WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Town of Cottesloe CHRMAP

Summary Report

Town of Cottesloe

11 August 2025

Document Status

Version	Doc type	Reviewed by	Approved by	Date issued
V01	Draft for Steering Committee Review	Astrid Stuer	Nick Dugan	26/7/2024
V02	Draft for Public Comment	Nick Dugan	Nick Dugan	21/2/2025
V03	Final	Nick Dugan	Nick Dugan	11/8/2025

Project Details

Project Name	Summary Report
Client	Town of Cottesloe
Client Project Manager	Shaun Kay
Water Technology Project Manager	Nick Dugan
Water Technology Project Director	Chris Beadle
Authors	Karl Ilich
Document Number	22040013 TOC CHRMAP R07 V03

Level 1, 21 Adelaide Street
Fremantle WA 6160
Telephone (08) 6555 0105
ACN 093 377 283
ABN 60 093 377 283

ACKNOWLEDGEMENT OF COUNTRY

The Board and employees of Water Technology acknowledge and respect the Aboriginal and Torres Strait Islander Peoples as the Traditional Custodians of Country throughout Australia. We specifically acknowledge the Traditional Custodians of the land on which our offices reside and where we undertake our work.

We respect the knowledge, skills and lived experiences of Aboriginal and Torres Strait Islander Peoples, who we continue to learn from and collaborate with. We also extend our respect to all First Nations Peoples, their cultures and to their Elders, past and present.

Artwork by Maurice Goolagong 2023. This piece was commissioned by Water Technology and visualises the important connections we have to water, and the cultural significance of journeys taken by traditional custodians of our land to meeting places, where communities connect with each other around waterways.

The symbolism in the artwork includes:

- *Seven circles representing each of the States and Territories in Australia where we do our work*
- *Blue dots between each circle representing the waterways that connect us*
- *The animals that rely on healthy waterways for their home*
- *Black and white dots representing all the different communities that we visit in our work*
- *Hands that are for the people we help on our journey*

EXECUTIVE SUMMARY

The Western Australian Planning Commission's "State Planning Policy No. 2.6: State Coastal Planning Policy" (WAPC, 2013, herein referred to as "SPP2.6") addresses climate change, sea level rise, increased coastal inundation and coastal erosion. SPP2.6 recommends that management authorities develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for land use or development vulnerable to coastal hazards. Specific CHRMAP Guidelines have been developed to assist this process (WAPC, 2019). Cottesloe has been identified as potentially exposed to erosion hazard. Therefore, this CHRMAP study aimed to investigate and plan for coastal hazards likely to affect Cottesloe.

This CHRMAP increases knowledge and understanding of coastal hazard risks and identifies risk management and adaptation measures for implementation. The outcomes will be used to inform local government policies, strategies and plans, including (but not limited to), planning strategies, community strategic plans, drainage strategies, asset management plans, and foreshore management plans. The project adhered to the WAPC (2019) guidelines with scope and deliverables consistent with their objectives and SPP2.6. In addition, the project has identified the strategic direction for coastal adaptation scenarios for the next 100 years (management time frame) and determined an implementation plan describing risk management measures to be undertaken to achieve this direction. Overall, this CHRMAP has developed flexible adaptation pathways for the region and will serve as a key reference for management, planning and policymaking for the short-term (0-25 years), medium-term (25-50 years), and long-term (100 years).

The study area shoreline was divided into two management units:

- MU1 - North of Cottesloe Groyne (including Cottesloe Groyne) to the North end of the Town's Jurisdiction
- MU2 - South of Cottesloe Groyne to the South end of the Town's Jurisdiction

A Coastal Hazard Assessment 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, 2033, 2048, 2073 and 2123. 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. Results derived from this study should not be over-interpreted at a micro-scale due to the assumptions applied and the limitations in resolution.

Importantly for this CHRMAP, storm erosion allowance distances have been determined based on numerical modelling of the study area and which are generally lower than the default WAPC recommended 40 m allowance.

Following the Hazard Assessment, a Coastal Assets and Community Values 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 seven categories: Public and Community, Environmental, Residential, Developed Foreshore Reserve, Commercial, Roads, and Heritage. The quantity of each asset category by Management Unit, category and planning horizon are presented for each erosion hazard. Inundation has been shown to not impact on any assets in the study area.

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. Engagement outcomes have informed the adaptation planning process. A Community Values assessment was used to identify key values and concerns for the study area and generate success criteria for the project:

- Preserve and protect the Town's beaches and natural assets such as vegetation and dunes,
- Ensure the natural environment is protected and sustained in its current condition or an improved condition,
- Preserve the function and opportunity for all types of water-based activities,
- Preserve and accommodate the existing surf lifesaving clubs,

- Continue to provide public amenities at the coast, such as parks, restrooms parking and access paths,
- Ensure that areas for community events and access to remain within the coastline,
- Minimise impacts on existing private property,
- Consider treatments for coastal areas that have current inundation and erosion issues,
- Develop solutions to coastal processes that are sustainable (financially, socially and built form),
- Revisit regularly with community and key stakeholders their values in relation to foreshore development.

A Vulnerability Analysis was undertaken to develop likelihood, consequence, level of risk, adaptive capacity and vulnerability ratings for the asset categories. All identified at-risk assets within the management units are presented for each of the planning horizons, for each hazard. Extreme vulnerability to erosion has been identified from the present day onwards in both MU1 and MU2 if no active intervention occurs – a do nothing scenario. This base-case scenario of assuming complete inaction (do nothing) over the project timeframe is not an acceptable option as it does not address the Town's obligation under other legislation such as the general duty of care to the community. The Town must take reasonable steps to manage risks on the land it manages.

Recommended adaptation options to manage the coastal erosion vulnerability are presented to give direction for future investigations and funding opportunities. The recommendations are preliminary as they are based on currently available information. The proposed options should be the subject of further investigations, surveys, policy review, impact investigations (environmental, visual and social), development approval and authorities' endorsement, local stakeholder and community engagement, preliminary design, detailed design, costing and any other applicable preparation work required prior to be implemented. The options should be optimised and modified following such additional investigations.

To address erosion along the Cottesloe coastline, a **combination of Planned / Managed Retreat and Protection with Beach Renourishment** has been shown to be the preferred approach as a result of this analysis.

A number of additional general investigations are recommended:

- Preparation of Asset Management Plans.
- Investigate opportunities for leaseback of land, land swaps and demarcating Special Control Areas in the context of planned and managed retreat.
- **Sand source feasibility study.**
- More detailed investigation of coastal hazards and options feasibility at priority locations such as the North Cottesloe Surf Life Saving Club and the section of coast immediately north of Cottesloe Groyne.
- Foreshore Management Plans (FMPs).

The CHRMAP is a strategic planning document that considers long timeframes. While the CHRMAP provides a rationale for coastal hazard management a substantial amount of preparatory work, detailed in the CHRMAP recommendations, is required before "on-the-ground implementation" can proceed.

CONTENTS

APPENDICES

Appendix A Establish the Context Chapter Report
Appendix B Risk Identification Chapter Report
Appendix C Vulnerability Analysis Chapter Report
Appendix D Risk Evaluation and Risk Treatment Options Chapter Report
Appendix E Assessment of Risk Treatment Options Chapter Report
Appendix F Implementation and Monitoring Chapter Report

LIST OF FIGURES

LIST OF TABLES

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 management authorities develop a **Coastal Hazard Risk Management and Adaptation Plan (CHRMAP)** for land use or development that is 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 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 risk management and adaptation hierarchy outlined in SPP2.6.

The study area for this CHRMAP is the entire shoreline within the Town's jurisdiction (see Figure 1-1). The study has been undertaken across two Management Units (MUs) being Management Unit 1 (North of Cottesloe Groyne, including the groyne) and Management Unit 2 (South of Cottesloe Groyne). The study area is shown in Figure 1-1, Figure 1-2, and Figure 1-3. The study area consists of various shoreline types and many coastal assets, involving multiple stakeholders:

- Physical controls – rubble mound rock groynes at Beach Street and Cottesloe Beach; seawalls at Cottesloe Beach.
- Sandy pocket and "perched" beaches backed and underlain by rock shelves and adjacent narrow foreshore reserve.
- Presence of various rock features including shore-attached reef and rock outcrops and cliffs.
- Roads along the shoreline – Curtin Avenue and Marine Parade.
- Two Surf Life Saving Clubs.
- Registered Aboriginal Heritage Site at Mudurup Rocks, south of the Cottesloe Surf Life Saving Club.
- Significant built infrastructure – buildings, car parks, shore-parallel dual use path, utilities, playgrounds.
- Large number of foreshore amenities such as showers, fencing, information signage, access paths and stairways.
- Highly valued recreational assets – beach and ocean areas used heavily by locals and visitors for many different pursuits.
- Commercial and residential property owners/ operators.

The objective of this CHRMAP stage is to increase knowledge and understanding of coastal hazard risks, and to 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 has adhered to the WAPC (2019) guidelines with scope and deliverables consistent with their objectives and SPP2.6 and follows the risk management and adaptation hierarchy of 'Avoid', 'Retreat', 'Accommodate' and 'Protect'. In addition, the project determines the strategic direction for coastal adaptation

scenarios from the present-day to 2123 (100-year management time frame) and identifies an implementation plan to achieve this direction. Overall, this CHRMAP has developed a flexible adaptation pathway for the region and serves as a key reference for management, planning and policymaking for the short-term (0-25 years), medium-term (25-50 years), and long-term (100 years).

Delivery of this project has occurred over 8 stages (as summarised in Figure 1-4), each of which represents a key hold point. The staged approached is developed according to the Town of Cottesloe scope and is in line with the CHRMAP Guidelines (WAPC, 2019). This report presents the CHRMAP project summary and makes recommendations to address erosion and inundation vulnerabilities. The red bubble displayed in Figure 1-4 indicates where this component sits with reference to the greater study.

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 chapter 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 Town 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
- Shoreline orientation
- Natural and manmade shoreline features, such as extended shoreline hardening (e.g. seawalls), and
- Points established by geological features and/or localised sediment transport regimes
- Coastal processes and potential hazard types.

