

Coastal Hazard Risk Management and Adaption Plan

Shire of Dandaragan

59917806



Prepared for
Shire of Dandaragan

21 June 2018

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Executive Summary

The Shire of Dandaragan is preparing for the threats of climate change and sea level rise to the coastal settlements of Cervantes and Jurien Bay. Historically, the coastal towns were established to service fishing industry, agricultural activities, and are popular holiday destinations and retirement locations. This Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) has been prepared to provide a long term view of the potential future coastal erosion impacts to the townships of Cervantes and Jurien Bay and highlight possible strategies to adapt to the changing future oceanic and coastal conditions.

Development of the Dandaragan CHRMAP has followed the requirements of Western Australian State Planning Policy No. 2.6: State Coastal Planning Policy (SPP2.6) and supporting guideline documents. Previous work had highlighted the two coastal townships within the Shire as being at risk of coastal erosion and these areas form the focus for this CHRMAP. The coastal zones of each township were divided into management units (four at Cervantes and four at Jurien Bay) with similar asset types and exposure to coastal hazards. The risk and vulnerability assessment was applied to each management unit and results highlighted the most vulnerable management unit located at Cervantes, for which more detailed assessment of adaptation options were investigated.

A range of options for addressing the challenges of coastal erosion and its effects on the coastal zone over the next decade and century have been outlined. While it is natural that local communities would prefer to protect and preserve the current features of the coastal zone, the reality is that unless some new and innovative protection methods are developed, the costs of maintaining current features will likely become prohibitively expensive at some point in the future, given current sea level rise predictions. The interim nature of protect options needs to be recognised across the community and, the potential adaption solutions optimised for social, environmental and economic (affordability) drivers.

The complex planning issues around setting the intent and establishing controls such as Special Control Areas, to either restrict development within currently developed areas and/or rezone currently undeveloped land to avoid future development, are discussed. A number of options were identified that aim to protect developed areas under imminent threat of a storm erosion event. An object of the state policy is to implement a beneficiary pays principle to apportion costs for protecting assets within defined coastal hazard areas. It is recommended that a comprehensive community and beach users engagement program be instigated to identify the key beneficiaries of any proposed protection option and its decommissioning at some future trigger, so the costs for implementation can be apportioned appropriately.

The recently released draft Planned and Managed Retreat Guidelines (WAPC, 2017) suggests the process for implementing future managed retreat may include compensation under provisions in the *Land Administration Act (1997)*. In reality, this is unlikely to occur in the Shire unless the State or Commonwealth Governments provide the majority of funding to acquire property. There is no obligation on Government to adopt a strategy that may invoke a requirement to compensate land owners for loss due to erosion. It is important to note that while the managed retreat option is recommended in this CHRMAP its future implementation will need further investigation of the implications for both Government and Private stakeholders. For Landowners who may be considering purchasing or developing lands in designated Hazard areas it is important to note that they should not assume any funds will be forthcoming to support future retreat.

A plan for implementation of recommended adaptation options over the next decade, to 2030 with a strategic view on the likely adjustments over the next century, to 2110 is outlined in the Gantt chart below.

