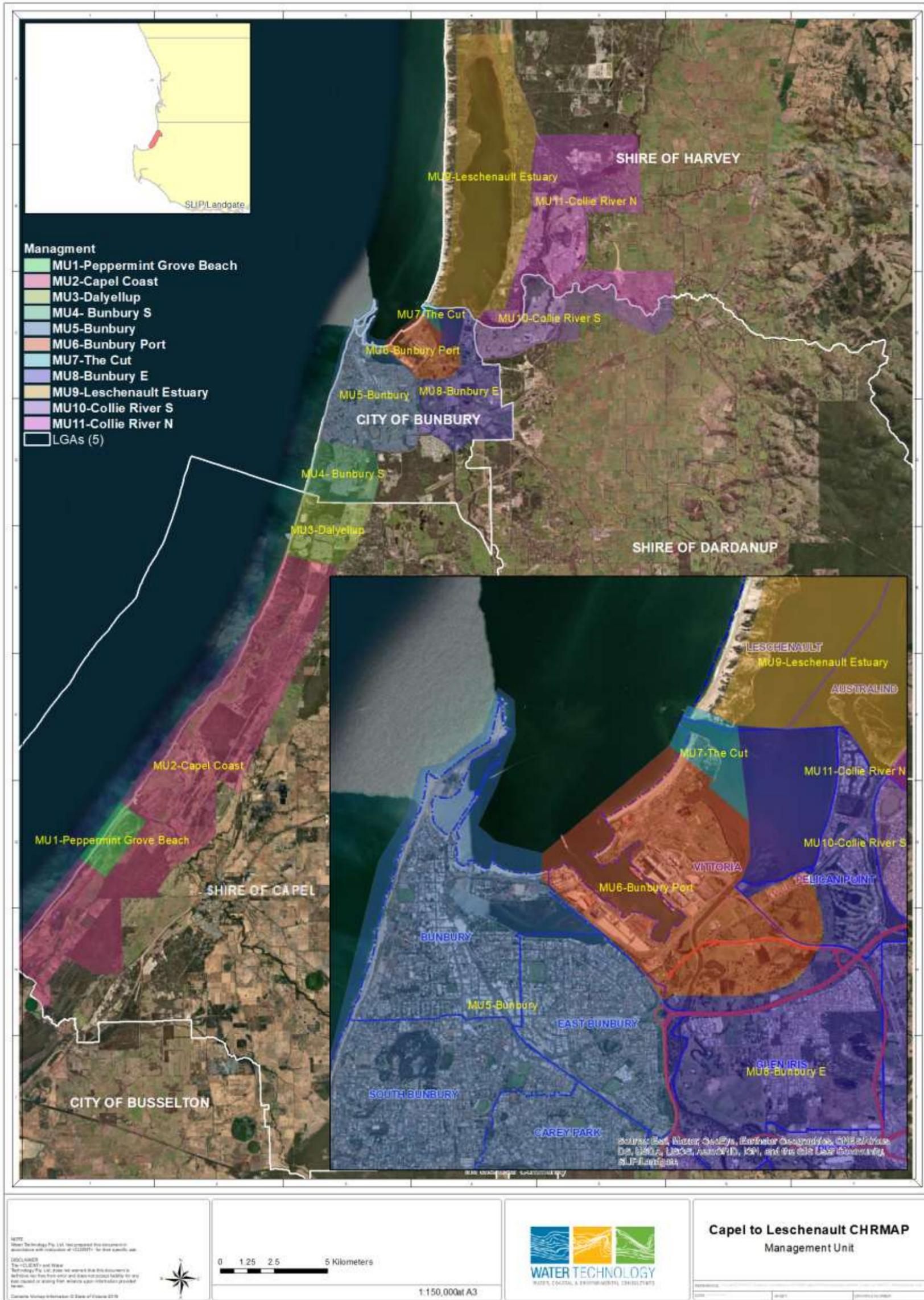


Figure 1-2 Study Area and Management Units



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 Shire 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 Shire shoreline can be subdivided into two primary management units:

- MU9 - Leschenault Estuary
- MU11 - Collie River North, consisting of lands on the northern side of Collie River

Open ocean coast within Shire of Harvey is excluded from the scope of this CHRMAP as it has been considered previously in another project.



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 needed to be considered in the CHRMAP, which are 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 hazards of coastal erosion and inundation 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 (<25years) 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

The Shire is located immediately north of Bunbury and extends to the Shire of Waroona. The Shire manages approximately 42 km of coastline covering about 1700 km² of land, but this study is restricted to the Leschenault Estuary and the tidally influenced flood plains of the Collie, Wellesley and Brunswick rivers. The open coastline west of the estuary was not considered as part of this project (coastal hazards along the open coast were previously investigated as part of the Shire of Harvey CHRMAP).

The Shire was first established as Brunswick Road District in 1894. In 1961, it became the Shire of Harvey under the Local Government Act 1960. The 2016 census indicates the Shire has an established population of about 26,000 and an annual growth rate of about 4%.

A map of the relevant project area for Harvey is shown in Figure 2-1. The Shire is bounded by the Collie River and the Cut to the south. The western shore of the estuary comprises coastal dunes of varying height. Surrounding the estuary and rivers are lowlands and flood plains. These locations are expected to be most impacted by coastal hazards. While inundation is considered to present the greatest risk here, shoreline stability and erosion risk will also be assessed.

Most residential lots are located at levels beyond the reach of historic floods on the eastern side of Cathedral Ave and Old Coast Rd. The area to the west of Old Coast Rd is primarily Conservation Park with scattered residential lots and foreshore development (e.g., Ridley Place, Leschenault Waterways Discovery Centre).

Damara (2016) undertook the Shire CHRMAP coastal hazard assessment and identified three types of hazards in this region including shoreline erosion, flood inundation, and landform mobility. Key points from the study were:

- Progressive erosion has occurred on the seaside of Leschenault Peninsula (area excluded from the current study). The erosion rate varied over time and was higher during the 1970s and from 2008 to 2015. The situation may be worsened by SLR, in particular during the erosive phases. Erosion on the seaside of Leschenault Peninsula may affect the overall landform stability of the Leschenault Estuary in the long term. The northern bank of the Cut was breached in 2012 due to erosion of the ocean shoreline extending behind the back of the training wall.
- Historic reports indicate storm tide inundation has been an infrequent hazard. The most extreme storm recorded at the site was TC Alby in April 1978, which generated a storm surge level of approximately 1.8 m AHD (or 1.2 m above HAT) at Bunbury tide gauge. The impact was reduced within Leschenault Estuary due to the restricted water exchange through the Cut. For more frequent winter storms, inundation levels are expected to be much lower. Riverine flooding is identified to be the more frequent hazard for low lying land in Leschenault Estuary and along the Collie River.

Within the estuary and immediate surrounds, the primary hazard is most likely associated with coastal inundation from storm surge and catchment flooding.