The study area shoreline was divided into two management units:

- MU1 - North of Cottesloe Groyne (including Cottesloe Groyne) to the North end of the Town’s Jurisdiction
- MU2 - South of Cottesloe Groyne to the South end of the Town’s Jurisdiction

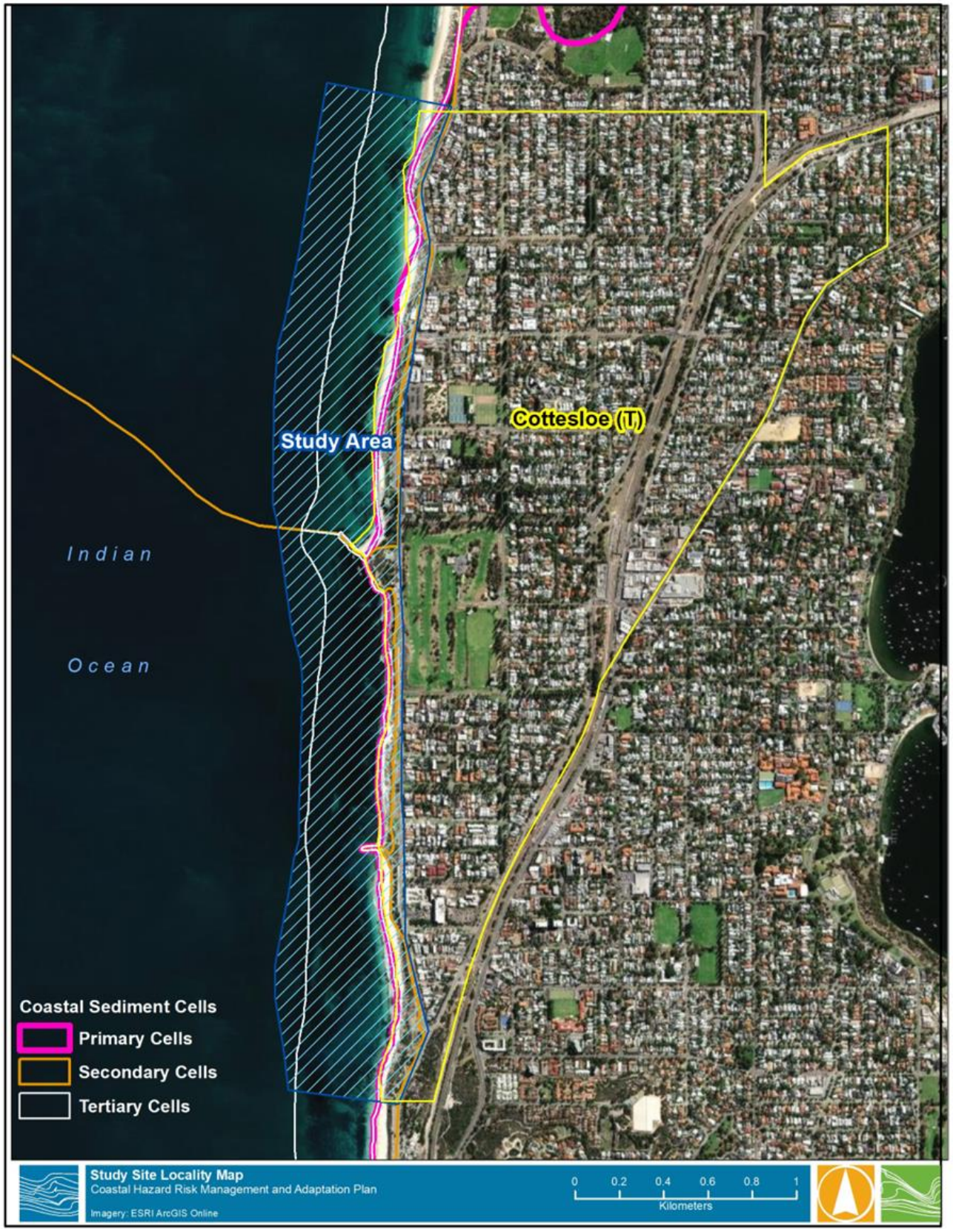

Figure 1-1 Study Area

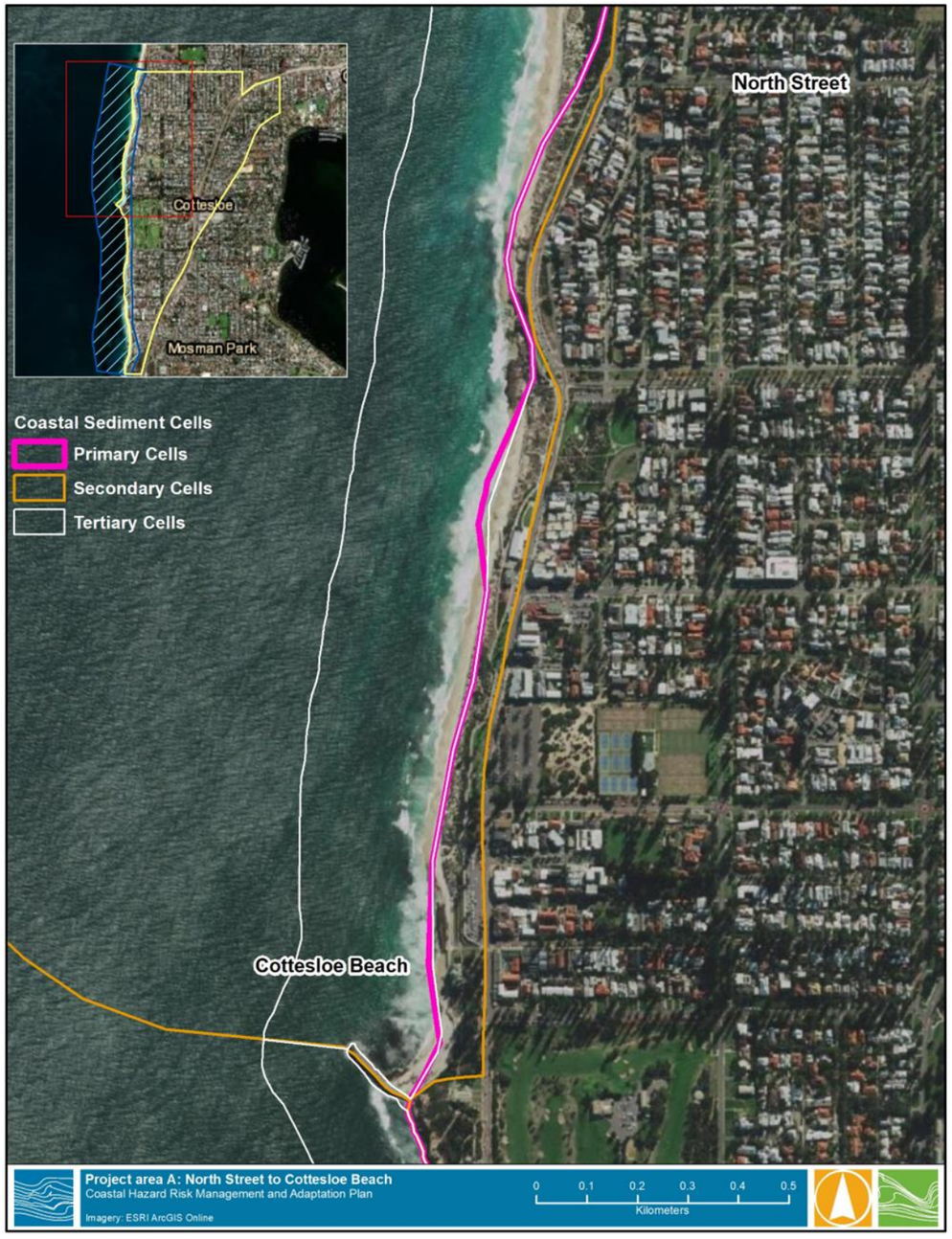

Figure 1-2 MU 1 North of Cottesloe Groyne, including Groyne, to the North End of Town's Jurisdiction

Figure 1-3 MU 2 South of Cottesloe Groyne to the South End of Town's Jurisdiction

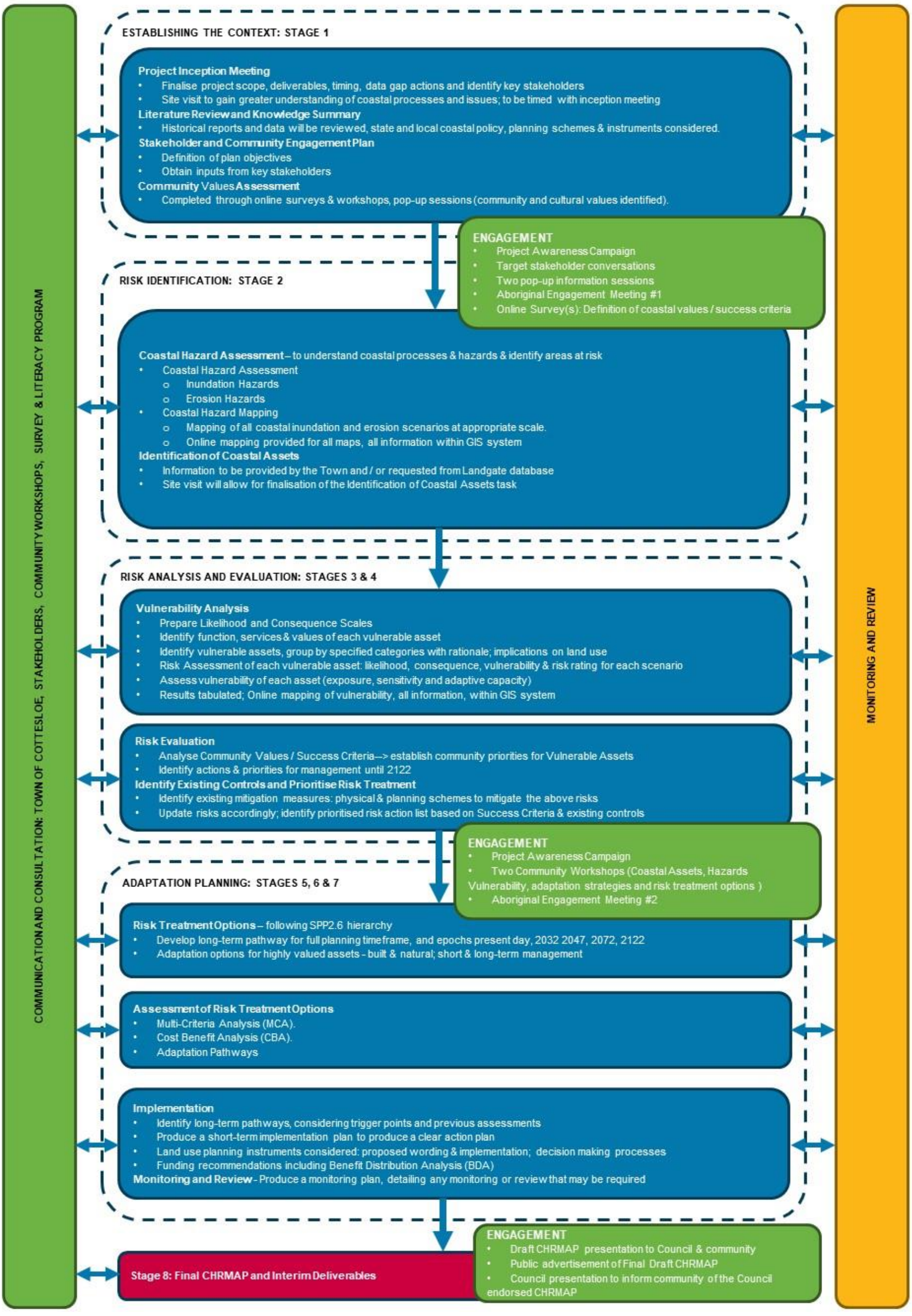

Figure 1-4 Methodology

2 ESTABLISH THE CONTEXT

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

2.1 Purpose

The purpose of this project was to prepare a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for the Town of Cottesloe.