Task Name	Start	Finish	Cost Estimate \$1,000s
Planning and Development Controls Review	1 Jan '18	28 Oct '20	\$155
Review Planning and Development Controls and Recommend Amendments as required	1 Mar '18	27 Sep '19	\$80
Amend current zone and SCA boundaries	1 May '18	31 Oct '18	\$15
Update SCA special provisions	29 Nov '18	30 Jan '19	\$20
Dandaragan LPS 7 Update and Endorsement by WAPC	17 Jan '20	30 Jun '20	\$40
Monitoring	1 May '18	14 May '29	\$410
Horizontal Shoreline Datum (Aerial Photo Analysis)	1 May '18	2 May '22	\$70
Annual Beach Profile Surveys	4 May '18	14 May '29	\$300
Post wave erosion Event (>2 yr ARI wave) Beach Profiles	11 Jan '19	17 Jan '19	\$30
Cyclone storm surge flooding Event	15 Mar '20	18 Mar '20	\$10
Specialist Investigations	4 Feb '19	28 Jul '26	\$415
Comprehensive investigation of each community and visitors be undertaken to identify beneficiaries of proposed protection areas	4 Feb '19	8 Nov '19	\$150
Investigate allowance for coastal foreshore reserve width to extend the 2110 Hazard line a sufficient distance to accommodate future relocation of foreshore assets	15 Mar '19	2 Jul '19	\$15
Assess Current and Future Sediment Budget in the Secondary Cell	1 Jul '19	30 Jun '22	\$80
Analysis of Storm Surge Inundation and Erosion event monitoring	14 May '20	5 Aug '20	\$40
Investigate Storm Surge and Coastal Processes Interactions to reassess triggers, set FFL, CHRMAP, Water Management Plans and Emergency Management Plan overlaps	25 Mar '26	28 Jul '26	\$50
Undertake economic analysis of options	17 May '20	17 Sep '20	\$80
Operational	1 Feb '18	28 Apr '20	\$80
Establish Data Management and GIS system (time series, spot levels and remote sensing) relating to shoreline monitoring and general flooding in each Township to allow identification of trends over time, and Trigger assessment	1 Feb '18	26 Mar '19	\$50
Update Asset database to incorporate end of life date to facilitate future management of assets	1 Feb '19	30 Sep '19	\$20
Notifications on property titles - Potentially affected land owners to be contacted directly	2 Jul '18	28 Apr '20	\$10
CHRMAP Review and Update (2023)	18 Feb '22	30 Nov '23	\$210
Review Hazard line estimates (S1, S2, S3 and S4)	18 Feb '22	21 Apr '22	\$25
Review Risk Assessment and Future Pathway Options	29 Apr '22	30 Jun '22	\$40
Community and Stakeholder Consultation	1 May '22	30 Jan '23	\$50
Update CHRMAP	24 Jun '22	2 Mar '23	\$80
CHRMAP 2022 Endorsement by WAPC	7 Jul '23	30 Nov '23	\$15
CHRMAP Review and Update (2028)	1 Feb '28	23 Nov '29	\$210
Review Hazard line estimates (S1, S2, S3 and S4)	1 Feb '28	27 Mar '28	\$25
Review Risk Assessment and Future Pathway Options	1 May '28	1 Nov '28	\$40
Community and Stakeholder Consultation	1 Feb '28	9 Oct '28	\$50
Update CHRMAP	10 Jul '28	16 Mar '29	\$80
CHRMAP 2027 Endorsement by WAPC	23 Jul '29	23 Nov '29	\$15

Abbreviations and Acronyms

Abbreviation	Description
AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
AS	Australian Standard
CHRMAP	Coastal Hazard Risk Management and Adaption Plan
DoP	Department of Planning (now part of DoPLH)
DoPLH	Department of Planning, Lands and Heritage
DoT	WA Department of Transport
HSD	Horizontal Shoreline Datum (see SPP2.6)
IPCC	International Panel on Climate Change
LAA	Land Administration Act
LGA	Local Government Area
LIDAR	Light detection and ranging
LPS	Local Planning Strategy
MCA	Multi-criteria analysis
MRA	M P Rogers and Associates
MSL	Mean sea level
NACC	Northern Agricultural Catchments Council
SCA	Special Control Area
SLR	Sea Level Rise
SPP	State Planning Policy
SPP2.6	State Planning Policy No 2.6: State Coastal Planning Policy (2013)
The Shire	Shire of Dandaragan
WA	Western Australia
WAPC	Western Australian Planning Commission
Wheatbelt PIF	<i>Wheatbelt Planning and Infrastructure Framework 2015</i>

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1 INTRODUCTION

1.1 Purpose

Globally, mean sea level (MSL) has risen since the nineteenth century and is predicted to continue to rise, at an increasing rate, through the twenty first century (Intergovernmental Panel on Climate Change [IPCC], 2014), bringing changes to the Western Australian (WA) coastline over the coming decades. To prepare for sea level rise (SLR) induced coastal hazards, such as coastal erosion and inundation, all levels of government are putting processes in place to ensure that communities understand the risks to values and assets on the coast, and to plan to adapt over time.