Land immediately adjacent to the Leschenault Estuary is primarily public foreshore reserve. Some public and private assets are located close to the estuary in Australind near Ridley Place. A concise CHRMAP was undertaken by Damara (2020) to evaluate potential coastal hazards and adaptation options for this area. Based on this assessment, the Shire prepared a foreshore management plan at Ridley Place, which proposed several new facilities including foreshore pathways, a playground, boardwalk, restaurant, kiosk, and toilets. Active vegetation management was identified as a “no regret” option for erosion control and protection of the foreshore area.

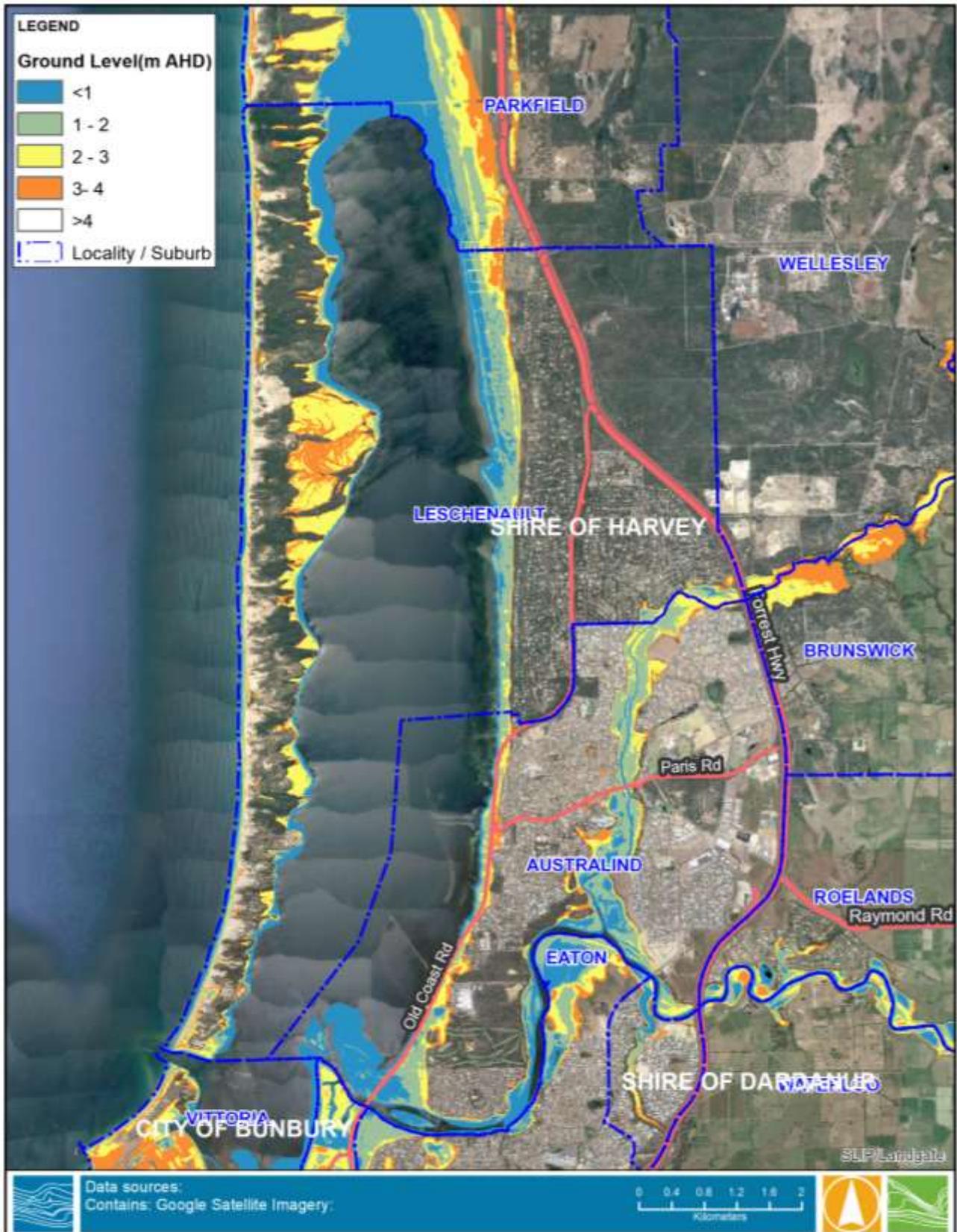


Figure 2-1 Shire of Harvey Project Area (Overlaid are Suburbs, Roads and ground levels)



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 2-2 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 2-3.

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); identified any potential planning issues that may constrain the CHRMAP process; and ensured that the adaptation plan aligns with state, regional and local planning frameworks.