The CHRMAP sets the framework for the assessment, by identifying coastal hazards, analysing vulnerability for specific assets, identifying and prioritising management and adaptation responses, and providing an implementation plan. It informs the community and stakeholders about potential coastal hazard risks; identifies community and stakeholders' values as well as key coastal infrastructure and assets at risk; and provides a clear pathway for Town of Cottesloe to address coastal hazard risks over time. Ultimately, the CHRMAP provides strategic guidance for coordinated, integrated and sustainable land use planning and management decision-making by the Town of Cottesloe. The CHRMAP also guides necessary changes to the Town of Cottesloe Local Planning Strategy, Local Planning Scheme and other relevant strategies and local planning policies.

2.2 Objectives

The overall objectives of this CHRMAP were to:

- Improve understanding of coastal features, processes and hazards in the study area.
- Identify significant vulnerability trigger points and respective timeframes for the relevant sediment cells to mark the need for immediate or medium-term risk management measures.
- Identify assets (natural and built) and the services and functions they provide situated in the coastal zone.
- Gain an understanding of asset(s)' vulnerability.
- Identify the value of the assets that are vulnerable to adverse impacts from coastal hazards.
- Determine the consequence and likelihood of coastal hazards on the assets, and assign a level of risk.
- Identify possible (effective) risk management measures (or 'actions') and how these can be incorporated into short and longer-term decision-making.
- Engage stakeholders and the community in the planning and decision-making process.

2.3 Scope

The CHRMAP identifies assets and values at high risk from coastal erosion and flooding in the study area. It proposes risk management measures to reduce these risks to acceptable levels, focusing on short-term actions but also providing strategic guidance for medium and long-term measures. The CHRMAP has focussed on preserving assets and values which provide public benefit, although private at-risk assets are also identified. This is achieved by following the process as outlined in Figure 2-1.

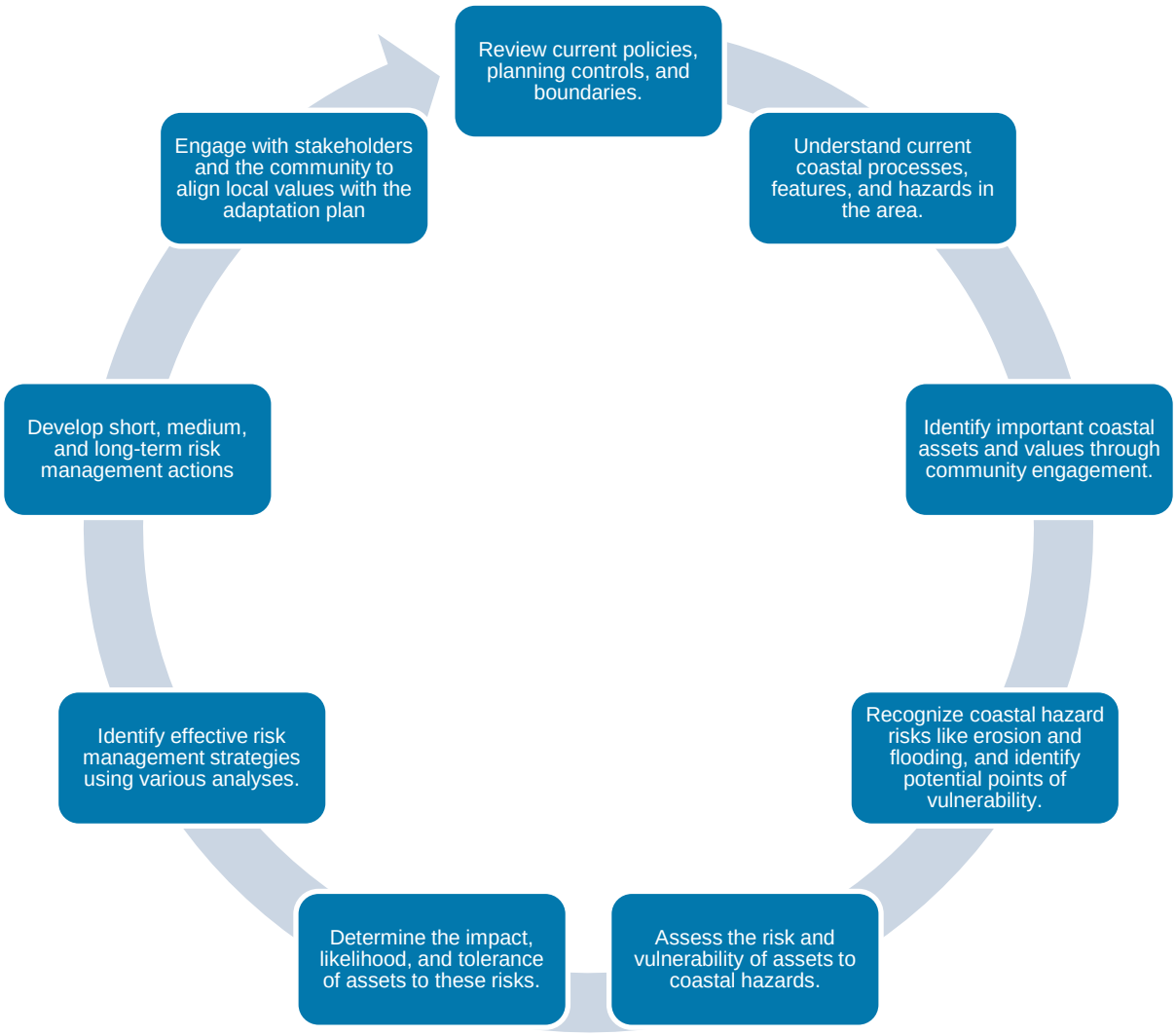

Figure 2-1 CHRMAP process

2.4 Local Context

The Town of Cottesloe's coastline spans approximately 4km from North Street to Vlamingh Memorial in the south and includes the iconic Cottesloe Beach and popular swim spot, Grant Street Beach. The Town's coastline is visited by residents and visitors alike, with beaches in the north popular for swimming and sunbathing, while the southern portion of the coastline is frequented by board riders and dogwalkers. The adjacent foreshore reserves support a variety of recreational and commercial land uses, including substantial built infrastructure situated in close proximity to the shoreline. Such infrastructure includes the Cottesloe and North Cottesloe Life Saving Clubs, Indiana Teahouse, restaurants and cafes, playgrounds, footpaths and several carparks, which may be subject to the impacts of coastal hazards at present or into the future.

The study area has a mixed sandy and rocky coastline, consisting of sections of 'sandy', 'rocky' (generally 'hard rock') and 'mixed sandy and rocky' coast per the definitions in SPP2.6, as well as 'hardened' shorelines being controlled by coastal structures. Much of the Town's coastline comprises rock platforms overlain by a sandy beach backed by remnant sand dunes. Nearshore reefs are present along much of the coastline and exposed rock is present, particularly during the winter months.

The wave climate in the Town is seasonal, with on average, higher wave energy during the winter months of May to October. The study area is afforded protection from offshore wave conditions by Rottnest Island to the

west and fringing limestone reef structures scattered adjacent to the coastline. Cottesloe groyne can provide local sheltering from inshore waves, depending on the wave-direction.

Longshore sediment transport within the study area has been shown to be mainly northward from September to April, associated with prevailing currents over the summer period. A southward movement of sediment is usually observed during the winter months of June and July. The result is a net northward movement of material annually (CZM & Damara 2008). Nearshore structures can obstruct this sediment movement. The most notable example of this is the Cottesloe groyne, which exhibits accretion of sediment at its northern side in winter and alternatively erosion at the same site during summer.

Cross-shore sediment movement is also seasonal, with sporadic periods of swell pushing sediment onto the shore, steepening the beach profile. Mid-year, the beach is reformed by the energy of winter storms eroding the beach face and redepositing sediment to form sandbars just offshore. These formations become stable towards the end of winter and act as a buffer, preventing wave breaking at the shore and the substantial shifting of sediment that can cause long-shore transportation and further erosion towards the spring and summer.