Changes to MSL over the past century have been observed for the coastline between Fremantle and Jurien Bay. *Sea Level Change in Western Australia – Application to Coastal Planning* (DoT, 2010) reviews information relating to SLR at a local scale and recommends an allowance for SLR be adopted for planning purposes. The WA State Government revised the State Planning Policy (SPP2.6) in 2013 to incorporate the projected SLR for WA of 0.9 m between 2010 and 2110 (**Figure 1-1**).

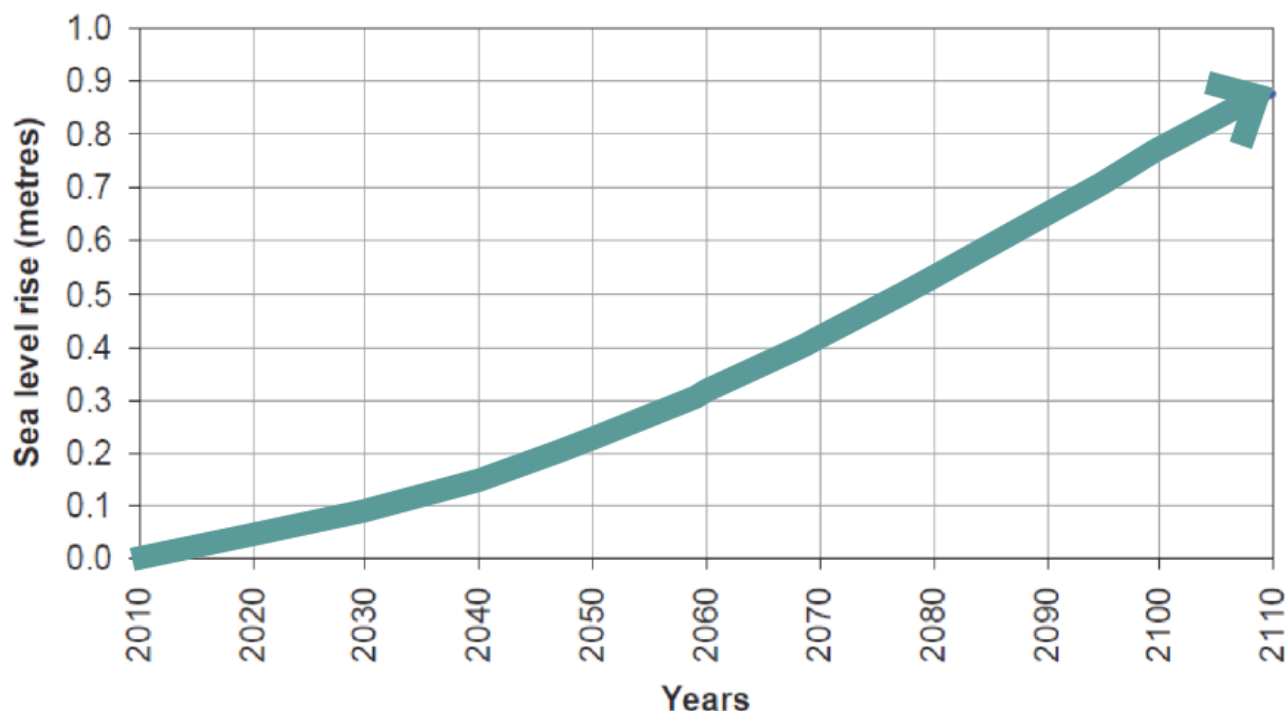


Figure 1-1 Recommended allowance for SLR in coastal planning for WA (source: DoT, 2010)