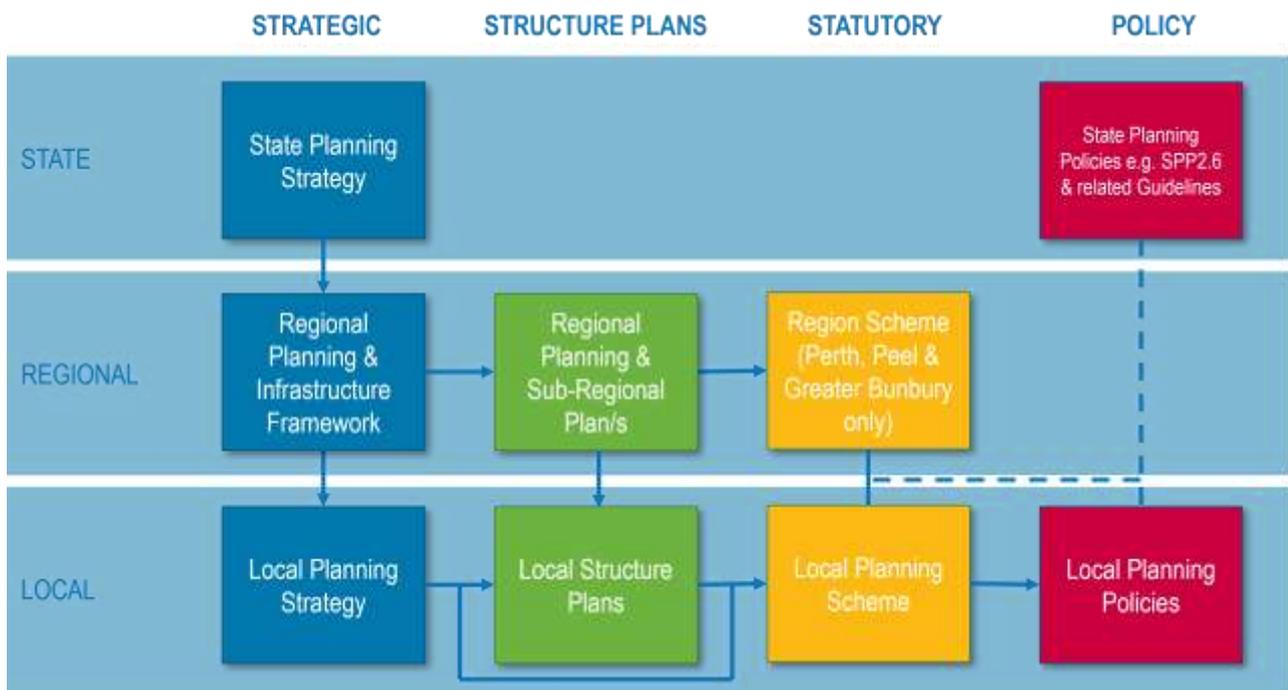


Figure 2-2 State Planning Framework for Western Australia

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

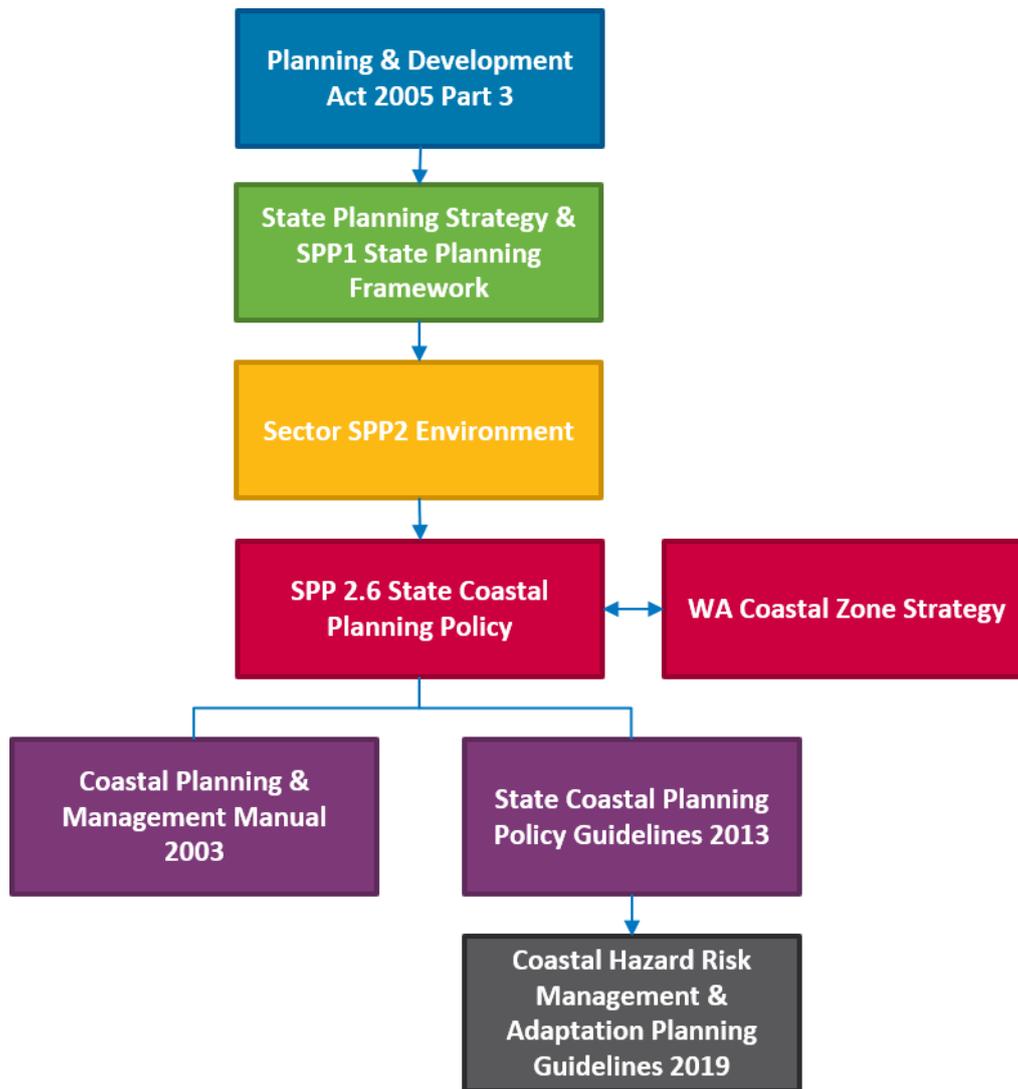


Figure 2-3 Policy Relationships

Regional and local planning documents were also reviewed for the 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 fit-for-purpose, and commensurate with the size and scope of the CHRMAP – so as 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 the identification of key issues and the selection of 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	<p>Establish 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.</p> <p>Provide tailored information for project communications (website content, media release, project information sheet, letter/email content, FAQs)</p> <p>Launch project – live project webpage, social media posts, launch of Coastal Assets and Values Survey to commence engagement phase of the project</p>
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	<p>Confirm the local community's values, and their perceptions of the key issues facing the study area. In this session, community members will have an opportunity to provide information regarding:</p> <ul style="list-style-type: none"> ▪ Community uses, and areas of high social, environment and cultural value; and/or ▪ 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.



CHRMAP Stage	Engagement Activity	Description
Stage F: Risk Treatment and Stage H: Implementation	Coastal Community Advisory Group	Two workshops with community members to calibrate the evaluation of options 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 the 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. Littoral drift processes could contribute this, 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 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
Estuary	<p>For shallow foreshore with/without riparian boundary, hazard lines defined by HSD+S1+S2+S3+uncertainty with fine-scale adjustment to define the HSD:</p> <ul style="list-style-type: none"> ▪ HSD defined by the location of riparian boundary / inundation line (HAT level, 0.6m AHD, as boundary of tidal inundation) / physical controls. ▪ Allowance for the current risk of storm erosion (S1). SBEACH model was used to evaluate the extent of erosion generated by the strongest possible waves in the Estuary. ▪ Allowance for historic shoreline movement trends (S2) estimated by review of historic vegetation lines/satellite images/historic reports. ▪ A fixed allowance of 50 m is assumed as a response to SLR (or S3) by 2120, as per SPP2.9 recommendations. <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. Tidal flats and dynamic river deltas are excluded from the current shoreline.</p>



Shoreline Type	Erosion Assessment
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"> ▪ a ‘foreshore reserve’ width of 30 m by 2120 for main waterways (Preston, Collie River, Capel River) ▪ 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.) <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 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
MU9 – Leschenault Estuary		<ul style="list-style-type: none"> ▪ Inundation along the eastern shoreline of the estuary is a risk from the present day. This affects foreshore reserve and residential / commercial assets. ▪ Significant portions of land may be affected by tidal inundation by 2120. Most of this is foreshore reserve, except for the Australind Tourist Park. ▪ The predicted extent of inundation is greater than the extent of erosion, especially along the eastern shoreline of the estuary.



Management Unit	Erosion & Inundation Hazard	Summary
<p>MU10 and MU11- Collie River Flood Plain</p>		<ul style="list-style-type: none"> ▪ Inundation is predicted to be mainly within the foreshore reserve. ▪ Erosion lines may impact some residential properties. <ul style="list-style-type: none"> – It is noted that a high-level study using policy setbacks provides no additional value to the planning and management of lands along the Collie River. Erosion lines along the mid- and upper Collie River streams were not mapped due to the dominant impact from inland processes (erosion primarily controlled by soil composition, river floods and vegetation growth). MU10 and MU11 should be managed in accordance with DWER foreshore management policies.