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

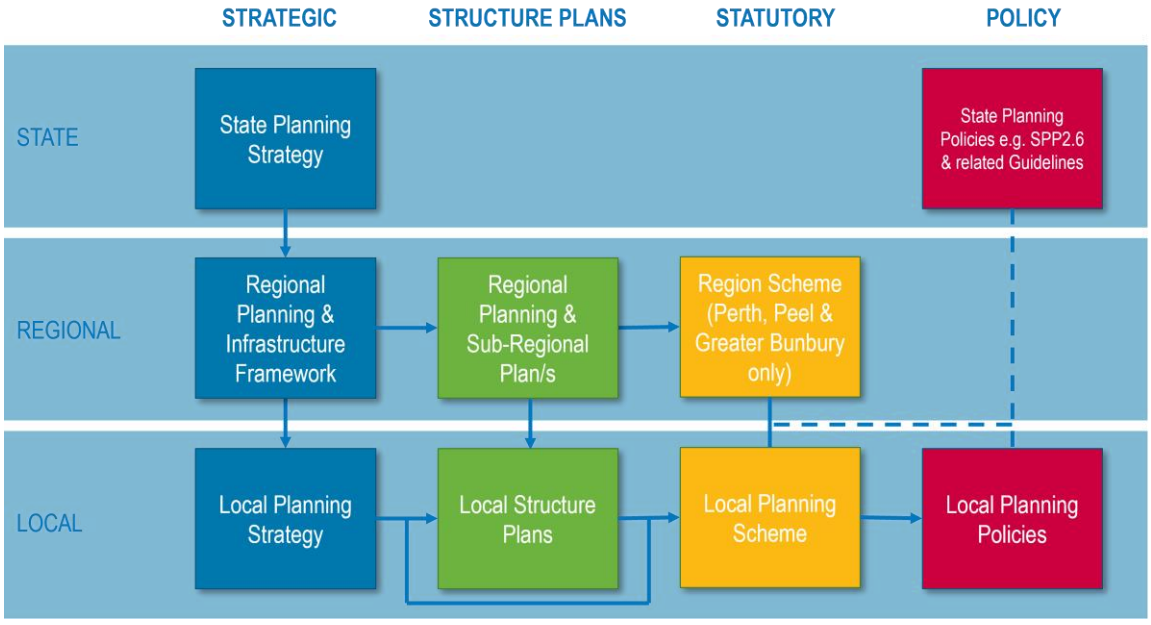

Figure 2-2 State Planning Framework for Western Australia

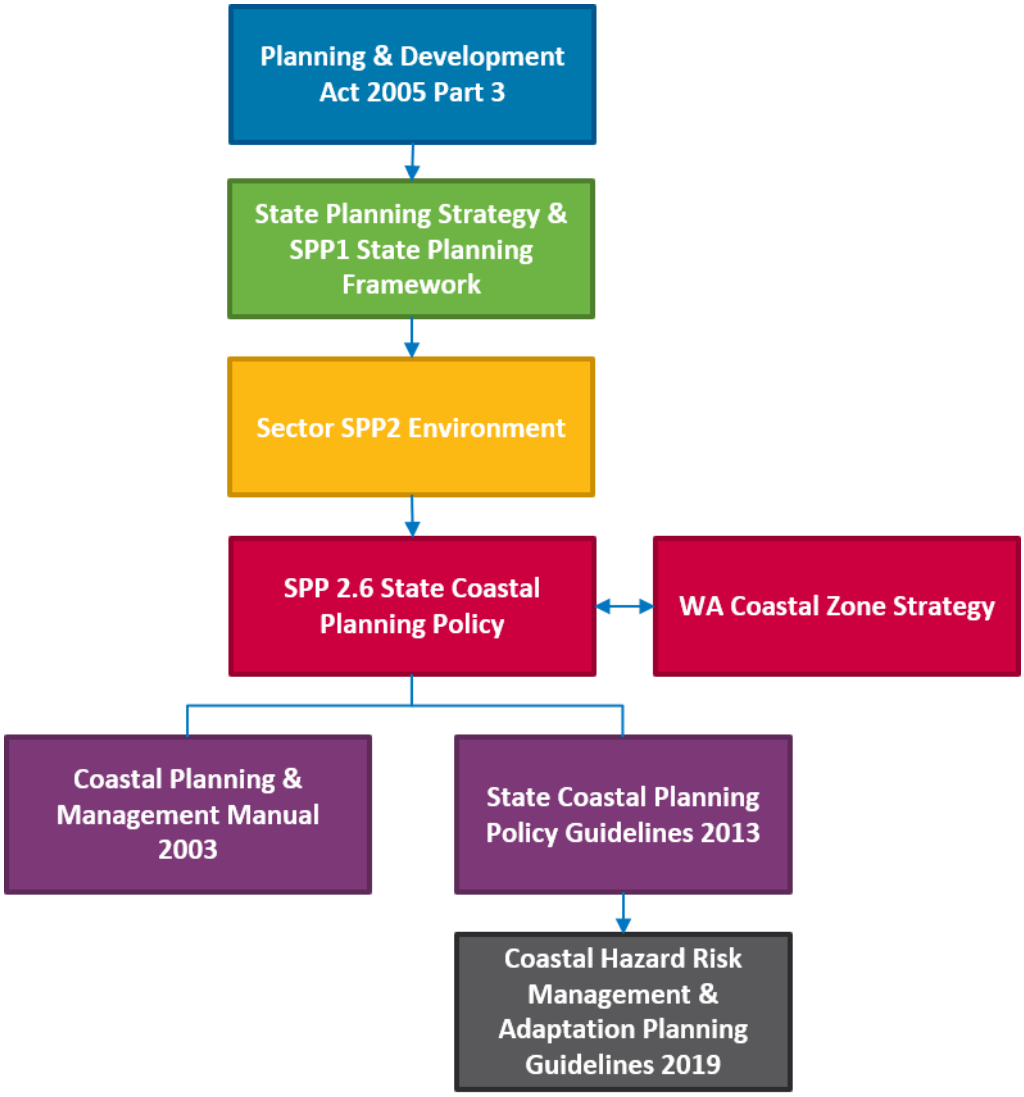

Figure 2-3 Policy Relationships

2.6 State Planning Policies and Strategies

The following state and local planning documents have been reviewed. Information relevant to the CHRMAP has been included below and are discussed further in the Establish the Context Report (Appendix A):

- State Planning Strategy 2050
- The WA Coastal Zone Strategy 2017
- State Planning Policy 2.6 – State Coastal Planning Policy, and associated Guidelines
- Coastal Hazard Risk Management and Adaptation Planning Guidelines 2019
- State Planning Policy 3.4: Natural Hazards and Disasters
- Metropolitan Region Scheme
- Perth and Peel @3.5 million and Sub-Regional Planning Framework
- Town of Cottesloe Local Planning Strategy
- Town of Cottesloe Local Planning Scheme No.3 (LPS 3)

- Local Planning Policy No.2 – Wearne Redevelopment, Lot 87 (8) Warton Street, Cottesloe (LPP2)
- Restricted Foreshore Centre Zone Design Guidelines for Setbacks
- Cottesloe Foreshore Masterplan

2.7 Community and Stakeholder Engagement

Key to the success of the CHRMAP project was to ensure that the adaptation 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 International Association of Public Participation (IAP2) documentation. A summary of the resultant engagement activities, participation and findings is presented in Table 2-1.

Table 2-1 Summary of engagement activities

Activity	Timing	Participants	Key Finding
Targeted Stakeholder Conversations	2022	6	The importance of the environment in its natural state was a theme, and the ability to use the area to recreate was highly valued. Clubs with members particularly valued social aspects since members use the area as a connection, enhancing health and wellbeing. Iconic nature, heritage, cultural features were identified as values for the area. Erosion is identified as a concern, since beach sand is important, for recreational use, 'Sculptures by the Sea', surf clubs.
Aboriginal Engagement Session	2022	4 cultural representatives	Mudurup Rocks were seen as a very important historical, heritage, cultural site to local Aboriginal people, a place where ceremonies are held. It was felt rock area should not be interfered with.
Pop-up Information Session	2022	68	Information sessions included displays about the project and affected areas, people viewed the information and chatted to the project team to gather more information about the project.
Coastal Values Survey	2022	131	Most appreciated the natural assets associated with the beach. Important places within the coastline are identified as Main Beach, North Cottesloe Beach, coastal paths, Cottesloe Groyne, dining out venues, cafes, Grant Street Beach. North beach zone identified as more active compared to south zone. Walking and swimming, being in nature were the most valued activities, and were valued as either very important or important for health and wellbeing. Sand erosion exposing rocks were identified as concerns.
Community Scenarios Workshops	2023	45	Two workshops to inform the community of the project and projected impact from coastal processes, as well as gather feedback about asset prioritisation, the perceived consequences of coastal hazards and the preferred adaptation strategies and management options along the coastline.

Activity	Timing	Participants	Key Finding
Draft CHRMAP	2024	N/A	Draft CHRMAP will be placed on the CHRMAP website for public comment.

2.8 Success Criteria

The values collated from the engagement were used to generate the success criteria for the CHRMAP. These values are key to the whole CHRMAP and help drive the selection of adaptation options. The success criteria are:

- Preserve and protect the Town's beaches and natural assets such as vegetation and dunes.
- Ensure the natural environment is protected and sustained in its current condition or an improved condition.
- Maintaining the natural state of any underdeveloped areas is important.
- Preserve and consider the cultural significance of Mudurup Rocks.
- Preserve the function and opportunity for all types of water-based and land-based activities, particularly those that help to improve the health and well-being of people.
- Preserve and accommodate the existing surf lifesaving clubs as these facilities were seen as a hub of water and land-based activities that also helped to improve social connection and mental wellbeing.
- Continue to provide public amenities at the coast, such as parks, restrooms parking and access paths.
- Ensure that areas for community events and access to remain within the coastline. Provide and maintain spaces and infrastructure for community events, arts and entertainment.
- Minimise impacts on existing private property.
- Consider treatments for coastal areas that have current inundation and erosion issues. Preserve the current uses of the beach areas.
- Develop solutions to coastal processes that are sustainable (financially, socially and built form) and locally responsive.
- Revisit regularly with community and key stakeholders their values in relation to development adjacent the foreshore.

3 RISK IDENTIFICATION

A Risk Identification 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 were produced defining the erosion and inundation extents for present day, 2033, 2048, 2073 and 2123.

A key policy objective of SPP2.6 is the provision of a coastal foreshore reserve. The coastal foreshore reserve is essentially a 'space' between the ocean and private land. It should accommodate a range of functions and values such as geomorphological integrity, biodiversity, heritage, public ownership, and access. The component of the coastal foreshore reserve to allow for coastal processes should be sufficient to mitigate the risks of coastal hazards by allowing for landform stability, natural variability, and climate change. The coastal foreshore reserve is a critical input into the coastal hazard risk management and adaption planning framework outlined in SPP 2.6. The assessment considers allowances for coastal erosion and storm surge inundation in parallel.

The Town's coastline features a mixture of sandy, rocky, and artificially hardened shorelines. 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. 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. Erosion response across the study area may differ to the predictions of this study. Further investigations are a recommendation of this CHRMAP.

3.1 Erosion Hazard Assessment Method

A desktop review of available information was undertaken, including:

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

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

- State Planning Policy 2.6 State Coastal Planning Policy (SPP2.6) – which provides a clear method for the evaluation of hazards in tidal areas.
- Coastal Hazard Risk Management and Adaptation Planning Guidelines (CHRMAP Guidelines; WAPC, 2019).

SPP2.6 stipulates the following components be considered when evaluating the coastal erosion risk:

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

SPP2.6 indicates the methods for determining the allowance for erosion for a sandy open coastline. The standard method from SPP2.6 was used, which considers erosion allowances relative to the present Horizontal Shoreline Datum (HSD). The HSD is defined as the active limit of the shoreline under storm activity. It is the

line from which the erosion hazard allowance is applied from. In this assessment HSD has been determined by the elevation of the 100-year ARI Peak Steady Water Level. The erosion hazard study was carried out by the following steps:

- Classification of the coast as Rocky, Mixed Sand and Rock, or Sandy coast.
- Identify HSD.
- Simulate storm erosion for the 100-year ARI storm (S1).
- Allowance for the current risk of storm erosion (S1) estimated by SBEACH numerical model.
- Evaluate historic shoreline movement trends based on historic vegetation lines (S2).
- Evaluate sea level rise impacts for the project timeframes (S3).
- Calculation of the uncertainty allowance as per SPP2.6
- Evaluate total erosion values for each coastal management zone and for the project timeframes.
- Mapping of erosion hazard lines defined by HSD+S1+S2+S3+uncertainty

3.2 Inundation Hazard Method

SPP2.6 requires the allowance for inundation to be the maximum extent of inundation calculated as the sum of extreme storm inundation (S4) plus the predicted extent of sea level rise at 2123. A detailed numerical modelling approach was used to assess coastal inundation with calibration to existing studies and information.

The allowance for the extent of coastal inundation has been calculated as the maximum extent of storm inundation during the 500-years average recurrence interval (ARI) storm event. This was defined as the peak steady water level calculated based on analysis of available measured water level data, plus an allowance for wave set-up.

3.3 Hazard Results

A key outcome of the coastal hazard assessment was the confirmation that coastal erosion is a significant hazard in the study area (Figure 3-1 and Figure 3-2). The inundation assessment, however, confirmed there are no expected inundation impacts, and as such inundation did not need to be considered further throughout the CHRMAP.

Figure 3-1 Erosion hazard lines for MU1.