Dandaragan's coastline is low lying and sandy, featuring coastal dunes, nearshore reefs and islands, seagrass meadows, fishing stocks and rare vegetation communities. Eliot et al. (2012) identifies that the coastline of the Hill Primary Coastal Compartment (Guilderton to Jurien Bay) features low lying sandy coastal landforms, that were identified as being at risk to the impacts of coastal processes (Eliot et al., 2012) and hence, the town sites located on these landforms are vulnerable to changing coastal processes as sea level rises. Coastal processes include a complex set of interactions between atmosphere (climate change) and ocean scale phenomena that interact with the coastal landforms resulting changes to beach shape and form. These processes are often summarised as coastal erosion events associated with short-lived intense storms, shoreline recession associated with climate change-induced sea level rise and oceanic extreme water level events that cause flooding of the coastal areas by sea water. For sandy coastlines, increases in local MSL generally result in shoreline recession, with a "rule of thumb" often used, that a 1 cm rise will result in 1 m of landward recession of the shoreline (**Figure 1-2**; CoastAdapt, 2017).

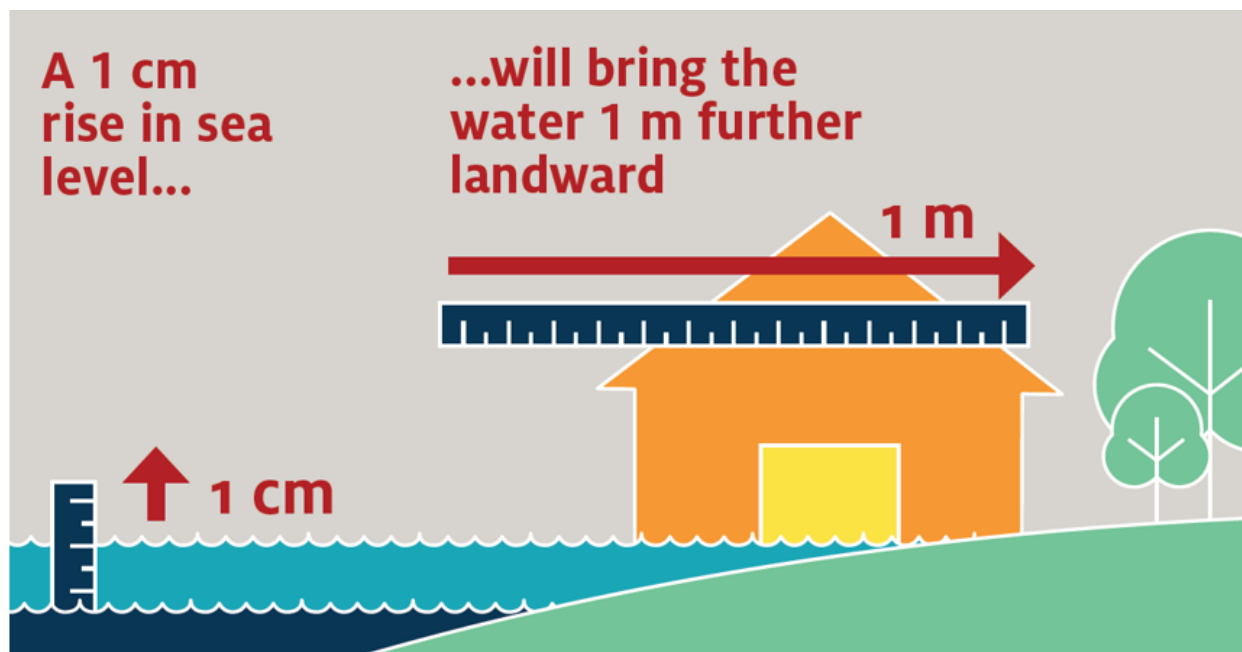


Figure 1-2 Influence of sea level rise on coastal erosion (source: CoastAdapt, 2017)

Development of this Coastal Hazard Risk Management and Adaption Plan (CHRMAP) is being undertaken by Cardno on behalf of the Shire of Dandaragan (hereafter called 'the Shire') to identify risks and plan adaptation responses to natural variability and the expected impacts of SLR for the Shire's coastline.