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 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 2nd 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 26th July 2021 to 10th 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 Project Steering Group (PSG), including administrative and elected members from PNP, the four LGAs, the Department of Planning, Lands and Heritage 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
- 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
MU9 – Leschenault Estuary	<ul style="list-style-type: none"> ▪ Inundation along the eastern shoreline of the estuary is a risk from the present day. This affects foreshore reserve and residential / commercial assets. ▪ Significant portions of land may be permanently inundated by 2120. The majority of this is foreshore reserve, except the Australind Tourist Park. 	<ul style="list-style-type: none"> ▪ Approximately 37 roads at risk of erosion by 2120; 25 by inundation ▪ By 2120, 359 environmental assets at risk from erosion; 314 by inundation ▪ 86 residential properties predicted to be impacted by erosion / permanent inundation by 2120 ▪ 170 residential properties predicted to be impacted by inundation by 2120 ▪ 43 agricultural / rural lots predicted to be impacted by inundation by 2120, 33 by erosion ▪ 2 Aboriginal Heritage assets at risk from both erosion and inundation from the present day ▪ Undeveloped foreshore at risk of erosion from the present day ▪ Public and community assets at risk of inundation from the present day; from erosion by 2050
MU11 - Collie River North	<ul style="list-style-type: none"> ▪ Inundation is mainly within the foreshore reserve (within CHRMAP study area bounds). ▪ Erosion lines may impact some residential properties; however, these properties are at the limit of these areas so highly sensitive to the somewhat subjective definition of the HSD. <ul style="list-style-type: none"> – It is noted that a high-level study using policy setbacks provides no additional value to the planning and management of lands along the Collie River. 	<ul style="list-style-type: none"> ▪ Approximately 13 roads at risk of erosion by 2120; 7 by inundation ▪ By 2120, 57 environmental assets at risk from erosion; 58 by inundation ▪ 49 residential properties predicted to be impacted by erosion by 2120 ▪ 35 residential properties predicted to be impacted by inundation by 2120 ▪ Undeveloped foreshore, public and community assets at risk of erosion and inundation from the present day



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 shown 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 Committee to ensure they reflect the community views.

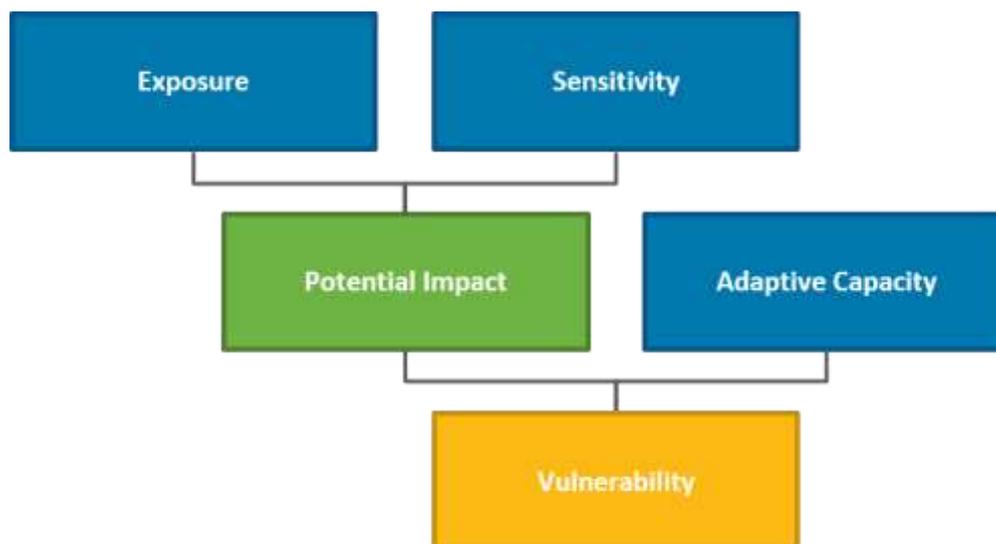


Figure 5-1 Vulnerability assessment components (reproduced from Allen Consulting, 2005)

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
Almost Certain	Expected to occur in most circumstances
Likely	Impact to asset shoreline for a given planning timeframe is likely
Possible	Impact to asset shoreline for a given planning timeframe is possible
Unlikely	Impact to asset shoreline for a given planning timeframe is unlikely
Rare	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 and 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
Insignificant	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
Minor	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
Moderate	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
Major	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
Catastrophic	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).

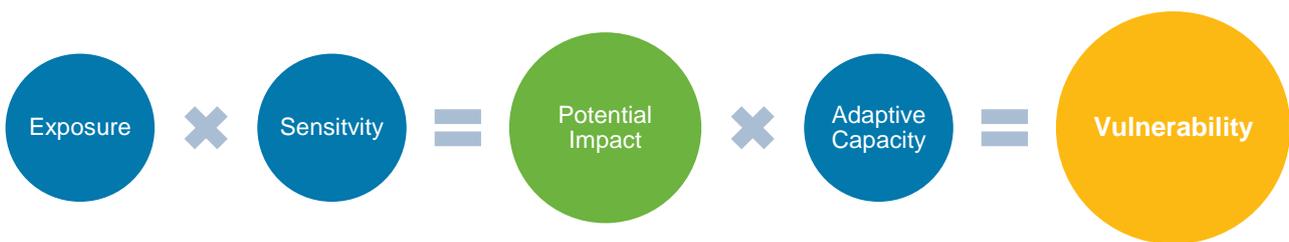


Figure 5-2 Vulnerability relationship

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
MU9-Leschenault Estuary					
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 (1Ex)	Extreme	Extreme	Extreme	
Commercial	High	High	Extreme	Extreme	
Public and Community	High	High	Extreme	Extreme	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	
Agricultural / Rural	Medium (1Hi)	High (1Ex)	Extreme	Extreme	
Aboriginal Heritage	Extreme	Extreme	Extreme	Extreme	
MU11-Collie River North					
Roads	High (4Ex)	Extreme	Extreme	Extreme	Erosion is a key risk for 5 of the 9 categories within this management unit. Adaptation in some form is required from the present day.
Residential	High (1Ex)	Extreme	Extreme	Extreme	
Public and Community	Extreme	Extreme	Extreme	Extreme	
Foreshore - Undeveloped	High	Extreme	Extreme	Extreme	
Environmental	Extreme	Extreme	Extreme	Extreme	