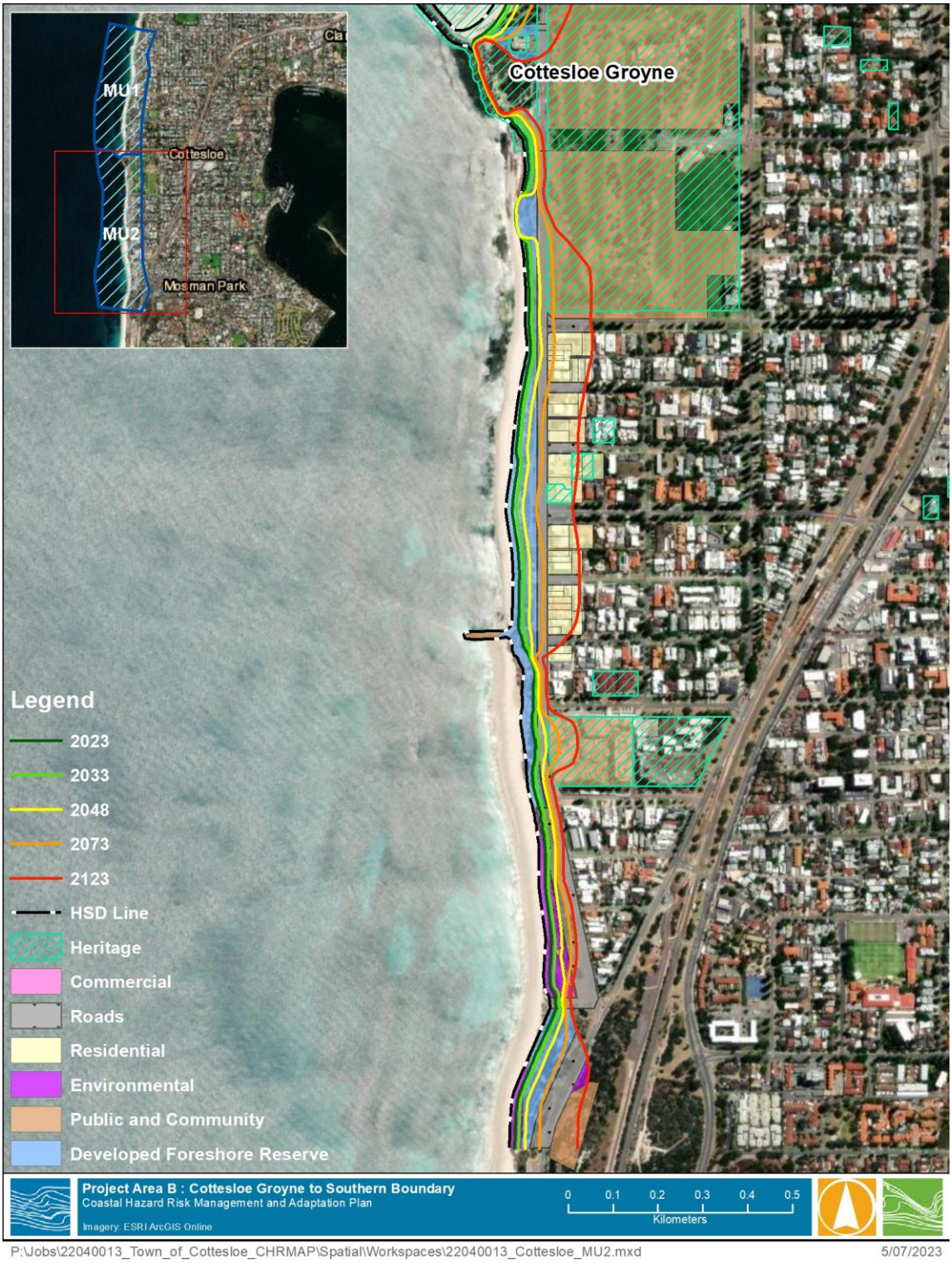

Figure 3-2 Erosion hazard lines for MU2

4 VULNERABILITY ANALYSIS

Assets at risk of coastal erosion were identified and assigned a vulnerability rating. The vulnerability results are presented in full in the Vulnerability Analysis Chapter Report (Appendix C). A summary of the results is presented below.

4.1 Asset Classifications

Assets are grouped according to classification for ease of interpretation. For the purposes of this report, Water Technology has grouped assets in line with Local Planning Scheme zones into categories: Public and Community, Environmental, Residential, Developed Foreshore Reserve, Commercial, Roads, and Heritage sites.

Public and Community

- This includes, Seaview Golf Course, Structures on beach, Cottesloe Groyne at Mudurup Rocks, Beach Street Groyne, Cottesloe concrete seawall, Local Centre, Town Centre, Public purposes – Special Uses.

Environmental

- This includes Beach, Foredune, Undeveloped foreshore, Local Parks and Recreation.

Residential

- This includes Residential, Residential Office.

Developed Foreshore Reserve

- This includes Foreshore Centre, Restricted Foreshore Centre, Public Carparks near coast/beach, Beach access, Local Parks and Recreation near coast/beach, areas of lower-value foreshore amenity such as paths, seating, playgrounds etc.

Commercial

- This includes Hotels, Ocean Beach Hotel owned properties, Development.

Roads

- This includes Scenic drives along coast, Local Roads, Regional Roads.

Heritage

- This includes Aboriginal heritage sites from DPLH database.

4.2 Identified Assets

Table 4-1 presents the identified assets by management unit and category.

Table 4-1 Summary of Vulnerable Assets, grouped by Management Unit & Planning Horizon.

Planning Horizon	2023 (present)	2033 (+10 years)	2048 (+25 years)	2073 (+50 years)	2123 (+100 years)
Asset Classification Group	**Management Unit 1 – MU1**				
Public and Community (m^2)	4,649	5,122	5,917	7,022	10,792
Environmental (m^2)	0				
Residential (m^2)	0	0	0	0	44,220
Developed Foreshore Reserve (m^2)	20,861	31,988	51,084	74,191	82,523
Commercial (m^2)	2,502	2,502	2,502	2,502	12,685
Roads (m^2)	0	0	611	12,208	46,463
Heritage (m^2)	13,583	17,009	22,708	31,852	33,513
Asset Classification Group	**Management Unit 2 – MU2**				
Public and Community (m^2)	758	758	857	3,792	23,089
Environmental (m^2)	5,332	8,177	11,652	12,629	13,826
Residential (m^2)	0	0	0	5,356	39,217
Developed Foreshore Reserve (m^2)	15,410	25,560	40,423	58,825	63,660
Commercial (m^2)	0				
Roads (m^2)	501	1,374	6,294	22,064	52,240
Heritage (m^2)	472	1,195	2,290	6,513	32,569

4.3 Analysis 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 4-1; the input components are displayed in blue.

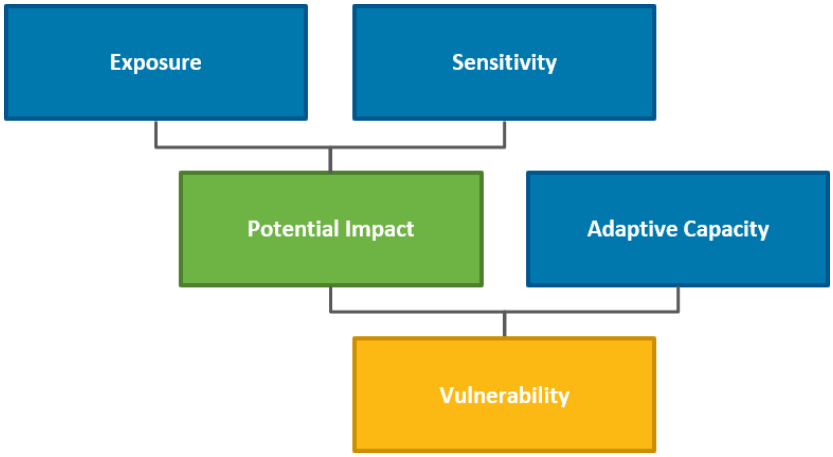

Figure 4-1 Vulnerability assessment components (reproduced from Allen Consulting, 2005)

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.

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.

Risk level, or **potential impact**, is calculated as the product of exposure and sensitivity (Figure 4-2). It provides a classification of the potential impact of coastal hazards on identified assets, which was determined for each project timeframe.

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.

Vulnerability is calculated as the product of potential impact (risk level) and the adaptive capacity (Figure 4-2). 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 Extreme, High, Medium and Low.

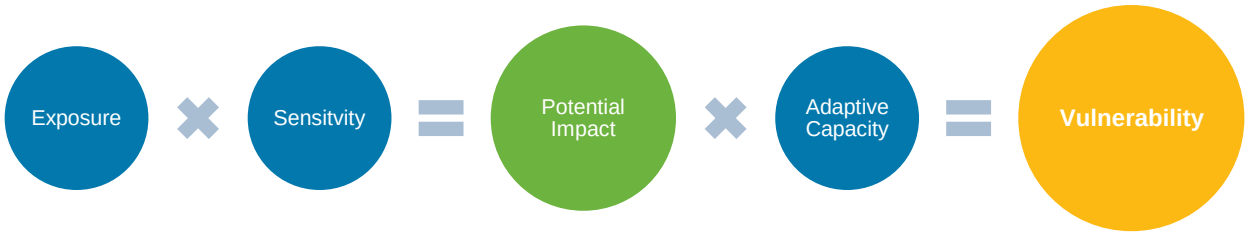

Figure 4-2 Vulnerability relationship

4.4 Results

The assessment method was applied to all identified asset categories for each planning horizon for each MU to identify vulnerability ratings as presented in Table 4-2. The following key observations can be made from the results:

- Although residential properties are not reached by present day erosion hazard lines (some properties are identified under erosion hazard lines by 2073) they are rated as having high (MU1) and extreme (MU2) levels of vulnerability in the present day because they have low adaptive capacity.
- Public and Community properties are vulnerable to erosion at present, including Cottesloe groyne. North Cottesloe SLSC building(s) is vulnerable to erosion by 2033 and the golf club is vulnerable to erosion by 2123.
- Developed foreshore reserve, beach, foredune and Roads are vulnerable to present day erosion hazards.
- The Indiana Tea Rooms building is presently vulnerable to erosion risk, noting the existing seawall functions as expected.

All categories are at high or extreme vulnerability to erosion from present day, except Developed Foreshore Reserve. Essentially most categories are considered unacceptably vulnerable and require adaptation planning to consider the best way to treat the risk.

Table 4-2 Erosion Vulnerability Ratings, grouped by Management Unit & Planning Horizon

Asset Classification Group	2023	2033	2048	2073	2123
Management Unit 1 – MU 1					
Public and Community	Extreme	Extreme	Extreme	Extreme	Extreme
Environmental					
Residential	High	Extreme	Extreme	Extreme	Extreme
Developed Foreshore Reserve	Medium	Medium	Medium	Medium	Medium
Commercial	Extreme	Extreme	Extreme	Extreme	Extreme
Roads	Extreme	Extreme	Extreme	Extreme	Extreme
Heritage	Extreme	Extreme	Extreme	Extreme	Extreme
Management Unit 2 – MU 2					
Public and Community	Extreme	Extreme	Extreme	Extreme	Extreme
Environmental	Extreme	Extreme	Extreme	Extreme	Extreme
Residential	Extreme	Extreme	Extreme	Extreme	Extreme
Developed Foreshore Reserve	Medium	Medium	Medium	Medium	Medium
Commercial	Not Applicable				
Roads	Extreme	Extreme	Extreme	Extreme	Extreme
Heritage	Extreme	Extreme	Extreme	Extreme	Extreme

5 RISK EVALUATION AND TREATMENT

A Risk Evaluation and Risk Treatment Options Chapter Report (Appendix D) was prepared, assessing any available controls against the vulnerability ratings assigned during the vulnerability analysis. Any vulnerability rating of medium or above is considered unacceptable and therefore both MUs need to be considered for risk treatment options.

5.1 Risk Management and Adaptation Hierarchy

SPP2.6 provides a risk management and adaptation hierarchy 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 5-1, 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.