The purpose of the CHRMAP is to:

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

This CHRMAP focuses on the impacts of coastal erosion and shoreline recession processes while the impacts of coastal inundation caused by high sea level events associated with, for example, cyclones tracking down the west coast will be addressed by the Shire in future.

1.2 Overview of the CHRMAP Process

The key policy governing coastal planning in WA is the *State Planning Policy No. 2.6: State Coastal Planning Policy* (Western Australian Planning Commission [WAPC], 2013a) (herein referred to as 'SPP2.6'). The SPP2.6 policy recommends that management authorities develop a CHRMAP using a risk mitigation approach to planning, that identifies the hazards associated with existing and future development in the coastal zone. SPP2.6 (WAPC 2013a) and the SPP2.6 Guidelines (WAPC 2013b) contain prescriptive details, for example in relation to scales of assessment, storm event types and sea-level rise allowances.

The WAPC (2014a) has also developed the *Coastal hazard risk management and adaptation planning guidelines* which are less prescriptive, but are aimed to ensure that planning is carried out using a risk based approach with due regard to stakeholder engagement, community consultation and education, and that a full range of adaptation options is considered. An overview of the CHRMAP process is shown in **Figure 1-3**.

Coastal planning in accordance with SPP2.6 also needs to take into consideration the requirements of other planning policies, including *Statement of Planning Policy No. 2: Environment and Natural Resources Policy* (WAPC, 2003) and *Statement of Planning Policy No. 3: Urban Growth and Settlement* (WAPC, 2006).

1.3 Guiding Principles and Concepts

Underlying the CHRMAP process are a number of guiding principles and concepts that are fundamental to understanding the purpose and outcomes of the process.

1.3.1 Equity

Equity is a concept that is central to the purpose of the CHRMAP process. Australia's coastline is highly valued by the community as a public asset, with stakeholders ranging from individual property owners adjacent to the coast, to all levels of government, ratepayers within the local government area (LGA), taxpayers in general and users both within and outside of jurisdictional boundaries.

Responsibility for coastal planning lies with both the State and Local Governments, and in making decisions these authorities need to consider equity of access, equity of enjoyment and equity in terms of who benefits, who pays and the allocation of public resources.

Equity is also relevant to considerations about how a protection structure (for example a groyne) might impact on coastal processes. Protection structures may exacerbate erosion immediately adjacent to the structure, and limit sediment availability for maintaining beaches and community values some distance from the protected area. Protection structures can also result in significant impacts to coastal ecosystems, well beyond the local area in which the structures are installed (Gittman et al., 2016). Coastal protection creates beneficiaries (those who are protected from hazards) and potentially creates disadvantage to others who may be considered to be affected parties. In this regard, coastal management has similarities to the management of water rights, if one user takes all the water upstream and leaves none for downstream users then this is not considered fair and equitable. In a future of eroding coastlines due to SLR, sand can be a valuable commodity. The challenge is to ensure that planning and management is as transparent and equitable as possible.