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

Management Unit	2020	2035	2050	2120	Summary
MU9-Leschenault Estuary					
Roads	Medium	Medium	Medium	Medium	<ul style="list-style-type: none"> 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. Inundation is an extreme risk for residential assets. Adaptation in some form is required from the present day. By 2050, inundation is an extreme risk for commercial assets. Adaptation in some form is required from the present day.
Residential	Extreme	Extreme	Extreme	Extreme	
Commercial	Medium	High (1Ex)	Extreme	Extreme	
Public and Community	High	High	High	High	
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	
Environmental	Medium	Medium	Medium	Medium	
Agricultural / Rural	Medium	Medium	Medium	Medium	
Aboriginal Heritage	High	High	High	High	
MU11-Collie River North					
Roads	Medium	Medium	Medium	Medium	<ul style="list-style-type: none"> Inundation is a medium / high risk for 4 of the 9 categories within this management unit. Adaptation in some form may be required from the present day. Inundation is an extreme risk for some residential assets. Adaptation in some form is required from the present day.
Residential	Medium (3Ex)	High (3Ex)	High (3Ex)	Extreme	
Public and Community	High	High	High	High	
Foreshore - Undeveloped	Medium	Medium	Medium	Medium	
Environmental	Medium	Medium	Medium	Medium	



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
MU9 – Leschenault Estuary	High	Extreme	Extreme	Extreme
MU11 – Collie River North	High	Extreme	Extreme	Extreme

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

Management Unit	2020	2035	2050	2120
MU9 – Leschenault Estuary	High	High	High	High
MU11 – Collie River North	Medium	Medium	Medium	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.

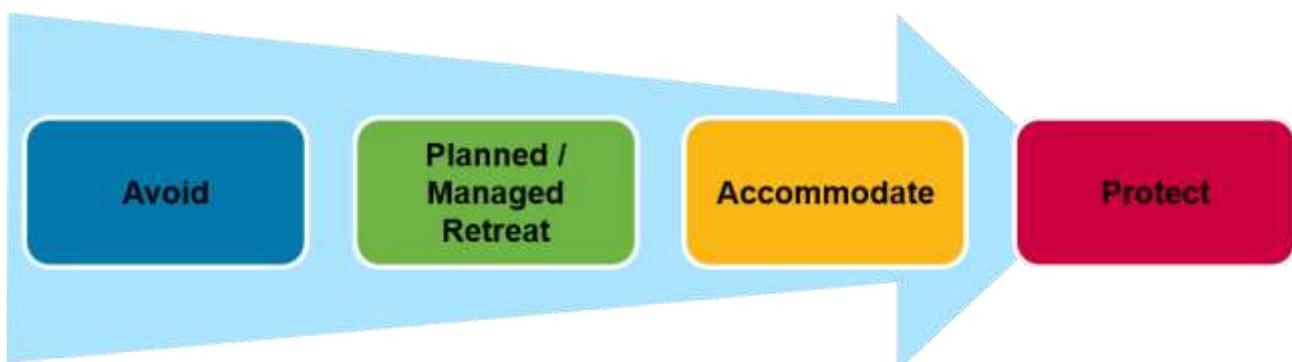


Figure 6-1 Coastal hazard risk management and adaptation planning hierarchy (adapted from WAPC, 2019)

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

An Initial assessment of options against the criteria was undertaken by Water Technology. 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 all of which are located outside the Shire of Harvey.

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In most cases it shall be 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	MU9	MU11
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	11	11
Leaving assets unprotected (PMR1)	2	2
Demolition / removal / relocation of asset from inside hazard area (PMR2)	7	7
Prevention of further development / prohibit expansion of existing use rights (PMR3)	6	6
Voluntary acquisition (PMR4)	5	5
Design assets to withstand impacts (AC1)	9	9
Beach nourishment or replenishment (PR1)	3	3
Groynes (PR2)	0	-1
Seawalls (PR3)	0	-1
Artificial reef (PR4)	-4	N/A
Offshore breakwater (PR5)	0	N/A
Levee / Weir / Storm Surge Barrier (PR6)	1	1
Monitoring (NR1)	7	7
Protection Structure Audit (NR2)	6	N/A
Notification on title (NR3)	6	6
Emergency evacuation plans (NR4)	6	7
Do nothing (DN1)	-11	-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, costs associated with Special Control Area (SCA) title notifications, emergency planning, and development restrictions were not included in our analysis. 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. Possibly, 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 scenario of economic inaction is also therefore different to the “Do-Nothing” adaptation option which would assume that no actions or management are undertaken by anyone over the planning timeframe, and that hazards and resultant asset loss/damage occurs 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 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 much stronger argument for the selection of 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
MU9 – Leschenault Estuary	PR2 - Groynes	PR1 – Beach Nourishment	<ul style="list-style-type: none"> ▪ PR2 is best value for the 2% discount rate (2%), and very close to PR1 for the 4% discount rate. ▪ Uncertainties around PR1 could pose some risk. ▪ PR5 is a more-expensive option but could be designed with amenity as a focus in this sheltered environment. Could be a tertiary option to consider following further consultation
MU11-Collie River North	PR1 – Beach Nourishment	Not applicable	<ul style="list-style-type: none"> ▪ PR1 is best value for all discount rates by a significant amount.

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

Management Unit	Recommended Option (s)	Notes
MU8, 9, 10, 11 Bunbury East, Leschenault Estuary, Collie River North and South	Not applicable	<ul style="list-style-type: none"> ▪ 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.



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 (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 Minninup Drain outlet near Tatton Place in Stratham.
- MU 3 (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 (City of Bunbury) - PR2 - Groynes to protect Bunbury Back Beach 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. As this work does not relate to the Shire it is not discussed further in this document.



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 a 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).

A Special Control Area is suitable across the CHRMAP area. There may be some merit in consolidating the existing CSA 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.

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 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 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.

8.1.1.3 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

Land can be reserved for '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 Shire has previously contemplated coastal planning and foreshore management principles in its Local Planning Strategy, its District Planning Scheme No. 1 and its Shire of Harvey Coastal CHRMAP which deals with the open coastline area of the Shire (excluded from this study). In addition, a number of conditions limit development close to waterbodies for visual landscape amenity and to respond to known flooding issues recognised in the Greater Bunbury Region Scheme.

There remains a need to establish a response to coastal hazards within the Shire's town planning legislative framework, which is clear and reflects the outcomes of this CHRMAP and also comprises the recommendations of the Shire of Harvey Coastal CHRMAP.

Structure Planning may be effective in the coastal zone where some property development or redevelopment may be considered adjacent the Leschenault Estuary foreshore (Cathedral Avenue) and adjacent the Collie River (MU9 and MU11).

Recommended land use planning instruments are detailed in Table 8-1.