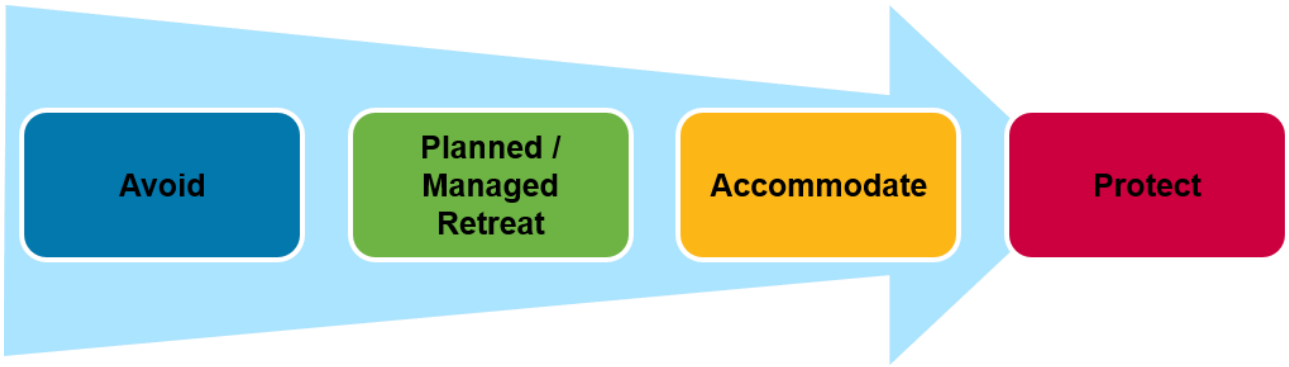

Figure 5-1 Coastal hazard risk management and adaptation planning hierarchy (adapted from WAPC, 2019)

Maintaining public access to the coast in developed areas is one of the main objectives of SPP2.6. The 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.

The CHRMAP process aims to minimise coastal hazards and maximise the beneficial use of the coast. Therefore, adaptation options should follow the following principles:

- Adaptation options should minimise coastal process interference and legacy issues.
- 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 to build resilient coastal communities.
- A key adaptation option will be the use of planning instruments, including managed Retreat.

5.2 Multi-Criteria Analysis

Successful risk management and adaptation planning requires identifying and diligently assessing suitable risk treatment options to select the best strategy. The selected risk treatment option should mitigate risk to an acceptable level whilst maximising the values important to the stakeholders.

A Multi-Criteria Analysis (MCA) was undertaken to assess suitable adaptation options for the study area. The MCA assessment criteria were as follows:

- Effectiveness
  - Ability for the option to mitigate the coastal hazard
- 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
  - Incorporates feedback provided by engagement workshop attendees in Winter 2023
  - 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 projections
  - If the option limits the feasibility of selecting other options in the future

The MCA results are a rating from negative, neutral to positive. The adaptation options with a rating of zero and above were recommended for further investigation in a Cost Benefit Analysis (CBA; Table 5-1). Following

review by the project Steering Committee it was decided to include three additional options for CBA analysis as they were supported by several people during the community and stakeholder engagement:

- Seawalls (PR3),
- Artificial reefs (PR4), and
- Offshore breakwaters (PR5).

Table 5-1 Multi-Criteria Analysis summary by Management Unit. Green indicates recommended for further investigation. Option codes refer to those used by WAPC, 2019.

Option	MU1 (North of Cottesloe Groyne, including Groyne)	MU2 (South of Cottesloe Groyne)
Locating assets in areas that will not be vulnerable to coastal hazards (AV)	N/A	11
Leaving assets unprotected (PMR1)	2	2
Demolition / removal / relocation of asset from inside hazard area (PMR2)	6	6
Prevention of further development / prohibit expansion of existing use rights (PMR3)	7	7
Voluntary acquisition (PMR4)	5	5
Design assets to withstand impacts (AC1)	N/A	N/A
Beach nourishment or replenishment (PR1)	7	7
Groynes (PR2)	1	1
Seawalls (PR3)	-4	-4
Artificial reefs (PR4)	-4	-4
Offshore breakwaters (PR5)	-2	-2
Levy / Weir / Storm Surge Barrier (PR6)	N/A	N/A
Monitoring (NR1)	8	8
Protection Structure Audit (NR2)	6	6
Notification on title (NR3)	8	8
Emergency evacuation plans (NR4)	N/A	N/A
Do nothing (DN1)	-8	-8

6 ASSESSMENT OF RISK TREATMENT OPTIONS

An Assessment of Risk Treatment Options Chapter Report (Appendix E) was prepared to analyse options using Cost-Benefit Analysis (CBA). A summary is provided below.

6.1 Cost-Benefit Analysis

The purpose of the CBA was to further examine the selection of adaptation options through economic analysis. In the previous project stage, potential adaptation options were assessed against a range of criteria, including cost. Options that may require significant financial investment and scored positively in the MCA were included in the CBA. A rigorous assessment of costs and benefits for each option assists with preferential selection to ensure that a selected adaptation option is economically defendable. The CBA has addressed valuing the loss of assets, managed retreat and physical protection options. Losses or costs are assessed at each project timeframe. Indirect costs that another user might consider to be a loss are not considered. For example, costs associated with Special Control Area (SCA) title notifications, emergency planning or development restrictions are not considered.

The cost-benefit of each 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, because the money required for a future expense could be spent elsewhere today to provide value over time (i.e., it can be invested now to generate a return). An expense that occurred today could not be invested elsewhere. In this case, all cashflows are costs, so options with a lower net present value are considered better investments from a financial standpoint.

The real discount rate chosen for this project was 4% with sensitivity analyses at 7% and 2%. This decision was based on similar assessments (DPMC, 2016; Transport for NSW, 2022; Baird, 2020; APH, 2018; Abelson and Dalton, 2018), the very long timeframe of analysis, and concerns that valuing future spending too low is at odds with resilient coastal planning principles.

The discount rate essentially converts all future costs back to today's dollar value for comparison (in the NPV). For example, a project with a cost of $1 million per year for 10 years would discount to an NPV of roughly $7.5 million, whereas a project that only has a single outlay of $10 million in 10 years' time would have an NPV of roughly $5.4 million, both discounted at 7%. A project that costs $10 million today would have an NPV of $10 million. This example shows the importance of when a cost is realised.

The CBA has been performed over the project timeframe – notionally 2023 to 2123, 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. Estimates beyond 2040 should be viewed as indicative trends only. Long-term adaptation pathways should always be monitored and updated over time.

The adaptation options recommended for further analysis following the MCA, and considered suitable for CBA, were:

- Planned/Managed Retreat – Voluntary acquisition of residential, commercial, public, tourism and environmental areas over various timeframes per MU as identified by the hazard mapping.
- Protect – Beach nourishment: Placement of sand within the beach profile and/or dunes to activate beach coastal processes and provide a sediment supply along the whole length of the relevant MU.
- Protect – Groynes: 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 beach nourishment.

- Protect – Seawalls: 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.
- Protect – Artificial reefs: 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. They are primarily effective when partnered with beach nourishment.
- Protect – Offshore breakwaters: Construction of an emergent offshore barrier to 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. They are primarily effective when partnered with beach nourishment.

The remaining adaptation options from WAPC (2019) which received a positive MCA score were not considered suitable for CBA and have been costed using traditional budgeting techniques. The base-case economic scenario of assuming complete inaction (do nothing) over the project timeframe was costed for each MU for each timeframe by multiplying the quantity of assets identified as vulnerable by the unit rate for that timeframe. This option is not an acceptable option as it does not address the Town's obligation under other legislation such as the general duty of care to the community. The Town must take reasonable steps to manage risks on the land it manages.

6.2 Results

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.

Review of the CBA results showed that the ranking of options for each MU by NPV depended on the discount rate. If options stayed in the same ranking for all three discount rates there would be a much stronger argument for selection of a single option with which to proceed.

For erosion, across both management units (MU1 and MU2) PR1 Beach Nourishment is recommended for implementation following further investigations to confirm assumptions and consider analysis of smaller sections of coast, noting:

- PR1 Beach Nourishment is recommended based on the results of the MCA and CBA combined. Best value for NPV 7% discount rate and has a positive benefit/cost ratio for all rates.
- PR1 Beach nourishment could also later be transitioned to both PR2 Groynes and PR3 Seawall if required.
- PR3 Seawall is not recommended as it would likely mean significant loss of the beach. Should the objectives of this MU change in the future PR3 Seawall may be suitable in the long-term as PR3 performs well across NPV 4% and 2% discount rates. It may suit smaller sub-sections of the MU, particularly if combined with PR1 Beach Nourishment.
- Assumes 2023 implementation with treatment of 1700m of shoreline for whole of MU1.
- Assumes 2047 implementation with treatment of 2100m of shoreline for whole of MU2.

A key assumption for the PR1 Beach Nourishment option is that a suitable sand source is available (grain size, volume, cleanliness and proximity). Further investigations are required to confirm the assumptions used in the analysis to develop a more accurate scope for the recommended options.

For both MUs the year of implementation has allowed for protection of some foreshore reserve as well as development further inland. This acknowledges the underlying qualitative value of the vegetated foreshore

reserve in line with the objectives of SPP2.6. If these areas were considered of very high importance in MU2 the implementation of protection options could be considered earlier. Alternatively if these areas were considered less important to this study area implementation could be delayed until more landward assets become unacceptably vulnerable. The existing estimate on the timeframe for implementation in MU2 shows that there is time to consider these competing priorities in more detail following further investigations to develop the options. Filling of any existing data and/or knowledge gaps (e.g. suitable sand source, costing assumptions) is considered critical in confirming the recommended options before processing with implementation. Likewise, the enforcement of planning regulations (e.g. limiting further development seaward of the hazard lines and limiting intensification) and undertaking ongoing monitoring of coastal processes is considered essential. Future CHRMAP reviews will be required to either confirm or change the recommended option before its recommended implementation timeframe.

Other non-CBA options also form part of the recommended management approach and are presented in Section 7, which also provides further detail for the investigations and implementation of options.

7 IMPLEMENTATION

An Implementation and Monitoring Chapter Report (Appendix F) was prepared to present recommended actions to progress coastal hazard adaptation planning for Cottesloe. A summary is provided below.

7.1 Implementation Strategy

It is recommended the Town execute a staged implementation strategy to incorporate the CHRMAP's strategic recommendations into its operations as outlined in Table 7-1.

Table 7-1 CHRMAP implementation strategy.

Milestone	Adaptation Actions	Adaptation Hierarchy
Prior to CHRMAP endorsement	Continue to accommodate development under the current planning framework with conditions requiring removal or relocation of the development once the Horizontal Shoreline Datum (HSD) is within the relevant S1[1] distance of the most seaward point of the development, in accordance with the CHRMAP Guidelines.	Planned/ Managed Retreat; Accommodate
CHRMAP Endorsement	Continue to accommodate development under the current planning framework with conditions requiring removal or relocation of the development once the HSD is within the S1 distance[1] of the most seaward point of the development. The Town shall update available mapping online to include the relevant data from the CHRMAP, including the HSD and S1 values for locations subject to erosion.	Planned/ Managed Retreat; Accommodate
Scheme Amendment / LPP Endorsement	Assess development against the amended planning framework which supports the adaptation hierarchy under the CHRMAP Guidelines, specifically: • Prohibit subdivision or rezoning of land which has been identified as being subject to erosion over the 100-year planning timeframe; • Prohibit development within the S1 distance of the HSD; • Accommodate development not identified as being impacted by erosion in the short-term (S1) with conditions for the managed retreat of the development once the most seaward point of the development is within the short-term erosion zone (HSD plus S1 erosion).	Avoid; Planned/ Managed Retreat; Accommodate
Protection Measures Implemented	Accommodate subdivision / development where protection measures have been undertaken in accordance with the CHRMAP and/or any other relevant assessment endorsed by a suitably qualified coastal engineer.	Accommodate; Protect

[1] S1 is the erosion distance from acute storm erosion from a 100-year ARI storm event. This is seen as the present-day erosion risk and varies along the beach. Details and distances are presented in Risk Identification Chapter Report (Appendix B).