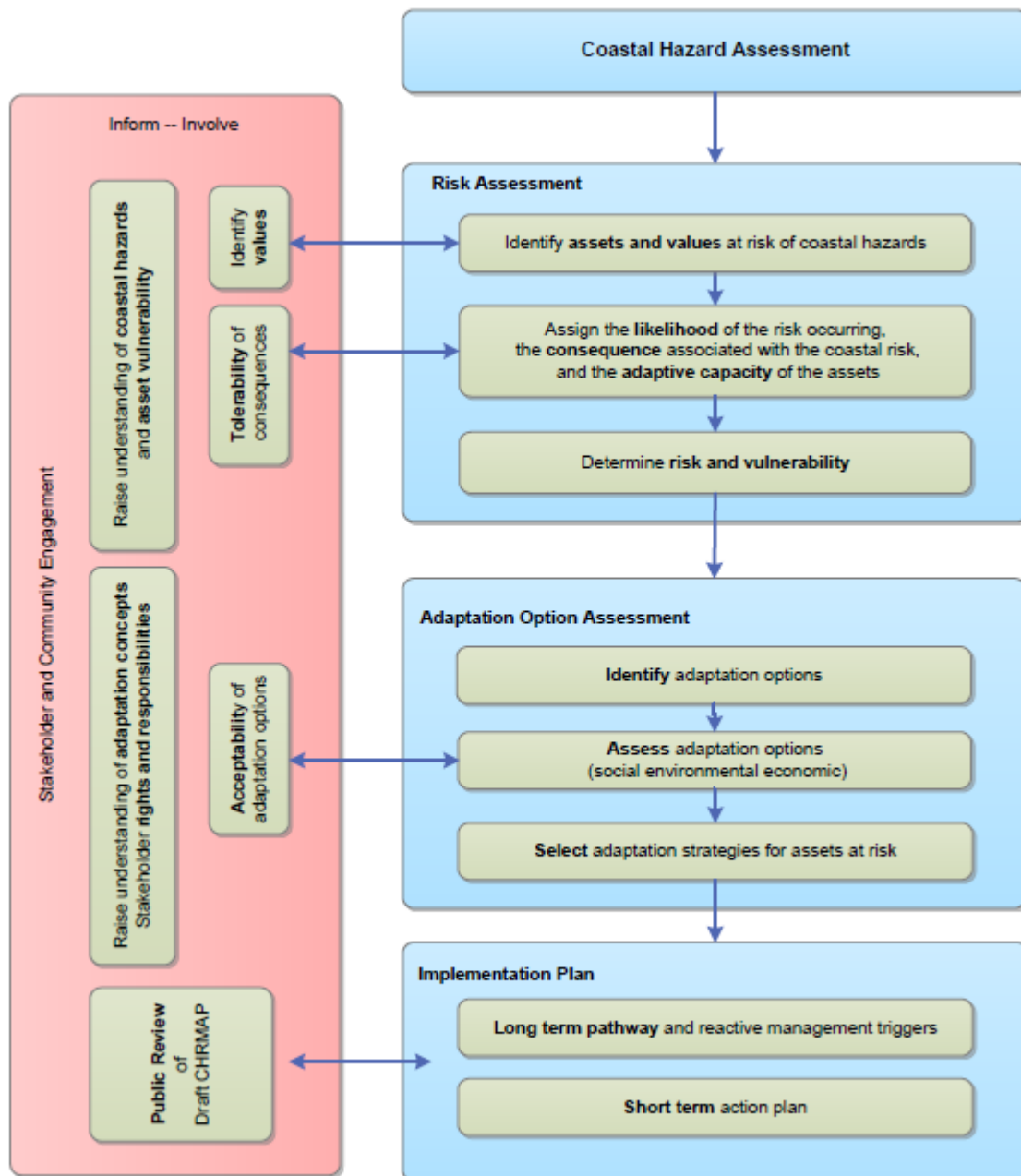


Figure 1-3 CHRMAP methodology flow chart (adapted from the CHRMAP Guidelines (WAPC, 2014a))

1.3.2 Coastal Foreshore Reservation

The coastal foreshore provides beach access, public space for recreation and conservation, is a tourist attraction and provides habitat for native flora and fauna. Importantly, it can also provide a buffer to protect built assets, such as buildings and infrastructure, from coastal hazards.