Table 8-1 Land use planning recommendations for the Shire of Harvey

Action	Description	Timing	Cost
LU1	<p>The Shire shall prepare an amendment to the District Planning Scheme No. 1 to include provisions relating to the coastal erosion and inundation hazard zones to 2120 as identified in this study and in the Shire of Harvey Coastal CHRMAP.</p> <p>The amendment shall insert a new Clause at <i>Part VIII – General Development Requirements, Clause 8.14</i> and shall read: <i>8.14 Coastal Hazard Risk Area Special Control Area</i> <i>a) Coastal Hazard Risk Area (Special Control Area) shown on the Scheme Map as SCA with a [insert colour here] border and a number and included in Appendix 16 – Special Control Areas.</i></p> <p>The amendment shall include insertion of Appendix 16 – Special Control Areas and the information provided in Table 8-2.</p>	Immediate	\$15,000
LU2	<p>The Shire shall prepare an amendment to the District Planning Scheme No. 1 to include a Foreshore Reserve encompassing all public land within the coastal erosion and inundation hazard zones to 2120 as identified in this study, which is not included in the Regional Open Space Regional Reserve within the Greater Bunbury Region Scheme.</p> <p>No amendment to the existing planning scheme text is required as the document does not reference these specifically. However, a new legend and mapping will be required for the relevant scheme maps.</p>	Aligned with LU1	\$5,000
LU3	<p>The Shire should prepare a Local Planning Policy (LPP) to be linked to the SCA under District Planning Scheme No. 1 and provide guidance for applicants and decision-makers in relation to assessment procedures and development standards on land prone to coastal hazards, which 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</p>	Aligned with LU1	\$15,000



Action	Description	Timing	Cost
	specify appropriate design responses for individual development proposals e.g., relocatable dwellings, prescribed setbacks and revegetation responses.		
LU4	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.	At application	N/A
LU5	The Shire shall notify all landholders that may be affected by coastal hazards by 2120 directly. 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 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 City 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 Shire 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.	Immediate	N/A
LU6	The Shire 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 LU7 below establishes the zone of interest.	Immediate	N/A
LU7	The Shire should undertake a review of its Local Planning Scheme generally, to provide for the updated Model Provisions from the Planning and Development (Local Planning Schemes) Regulations 2015. During this review, the Foreshore Reserve noted in LU2 can be introduced in the model format, and should include the following objectives: <ul style="list-style-type: none"> ▪ set aside areas for foreshore reserved abutting a body of water or water course ▪ provide for the protection of natural values and processes, including a coastal retreat to accommodate a range of active and passive recreational uses that would be capable of relocation or rehabilitation In this review, a detailed consolidation of Clauses and provisions modelled on the current planning framework can be inserted.	In line with suitable timeframes as required by the WAPC and orderly and proper planning	TBC (a broader review is required based on the age of the existing scheme)



Action	Description	Timing	Cost
LU8	Notwithstanding LU7, if the preparation of scheme amendments noted in LU1 and LU2 precede the scheme review recommended in LU7, the amendment should also comprise a review of other clauses within the existing scheme, to ensure there is no overlay between a number of clauses which would cause confusion or create onerous red tape. This includes consideration of Clause 7.2, 7.3, 8.8, Schedule 3 (3.7 Area 6). Schedule 4 (4.4), Schedule 6 (6.3) and Schedule 15 (Area 1 and Area 6). Consolidation is recommended where it can be achieved	Aligned with LU1	\$5,000

Table 8-2 Content for Shire of Harvey local planning scheme amendment appendix in accordance with LU1.

Item	Recommended Text
Name of Area	SCA 1 – Coastal Hazard Risk 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"> ▪ To ensure land in the coastal zone is continuously provided for coastal foreshore management, public access, recreation and conservation. ▪ To ensure public safety and reduce risk associated with coastal erosion and inundation. ▪ To avoid inappropriate land use and development of land at risk from coastal erosion and inundation. ▪ 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. ▪ 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.
Additional Provisions	<ol style="list-style-type: none"> 1. All proposed development within the SCA requires approval 2. In considering proposed structure plans, subdivision or development applications due regard shall be given to – <ol style="list-style-type: none"> a) the Capel to Leschenault Coastal Hazard Risk Management and Adaptation Plan 2023. b) State Planning Policy 2.6 -State Coastal Planning Policy; and b) Relevant local planning policies. 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. The notification is to read as follows for land within the coastal hazard area at 2050: <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 and is subject to conditions of development approval which require removal and/or rehabilitation of development to pre-development conditions if any one of the following events occurs:</i> <ol style="list-style-type: none"> a) <i>the most landward part of the Horizontal Shoreline Datum being within [x insert here] metres of the most seaward part of the lot boundary.</i> b) <i>a public road no longer being available or able to provide legal access to the property.</i>



Item	Recommended Text
	<p>c) <i>when water, sewerage or electricity to the lot is no longer available as they have been removed/decommissioned by the relevant authority due to coastal hazards.</i>"</p> <p>The notification is to read as follows for land within the coastal hazard area from 2051 - 2120: <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> <p>a) temporary or non-permanent structures not used for human habitation. b) extensions to an existing single, grouped or multiple dwelling where the net floor area of the proposed extensions is no more than 50m²; and c) a change of use where no new structures are proposed.</p>
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"> ▪ Coastal hazards may impact the development subject of this approval 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. ▪ 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). ▪ 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). ▪ Should the development be affected by Coastal Hazards in the future the applicant will be responsible for relocating/removing the development and all associated costs. 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. ▪ 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.

NB: It is noted that the Shire of Harvey Coastal CHRMAP includes a recommendation to increase the regional open space reservation in the Greater Bunbury Region Scheme. This may not be necessary if the Foreshore reservation is included in the scheme amendment or the scheme review for areas outside the Regional Reservation. The Foreshore Reserve will ensure visibility of the foreshore management role of the reserve and not imply a 'recreational' component. Both actions should be considered together.



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 LGAs 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 LGAs 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. The Department of Planning, Lands and Heritage administers Coastwest grants.

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. The Department of Planning, Lands and Heritage administers CMPAP grants.

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 the 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, environmental impact investigation, 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:

1. 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.
2. 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.



3. 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.
4. 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.
5. 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.
6. 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
7. 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. The southern half of the eastern shore of Leschenault Estuary should aim to have beach profiles at the end of winter every two to three years while the rest of MU9 and all of MU11 could be undertaken every three to five years. More frequent profiles (up to every six months following summer and winter seasons) could be undertaken for areas of concern following collection and review of less frequent datasets.
 - 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. 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.
 - e. 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 the southern half of the eastern shore of Leschenault Estuary in MU9.

8.5.2 Trigger Points

The CHRMAP consider 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 Shire 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 to update the coastal hazard assessment when the triggers are reached.

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 (several possible Options): Undertake works as necessary to prevent erosion to 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 (Design Assets to Withstand Impacts – AC1): limit damage from inundation events through finished floor level requirements
- Protect (Levee / Barrier – PR6): Undertake works as necessary to prevent or limit inundation of assets exposed along the coast

8.7 Recommendations

8.7.1 Short-Term Recommendations

Primary short-term recommendations are summarised for each MU in Table 8-3 below. All recommendations, including supporting components and additional investigations are described in more detail in Table 8-4 and Table 8-5 below.



Table 8-3 Shire of Harvey short-term recommendations. Note costs are budget estimates that have not had NPV applied here.