7.2 Recommended 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 use in reducing risk exposure. The following measures are recommended:

- The introduction of a **Special Control Area** (SCA) into the Town's local planning scheme is considered the most appropriate statutory planning mechanism to holistically address coastal erosion. An amendment to the local planning scheme will be required to introduce the SCA over all zoned land located seaward of the 2123 coastal processes setback line.
- A **local planning policy** (LPP) can be prepared by a local government in accordance with Schedule 2 of the Planning and Development (Local Planning Schemes) Regulations 2015. The purpose of a LPP is to guide the development and use of land in relation to a particular matter. LPPs allow a level of discretion and flexibility to be applied in the decision-making process given they are a due regard planning instrument.
- Freehold land identified as being at risk of coastal erosion should have a **notification registered on its certificate of title** to ensure current and future landowners are aware of the potential for the land to be impacted by coastal processes.

Additional instruments that can be considered for implementation include:

- Updates to the Local Planning Strategy to reference SPP2.6 and avoid the identification of at-risk land for further intensification of development through rezoning or subdivision.
- Preparation of a foreshore management plan to provide a strategy to deliver the recommendations of the CHRMAP for foreshore reserves throughout the Town.
- The use of restrictive covenants to restrict development in high-risk areas or limit the use of certain protective barriers which may contradict the recommendations of the CHRMAP.
- Introduction of special area rates to equitably distribute costs associated with protection options across beneficiaries.
- The application of SPP2.6 in the structure planning process where the comprehensive redevelopment of land remains an option.
- Internal processes and systems to ensure coastal hazard information and data is readily available and accessible to landowners, prospective buyers and the real estate industry.

The intent of these instruments aligns with guidance provided in the WA Coastal Zone Strategy, noting that private parties are responsible for managing risks to their private assets and incomes, which might arise from coastal erosion and inundation hazards.

There is an identified need to establish a response within the town planning legislative framework to manage the risks of coastal hazard to an acceptable or tolerable level. Any changes to the land use planning framework to reflect the identified risks would be undertaken after a detailed investigation into proposed coastal protection measures, as the specific coastal protection measure may alter the land use instrument required. The Town should prepare an amendment to the Local Planning Scheme to include provisions relating to the coastal erosion hazard zone.

7.3 Funding options

There exist revenue-raising mechanisms available for obtaining funds to assist implementation. Funding mechanisms that should be considered include:

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

7.4 Monitoring and Review

Monitoring is essential to managing coastal hazards, tracking when coastal hazards reach trigger points, understanding the coastline evolution, capturing changes to vulnerabilities and measuring the success of coastal management actions. Coastal monitoring will be required throughout the whole planning timeframe to inform ongoing implementation and to increase the knowledge base for subsequent CHRMAP revisions and targeted investigations. 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 monitoring activities are recommended to record the evolution of coastal trigger points:

1. Continue the 6-monthly beach and dune surveys the Town has been undertaking since 2014. The beach survey may also be continuous along the coast using LiDAR (or other appropriate technique) to enhance the understanding of coastal processes and beach responses. Additionally, surveys should 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. 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 methods used.
2. Corresponding monitoring photos should be taken at the same time as beach surveys, and the remote shoreline imagery undertaken by the Town since 2014 should continue.
3. Regular monitoring of existing coastal management structures (Protection Structure Audit – NR2) e.g., seawalls and beach groynes. 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. Monitoring would then be incorporated into the Town's existing asset management reporting systems.

Additionally, the ongoing state and federal monitoring should continue:

- Shoreline vegetation movement analysis from aerial photos undertaken by DoT,
- Water level, wave monitoring and bathymetric survey undertaken by DoT,
- Wind recording by BOM.

7.4.1 Trigger Points

Ongoing monitoring shall be used to inform when certain triggers are close to be being exceeded. The CHRMAP consider four types of trigger points, as follows:

- Proximity trigger: Where the most landward part of the Horizontal Shoreline Datum (HSD) is within the Storm Erosion Allowance (S1) of the most seaward point of a public asset of interest or private property lot boundary. WAPC recommends a minimum (S1) distance of 40m in the absence of numerical modelling. Because detailed numerical modelling was undertaken for this CHRMAP project results can be used as the present-day erosion risk, which varies along the beach, rather than the default 40m recommended by WAPC**. Details and distances are presented in Risk Identification Chapter Report (Appendix B).** 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 shall require LGA approval before being repaired. The review process should involve re-fit of minor or moderately damaged assets to accommodate coastal hazards in the future, or removal and redevelopment outside the hazard zone for damaged assets.

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

7.4.2 CHRMAP Review

This CHRMAP should be updated at least every 10 years to maintain currency and should be a "living document". An earlier review should be considered when the following occur:

- Substantial storm events generating severe coastal hazards approaching or exceeding the CHRMAP projections.
- Significant changes to land-use planning – such as complex amendments to a Local Planning Scheme or the full review of the Planning Scheme.
- New information becomes available which substantially affects the summary of local community values and assets (natural or built). This may typically occur when consulting the community regarding other documents such as the Local Planning Scheme or Foreshore Management Plan, or the occurrence of a significant storm event.
- New information becomes available (filling of existing data gaps) that has the potential to alter the recommended protection measure from the CHRMAP. For example, should further investigations show that no economically viable local sand source is available, alternative recommendations other than beach nourishment might be required.
- Hazard modelling for the study area is updated given any of the following:
  - recent data collection,
  - planning changes,
  - updates in climate change science, specifically local sea level rise projections,
  - coastal engineering methodology,
  - changes to the CHRMAP success criteria by coastal land managers, or
  - triggers are reached.

- Coastal management operations within the study area should consider the status of both short and long-term adaptation strategy progress, including assessment of the performance and review of any identified strategies.

7.5 Key Considerations

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 MCA and CBA 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 and applied across the whole MU to draw comparisons between several options.

The CHRMAP 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 is recommended that further work is undertaken to identify priority sections of MU’s and consider the use of composite treatment options in these MU’s. This may see some sections of the current MU’s being managed in different ways rather than one option for each MU. Appropriate supporting analysis is needed to propose preferred treatment options on smaller sections of coastline than the MU’s presented in this CHRMAP as the cost benefit analysis has considered these boundary extents and quantities. It is anticipated the current MU’s could be further split based on the projected hazard extents and predominant foreshore use.

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. Some interim management options may also be progressed, such as the placement of dune fences and re-vegetation to reduce erosion rates and loss of windblown sand.

7.5.1 Further Investigations

Information gaps identified in the CHRMAP should be addressed early. Some of these gaps can be closed by the collection of data. 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 following investigations are recommended:

1. Preparation of an Asset Management Plan to identify existing infrastructure and recreational facilities in the coastal erosion hazard zone and provide 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.

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. Investigate opportunities for demarcating Special Control Areas, and for introducing development restrictions.
4. Sand source feasibility study – Both MU's have recommended sand nourishment as the preferred option. 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 study is undertaken 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 used 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.
5. More detailed investigation of coastal hazards and the feasibility of treatment options at priority locations such as the North Cottesloe Surf Life Saving Club and the section of coast immediately north of the Cottesloe groyne. Targeted CBA and BDA analysis should be undertaken for prioritised sections of coast following the collection of suitable data and information.
6. Foreshore Management Plans (FMPs) - Updated foreshore management plans for the study area 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 - noting protection via sand nourishment has been recommended. Focus should be given to protection of the coastal foreshore reserves, and the existing land use and development east of Marine Parade.
    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 review of existing beach access points, ensuring appropriately fenced and signed paths, and signage for dune repair.
    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 and FAQ's. The education strategy should also include appropriate on-ground signage and information for beach access.
    g. Monitor impacts of general beach access on nesting habitats and migratory bird species in dune areas.

7.5.2 Surf Life Saving Clubs

Throughout the engagement activities undertaken during this CHRMAP project the important nature and role of the Cottesloe and North Cottesloe Surf Life Saving Clubs to the local and broader community has been clearly and repeatedly raised by community members.

SPP2.6 (WAPC, 2013) recognises that Surf Life Saving Clubs and their facilities may need to occur within an area identified to be potentially impacted by physical coastal processes within the 100-year planning

timeframe. SPP2.6 requires they be considered within a CHRMAP framework, identified in a strategic plan and co-located with other public recreation and coastal node facilities. Any proposed development will be assessed on a case-by-case basis against the SPP2.6 Policy Measures and in consultation with other relevant agencies and community.

7.5.2.1 North Cottesloe Surf Life Saving Club

The North Cottesloe Surf Life Saving Club is co-located with other public buildings some of which are leased for private commercial business such as cafes/restaurant. These buildings are projected to become directly vulnerable to coastal erosion around 2033. As such it is recommended that these facilities are investigated in more detail as a priority site for the Town. Should protection via beach nourishment be implemented by the Town for MU1 then these buildings will also be protected. Alternatively further investigations could consider an alternative location for these facilities or targeted protection measures.

7.5.2.2 Cottesloe Surf Life Saving Club

The Cottesloe Surf Life Saving Club is projected to become directly vulnerable to coastal erosion around 2073, but only if no active management occurs to the section of coast immediately north of the Cottesloe groyne. As such it is recommended that these facilities are investigated in more detail after key decision making occurs for MU1. If protection is implemented, then the Club facilities will also be protected. It is recommended that the section of coast immediately north of the Cottesloe groyne are investigated in more detail as a priority site for the Town, following confirmation of the condition and remaining design life of the relevant coastal protection structures.

7.6 Implementation Plan

Medium (25 – 50 years) and long-term (50 – 100 years) implementation provides a strategic consideration of how the Town 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:

- Continuing to action the revised planning instruments implemented in the short-term.
- 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 possible that options using sand or rock resources to protect assets near the coast may become economically unsustainable.
- Implementing planned managed retreat if protection is found not to be feasible.

Long-term adaptation strategies/pathways have been recommended for each MU for erosion 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.

The two primary coastal management actions for mitigating erosion hazards at Town of Cottesloe 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 (PR1 – Beach Renourishment): Undertake works as necessary to prevent erosion to assets. This is anticipated as relatively small scale works initially to maintain approximately the same level of beach and foreshore amenity currently experienced (Figure 7-1). If significant storm damage occurs or pre-emptive works are preferred larger scale works with additional foreshore vegetation rehabilitation could occur. If more frequent management works are undertaken the sandy beach could be rebuilt as required with small beach width amounts and volumes.