SPP2.6 Schedule One provides guidance for calculating the component of the coastal foreshore reserve required to allow for coastal processes, to be contained in an appropriate coastal foreshore reserve (determined in accordance with SPP2.6 Clause 5.9) of greater width. This should ensure that, at the end of the planning timeframe, a coastal foreshore reserve is still present and not exposed to the adverse impacts of erosion and inundation. It is behind this reserve that development is able to be considered. Having said this, Schedule One also contains Clause 7 – Variations that outlines specific instances where certain types of

development may be considered appropriate to locate within a coastal foreshore reserve, regardless of the allowance for physical coastal processes.

The allowance for physical processes is based on the 100 year hazard line, determined in accordance with SPP2.6. In addition to the allowance for physical processes, such as erosion, the foreshore reserve includes land allocation for maintaining the values, functions and equitable use of the coast over the 100 year planning timeframe (see **Figure 1-4**).

Permanent and easy public access to the beach and coastal foreshore reserves is a fundamental coastal planning objective. The coast and coastal foreshore reserves are public assets which should not, now or in the future, become the exclusive domain of private landowners by virtue of the erosion of coastal reserves or other coastal processes. Coastal reserves should be wide enough to perform recreation and/or conservation functions (according to the reasons for their initial designation) even if they are affected by coastal erosion or diminution due to SLR.

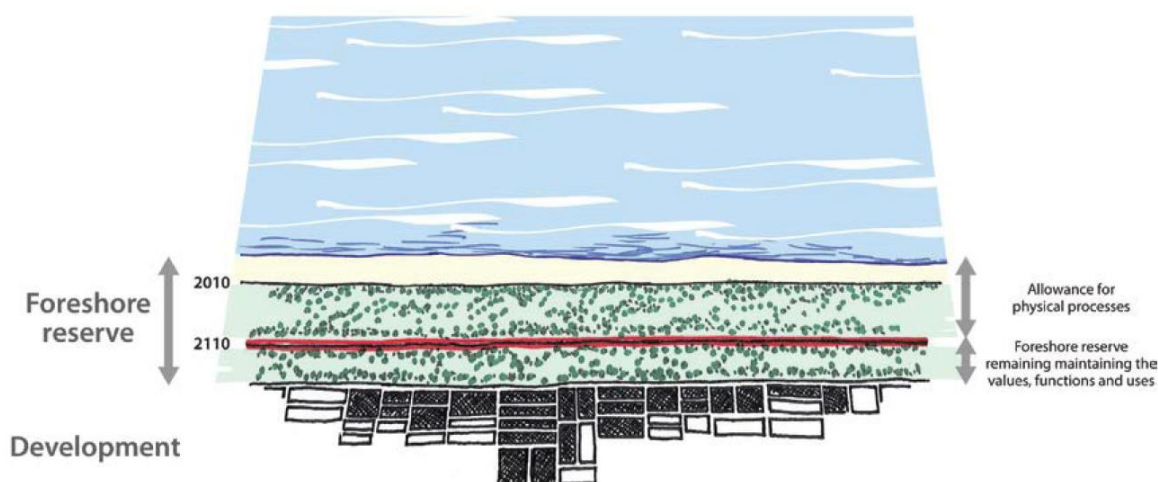


Figure 1-4 Coastal foreshore reserve – sandy coast example (source: WAPC, 2013b)

1.3.3 Rights and Responsibilities

In WA, landowners own the rights to develop and use land as granted by land use regulations; they do not own the land itself. There is no law requiring the government (at any level) to provide protection of private property from natural hazards, nor compensation when land is lost to the sea. There are, however, several laws that allow the intervention of governments to enforce eviction if private property becomes uninhabitable, or removal of property if it constitutes a public risk. In the event of coastal erosion causing a property to “fall into the sea”, and the land to disappear below the high water mark, the loss is to be borne by the property owner.

Nonetheless, it is the aim of all levels of government to protect the interests of all Australians, and the CHRMAP process ultimately intends to minimise risks and maximise beneficial use of the coast from an economic, social and environmental perspective. Mechanisms for managed retreat may require public expenditure and in some instances, where public good can also be demonstrated, protection may also be publicly funded. Where the benefits of a particular coastal protection measure are limited to private beneficiaries, there is an expectation that the cost will be borne by those beneficiaries under the “user pays” principle.