Location	Erosion Recommendations	Inundation Recommendations
MU9 – Leschenault Estuary	<p>Protection with Groynes (PR2)</p> <ul style="list-style-type: none"> Assumes 63 rock groynes, 30m long, approximately 100m apart or as required to treat 25% of shoreline in MU Locations to be determined Present day Implementation Estimates present-day capital spend of \$10.4M with ~2% annual maintenance cost 	<p>Requires further investigation</p> <ul style="list-style-type: none"> 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 It is recommended a feasibility analysis is undertaken 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
MU11 – Collie River North	<p>Protection with Beach Renourishment (PR1)</p> <ul style="list-style-type: none"> Nourishment along bank of river for 2,400m Assumes suitable sand source available (grain size, volume, cleanliness, proximity) 2035 implementation Estimates 2035 capital spend of \$0.6M with ~10% annual maintenance cost 	<p>Requires further investigation</p> <ul style="list-style-type: none"> 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 It is recommended a feasibility analysis is undertaken 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

8.7.2 Medium and Long-Term Recommendations

Medium- and long-term recommendations are summarised in Table 8-4 and Table 8-5 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 8-4 MU9 Leschenault Estuary Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Recommended Short-Term Option to address Erosion is Protection with Groynes (PR2)	<ul style="list-style-type: none"> Assumes 63 rock groynes, 30m long, approximately 100m apart or as required to treat 25% of shoreline in MU Locations to be determined Assumes present day implementation 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Completed CHRMAP Monitoring Confirmation of design, costs and funding Construction likely to be staged 	<ul style="list-style-type: none"> \$15.5M at NPV 4% for a 100-year timeframe Detailed design and costings estimated at \$250,000 	<ul style="list-style-type: none"> Operational Grants Specified Area Rate Levies User Pays 	x	x	x		
Recommended Short-Term Option to address Inundation requires further investigation	<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> Jointly between State Government and LGA's 	<ul style="list-style-type: none"> Completed CHRMAP Monitoring Investigation of Options, design, costs and funding Confirmation of SLR in accordance with projections to 2035 	<ul style="list-style-type: none"> Further feasibility investigations estimated at \$200,000 	<ul style="list-style-type: none"> Operational Grants Specified Area Rate Levies User Pays 	x	x	x		
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	<ul style="list-style-type: none"> Item cost for investigations and management plans 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Completed CHRMAP 	<ul style="list-style-type: none"> \$150,000 	<ul style="list-style-type: none"> Operational 	x	x			
Leaving assets unprotected (PMR1)	<ul style="list-style-type: none"> To 2035 for low-value public assets Assumes a clean-up rate following damage/loss No private land acquisition included Maintenance assumes ongoing allowance for foreshore reserve 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Storm damage Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable 	<ul style="list-style-type: none"> \$351,000 (Plus 3% annual maintenance of \$10,530) 	<ul style="list-style-type: none"> Operational 	x	x	x		
Demolition / removal / relocation of asset from inside hazard area (PMR2)	<ul style="list-style-type: none"> Preparation of Asset Management Plan To 2035 for public-built assets Maintenance assumes ongoing allowance for foreshore reserve Removal / Relocation of assets as required Allows for removal of building – Leschenault Discovery Centre 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable 	<ul style="list-style-type: none"> \$853,000 (Plus 1% annual maintenance of \$8,530) 	<ul style="list-style-type: none"> Operational Grants 	x	x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	<ul style="list-style-type: none"> Item cost for investigations and management plans 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 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Completed CHRMAP 	<ul style="list-style-type: none"> \$150,000 (Plus 1% annual maintenance of \$1,500) 	<ul style="list-style-type: none"> Operational Grants 	x	x			
Design assets to withstand impacts (AC1)	<ul style="list-style-type: none"> Item cost for investigations and management plans – primarily any case-by-case work needed for public assets 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Completed CHRMAP 	<ul style="list-style-type: none"> \$500,000 (Plus 1% annual maintenance of \$5,000) 	<ul style="list-style-type: none"> Operational Grants 	x	x			



Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Monitoring (NR1)	<ul style="list-style-type: none"> Beach survey for storm behaviour and to track HSD and inundation levels Routine beach profiles every two to three years in Spring 	<ul style="list-style-type: none"> LGA Can seek support and assistance from DoT 	<ul style="list-style-type: none"> Completed CHRMAP Severe storm event(s) 	<ul style="list-style-type: none"> \$25,000 (Plus 10% annual maintenance of \$2,500) 	<ul style="list-style-type: none"> Operational Grants 	x	x	x		
Protection Structure Audit (NR2)	<ul style="list-style-type: none"> Item cost to inspect condition, influence on sediment transport and inundation and remaining design life on all coastal management structures Includes walls along Collie R. 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Completed CHRMAP 	<ul style="list-style-type: none"> \$50,000 (Plus 2% annual maintenance of \$1,000) 	<ul style="list-style-type: none"> Operational Grants 		x	x		
Notification on title (NR3)	<ul style="list-style-type: none"> Item cost for investigations and implementation plans 	<ul style="list-style-type: none"> LGA Can seek support and assistance from DPLH, WALGA 	<ul style="list-style-type: none"> Completed CHRMAP 	<ul style="list-style-type: none"> \$250,000 (Plus 1% annual maintenance of \$2,500) 	<ul style="list-style-type: none"> Operational Grants 	x	x			
Emergency evacuation plans (NR4)	<ul style="list-style-type: none"> Item cost for investigations and evacuation plans 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Completed CHRMAP 	<ul style="list-style-type: none"> \$250,000 (Plus 1% annual maintenance of \$2,500) 	<ul style="list-style-type: none"> Operational Grants 	x	x			
INVESTIGATION 1 Sand Source Feasibility Study	<ul style="list-style-type: none"> Determine the capacity and cost of local sand supplies, including both land-based and marine sources Likely require repetition over Medium-term 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 	<ul style="list-style-type: none"> LGA Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments 	<ul style="list-style-type: none"> Completed CHRMAP 	<ul style="list-style-type: none"> \$30,000 Assumes only undertaken for this MU in isolation, but synergies should be investigated. 	<ul style="list-style-type: none"> Operational Grants 	x	x		x	
INVESTIGATION 2 Rock Source Feasibility Study	<ul style="list-style-type: none"> Analyse the availability of rock in terms of density, quarry yields, location and costs Likely require repetition over Medium-term Focus for this MU is small to medium armour rock 	<ul style="list-style-type: none"> LGA Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments 	<ul style="list-style-type: none"> Completed CHRMAP 	<ul style="list-style-type: none"> \$30,000 Assumes only undertaken for this MU in isolation, but synergies should be investigated. 	<ul style="list-style-type: none"> Operational Grants 	x	x		x	
INVESTIGATION 3 Update Foreshore Management Plans (FMPs)	<ul style="list-style-type: none"> Prepare an updated Foreshore Management Plan 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 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Completed CHRMAP 	<ul style="list-style-type: none"> \$30,000 Assumes only undertaken for this MU in isolation, but synergies should be investigated. 	<ul style="list-style-type: none"> Operational Grants 	x	x	x	x	x
Recommended Medium and Long-term pathway to address Erosion is Protection with Groynes (PR2)	<ul style="list-style-type: none"> Monitoring will determine the need for additional stages of groynes in future and the eventual need for major refurbishment or replacement of the structures and associated beach renourishment 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Monitoring Updated CHRMAP 	<ul style="list-style-type: none"> \$15.5M at NPV 4% for a 100-year timeframe Annual maintenance estimate of approximately \$0.2M 	<ul style="list-style-type: none"> Operational Grants Specified Area Rate Levies User Pays 				x	x



Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Recommended Medium and Long-term pathway to address inundation requires further investigation	<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> Jointly between State Government and LGA's 	<ul style="list-style-type: none"> Monitoring Updated CHRMAP 	<ul style="list-style-type: none"> To be determined following further investigations 	<ul style="list-style-type: none"> Operational Grants Specified Area Rate Levies User Pays 				x	x



Table 8-5 MU11 Collie River North Recommendations

Recommendation	Notes	Responsibility	Trigger	Cost	Funding	2023-2025	2025-2030	2030-2035	2035-2050	2050-2120
Recommended Short-Term Option to address Erosion is Protection with Beach Renourishment (PR1)	<ul style="list-style-type: none"> Nourishment along bank of river for 2,400m Assumes suitable sand source available (grain size, volume, cleanliness, proximity) 2035 implementation 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Completed CHRMAP Monitoring Confirmation of design, costs and funding Construction likely to be staged 	<ul style="list-style-type: none"> \$1.0M at NPV 4% for a 100-year timeframe Annual cost estimate of approximately \$50,000 	<ul style="list-style-type: none"> Operational Grants Specified Area Rate Levies User Pays 	x	x	x		
Recommended Short-Term Option to address Inundation requires further investigation	<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> Jointly between State Government and LGA's 	<ul style="list-style-type: none"> Completed CHRMAP Monitoring Investigation of Options, design, costs and funding Confirmation of SLR in accordance with projections to 2035 	<ul style="list-style-type: none"> Further feasibility investigations estimated at \$200,000 	<ul style="list-style-type: none"> Operational Grants Specified Area Rate Levies User Pays 	x	x	x		
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	<ul style="list-style-type: none"> Item cost for investigations and management plans 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Completed CHRMAP 	<ul style="list-style-type: none"> \$150,000 	<ul style="list-style-type: none"> Operational 	x	x			
Leaving assets unprotected (PMR1)	<ul style="list-style-type: none"> To 2035 for low-value public assets Assumes a clean-up rate following damage/loss No private land acquisition included Maintenance assumes ongoing allowance for foreshore reserve 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Storm damage Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable 	<ul style="list-style-type: none"> \$44,000 (Plus 3% annual maintenance of \$1,320) 	<ul style="list-style-type: none"> Operational 	x	x	x		
Demolition / removal / relocation of asset from inside hazard area (PMR2)	<ul style="list-style-type: none"> Preparation of Asset Management Plan To 2035 for public-built assets Maintenance assumes ongoing allowance for foreshore reserve Removal / Relocation of assets as required 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Audit of assets within 2035 erosion and inundation hazard zone and identification of assets where damage would be unacceptable 	<ul style="list-style-type: none"> \$97,000 (Plus 1% annual maintenance of \$970) 	<ul style="list-style-type: none"> Operational Grants 	x	x	x		
Prevention of further development / prohibit expansion of existing use rights (PMR3)	<ul style="list-style-type: none"> Item cost for investigations and management plans 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 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Completed CHRMAP 	<ul style="list-style-type: none"> \$100,000 (Plus 1% annual maintenance of \$1,000) 	<ul style="list-style-type: none"> Operational Grants 	x	x			
Design assets to withstand impacts (AC1)	<ul style="list-style-type: none"> Item cost for investigations and management plans – primarily any case-by-case work needed for public assets 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Completed CHRMAP 	<ul style="list-style-type: none"> \$150,000 (Plus 1% annual maintenance of \$1,500) 	<ul style="list-style-type: none"> Operational Grants 	x	x			
Monitoring (NR1)	<ul style="list-style-type: none"> Beach survey for storm behaviour and to track HSD and inundation levels Routine beach profiles every three to five years in Spring 	<ul style="list-style-type: none"> LGA Can seek support and assistance from DoT 	<ul style="list-style-type: none"> Completed CHRMAP Severe storm event(s) 	<ul style="list-style-type: none"> \$10,000 (Plus 10% annual maintenance of \$1,000) 	<ul style="list-style-type: none"> Operational Grants 	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"> Item cost for investigations and implementation plans 	<ul style="list-style-type: none"> LGA Can seek support and assistance from DPLH, WALGA 	<ul style="list-style-type: none"> Completed CHRMAP 	<ul style="list-style-type: none"> \$100,000 (Plus 1% annual maintenance of \$1,000) 	<ul style="list-style-type: none"> Operational Grants 	x	x			
Emergency evacuation plans (NR4)	<ul style="list-style-type: none"> Item cost for investigations and evacuation plans 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Completed CHRMAP 	<ul style="list-style-type: none"> \$100,000 (Plus 1% annual maintenance of \$1,000) 	<ul style="list-style-type: none"> Operational Grants 	x	x			
INVESTIGATION 1 Sand Source Feasibility Study	<ul style="list-style-type: none"> Determine the capacity and cost of local sand supplies, including both land-based and marine sources Likely require repetition over Medium-term Focus for this MU is sand nourishment for river shoreline, but should also consider the need for appropriate fill to raise height of land in the inundation hazard zone 	<ul style="list-style-type: none"> LGA Can seek support from neighbouring LGA's, PNP, Southern Ports and state departments 	<ul style="list-style-type: none"> Completed CHRMAP 	<ul style="list-style-type: none"> \$30,000 Assumes only undertaken for this MU in isolation, but synergies should be investigated. 	<ul style="list-style-type: none"> Operational Grants 	x	x		x	
INVESTIGATION 2 Update Foreshore Management Plans (FMPs)	<ul style="list-style-type: none"> Prepare an updated Foreshore Management Plan 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 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Completed CHRMAP 	<ul style="list-style-type: none"> \$30,000 Assumes only undertaken for this MU in isolation, but synergies should be investigated. 	<ul style="list-style-type: none"> Operational Grants 	x	x	x	x	x
Recommended Medium and Long-term pathway to address Erosion is Protection with Beach Renourishment (PR1)	<ul style="list-style-type: none"> Monitoring will determine frequency and ongoing volume requirements beach renourishment 	<ul style="list-style-type: none"> LGA 	<ul style="list-style-type: none"> Monitoring Updated CHRMAP 	<ul style="list-style-type: none"> \$1.0M at NPV 4% for a 100-year timeframe Annual cost estimate of approximately \$50,000 	<ul style="list-style-type: none"> Operational Grants Specified Area Rate Levies User Pays 				x	x
Recommended Medium and Long-term pathway to address inundation requires further investigation	<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> Jointly between State Government and LGA's 	<ul style="list-style-type: none"> Monitoring Updated CHRMAP 	<ul style="list-style-type: none"> To be determined following further investigations 	<ul style="list-style-type: none"> Operational Grants Specified Area Rate Levies User Pays 				x	x



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





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