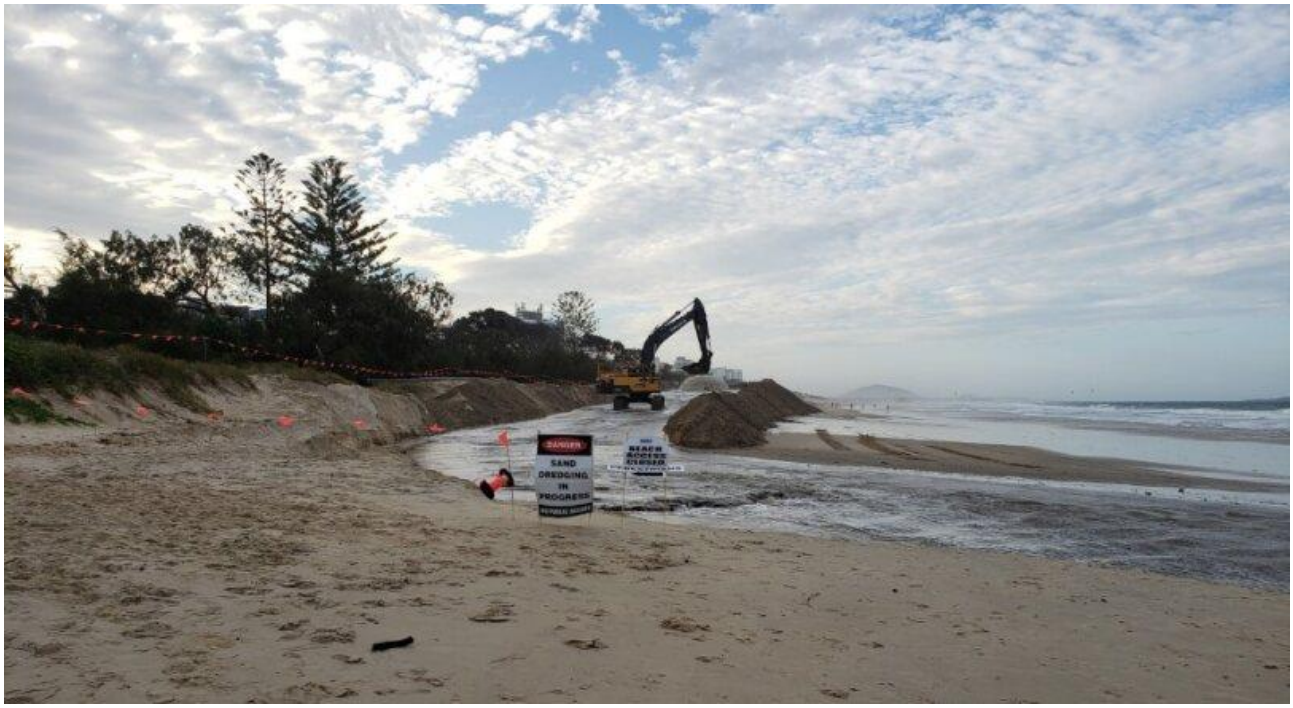

Figure 7-1 Beach nourishment underway at Sunshine Coast, QLD

The detailed implementation plan for MU1 and MU2 is presented in Table 7-2 with recommendations presented in order of priority. The focus should be on implementing land use planning; undertaking investigations and monitoring; and relocating assets as they become exposed to erosion hazards. Most importantly, a sand sourcing study shall confirm the availability and cost of suitable sand in the area to implement the recommended beach nourishment activities. Subject to the results of the sand sourcing feasibility study the medium-term pathway recommended is protection via beach renourishment. There is time to monitor and confirm assumptions. Beach nourishment without associated structures currently presents as the best value option to achieve the project goals. Following further investigations, protection with structures at prioritised locations could be possible.

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

Future investigations are required to confirm they are suitable, including further consultation with stakeholders and the community. Subsequently a likely outcome is that a combination of options may be the preferred approach in some locations. The recommendations are based on the analysis presented in this report. Additional considerations may be incorporated into future analyses.

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

Table 7-2 Implementation plan with recommendations in priority order.

Recommendation	Notes	Responsibility	Trigger	Cost (if known) and Funding	Short-term	Before 2050	2050-2125
INVESTIGATION 1 Update Foreshore Management Plans (FMPs)	■ Prepare an updated Foreshore Management Plan (FMP) ■ An updated FMP could help increase the protective capacity of the natural foreshore dune system. Updates should address the requirements of SPP2.6 and incorporate the findings of this CHRMAP ■ Increased protective capacity by better management of beach and dune ensures better erosion resilience.	■ LGA	■ Completed CHRMAP	■ $60,000 ■ Operational ■ Grants	MU1 and MU2	Continue	Continue
INVESTIGATION 2 Detailed investigation of coastal hazards and feasibility of treatment options at priority locations such as North Cottesloe Surf Life Saving Club, coast immediately north of Cottesloe groyne	■ Site specific details of coastal hazards could help increase the protective capacity of the assets.	■ LGA	■ Completed CHRMAP	■ $30,000 ■ Operational ■ Grants .	MU1		
INVESTIGATION 3 Sand Source Feasibility Study	■ Determine the capacity and cost of local sand supplies, including both land-based and marine sources. ■ Likely requires repetition over Medium-term.	■ LGA	■ Completed CHRMAP	■ $75,000 ■ Operational Grants	MU1 and MU2		
Monitoring (NR1)	■ Bathymetric survey to monitor nearshore zone approximately every 5 years. ■ Six monthly beach profile surveys along the entire extent of the Town's shoreline, extending from the top of primary dune or fixed infrastructure to the approximate depth of closure offshore.	■ LGA ■ Can seek support and assistance from DoT	■ Completed CHRMAP ■ Severe storm event(s)	■ $20,000 annually ■ Operational ■ Grants	MU1 and MU2	Continue	Continue
Notification on title (NR3)	■ Item cost for investigations and implementation plans.	■ LGA ■ Can seek support and assistance from DPLH, WALGA	■ Completed CHRMAP	■ $100,000 ■ (Plus 1% annual maintenance of $1,000) ■ Operational ■ Grants	MU1 and MU2		
Protection Structure Audit (NR2)	■ Item cost to inspect coastal asset condition, influence on sediment transport and remaining design life on all coastal management structures. ■ Includes rubble mound rock groynes at Beach Street and Cottesloe Beach, seawalls at Cottesloe Beach.	■ LGA	■ Completed CHRMAP	■ $30,000 ■ (Plus 10% annual maintenance of $3,000) ■ Operational ■ Grants	MU1 and MU2	Continue	Continue
Demolition / removal / relocation of asset from inside hazard area (PMR2)	■ Preparation of Asset Management Plan to 2048 for public-built assets. ■ Maintenance assumes ongoing allowance for foreshore reserve. ■ Removal / Relocation of assets as required.	■ LGA	■ Audit of assets within 2048 erosion hazard zone and identification of assets where damage would be unacceptable	■ $3,200,000 ■ (Plus 1% annual maintenance of $32,000) ■ Operational ■ Grants	MU1 and MU2	Continue	Continue

Recommendation	Notes	Responsibility	Trigger	Cost (if known) and Funding	Short-term	Before 2050	2050-2125
Prevention of further development / prohibit expansion of existing use rights (PMR3)	■ 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.	■ LGA	■ Completed CHRMAP	■ $60,000 ■ (Plus 1% annual maintenance of $600) ■ Operational ■ Grants	MU1 and MU2	Continue	Continue
Leaving assets unprotected (PMR1)	■ To 2048 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.	■ LGA	■ Storm damage ■ Audit of assets within 2048 erosion hazard zone and identification of assets where damage would be unacceptable	■ $130,000 ■ (Plus 3% annual maintenance of $3,900) ■ Operational	MU1 and MU2	Continue	Continue
Recommended Medium Term option to address Erosion is Protection with Beach Nourishment (PR1)	■ Assumes suitable sand source available (grain size, volume, cleanliness, proximity). ■ 2047 implementation is projected for MU2 and Present Day implementation for MU1 has been allowed for to ensure a wide sandy beach. The priority action is to undertake the sand source feasibility study and beach monitoring.	■ LGA	■ Monitoring ■ Updated CHRMAP	■ Approximate capital cost of $19.14M for MU1 and $8.45M for MU2 at NPV 4% for ■ Annual maintenance estimate of approximately $0.4M. ■ Operational ■ Grants ■ Direct beneficiaries	MU1	MU2, MU1	MU2, MU1

8 PUBLIC REVIEW AND COMMENT PERIOD

A draft version of this document was released for public review and comment for 6 weeks and closed mid-May 2025. Eleven public comments were received which can be broadly summarized as follows:

- There is general acceptance for the Town to defend (sand nourishment and seawalls where needed) but not at its cost and this approach should be complemented with the introduction of special planning control areas (LPS amendment).
- A request to model the scenario where the Dutch Inn Groyne is removed because there is a view that this is eroding beaches south of this location.
- There is no erosional issue.
- The dredging along other parts of the coastline is causing the predicted erosion and consideration needs to be given towards ceasing such detriments.
- Introducing planning controls is inequitable because this will affect property values and other strategies should be considered.
- An artificial reef design was provided (fish habitat protection zone may limit the ability to implement).
- The State and Federal Government should fund the erosion prevention given that Cottesloe is a renowned tourist destination.

Edits have been made in this document's Final version in response to the submissions received. The draft reporting and public comments were presented to Councillors on Tuesday 5th August 2025.

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

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

High-level concept design work has been undertaken to allow budget estimates. Further consideration of the local coastal processes, design and costs is required before these recommendations can be progressed to seek funding, environmental impact assessment and approvals / endorsement. Composite protection options may be effective, including sections of sand nourishment in combination with other structures. Further localised engagement is recommended through this process, including with the Surf Life Saving Clubs as they are recognised as unique developments. Local monitoring of coastal processes, as recommended, combined with targeted engagement will allow for more detailed consideration of options.

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX A
ESTABLISH THE CONTEXT CHAPTER REPORT

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX B
RISK IDENTIFICATION CHAPTER REPORT

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX C
VULNERABILITY ANALYSIS CHAPTER REPORT

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX D
RISK EVALUATION AND RISK TREATMENT OPTIONS CHAPTER REPORT

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX E
ASSESSMENT OF RISK TREATMENT OPTIONS CHAPTER REPORT

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX F
IMPLEMENTATION AND MONITORING CHAPTER REPORT

Melbourne

15 Business Park Drive
Notting Hill VIC 3168
Telephone (03) 8526 0800

Sydney

Suite 3, Level 1, 20 Wentworth Street
Parramatta NSW 2150
Telephone (02) 9354 0300

Brisbane

Level 5, 43 Peel Street
South Brisbane QLD 4101
Telephone (07) 3105 1460

Adelaide

1/198 Greenhill Road
Eastwood SA 5063
Telephone (08) 8378 8000

Perth

Level 1, 21 Adelaide Street
Fremantle WA 6160
Telephone (08) 6555 0105

New Zealand

7/3 Empire Street
Cambridge New Zealand 3434
Telephone +64 27 777 0989

Wangaratta

First Floor, 40 Rowan Street
Wangaratta VIC 3677
Telephone (03) 5721 2650

Geelong

51 Little Fyans Street
Geelong VIC 3220
Telephone (03) 8526 0800

Wimmera

597 Joel South Road
Stawell VIC 3380
Telephone 0438 510 240

Gold Coast

Suite 37, Level 4, 194 Varsity Parade
Varsity Lakes QLD 4227
Telephone (07) 5676 7602

watertech.com.au