1.3.4 Hazards and Risks

A hazard is a potential source of harm or adverse impact. Sea level rise is predicted to result in hazardous erosion and coastal inundation along the Dandaragan coastline. Coastal erosion and inundation hazards are calculated in accordance with SPP2.6 and may be used to identify assets and values at risk of coastal hazards (see **Figure 1-3**). This current CHRMAP focuses on coastal erosion hazards. Hazards associated with coastal inundation will be included in future CHRMAP reviews and updates, as resources to carry out these assessments become available.

Details of relevant coastal hazard assessments are provided in the Coastal Erosion Hazard Assessment Reports (MP Rogers and Associates [MRA], 2016 and GHD, 2015). Key outcomes are summarised in **Section 2**, and hazard maps derived from these reports are presented in **Appendix A**.

Risk is defined as a hazardous event or circumstance and the consequences that may flow from it. Risk is measured in terms of a combination of the likelihood of a hazard occurring and the consequence of that hazard occurring (likelihood and consequence) (see **Section 2.8.1**).

1.3.5 Assets and Values

An asset is defined as a useful or valuable entity. In the current CHRMAP, assets include:

- > Natural features such as beaches and native vegetation;
- > Approved buildings and other structures (houses, sheds, shade structures);
- > Infrastructure such as fences, lighting, water and sewerage;
- > Roads, paths and walkways; and
- > Coastal structures, such as jetties, boat ramps, seawalls and groynes.

As defined in *Climate change adaptation for settlements and infrastructure – A risk based approach* (AS 5334-2013) an asset's value can be tangible or intangible, financial or non-financial. Examples of non-tangible assets include ecological function and coastal views. The value of an asset includes consideration of risks and liabilities, and can be positive or negative at different stages of the asset's life. Economic assets can be further categorised as public or private.

Values in the context of the CHRMAP further encompass the economic, social (including heritage) and environmental values of the coastal area.

1.3.6 Adaptive Capacity

Adaptation is defined by SPP2.6 as:

“an adjustment in natural or human systems in response to actual or expected stimuli or their effects, which moderates harm or exploits beneficial opportunities. Adaptation is the means for maximising the gains and minimising the losses associated with coastal hazards over the planning timeframe.”

WAPC (2014a) further defines adaptive capacity as reflecting the ability of an asset to change in a way that makes it better equipped to deal with external influences (for example coastal climate change impacts).

In this CHRMAP, adaptive capacity has also been assessed in relation to the ease with which an asset can be modified to reduce risk (for example raising the height of a seawall) or relocated (for example moving a wooden walkway inland).

1.3.7 Vulnerability

Vulnerability has a specific meaning in the context of risk-based approaches to climate change adaptations, in accordance with Australian Standards (AS 5334-2013) and SPP2.6, which defines vulnerability as:

“the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. Systems that are highly exposed, sensitive and less able to adapt are vulnerable”

This report uses vulnerability as the final outcome of the risk assessment process, combining likelihood and consequence of hazards with the adaptive capacity of assets in a stepwise process (see the 'Risk Assessment' component of **Figure 1-3**).

1.3.8 Temporal scales

Coastal hazard assessment and management needs to consider a number of different timeframes (**Figure 1-5**). SPP2.6 specifies the need for identifying risks and extending planning considerations out to a one hundred year planning horizon (also described as 'long term' in this report). Practical planning for implementation, from

the Shire's point of view, requires a focus on the 'immediate term' (the next 5 years), and the 'short term' (up to the 2030 planning timeframe). 'Medium term' is also used throughout this report to refer to the period up to the 2070 planning timeframe.

The need for identifying potential long term risks is important to ensure that these risks are taken into consideration in the Shire's asset management strategy and statutory planning framework. The long term perspective is also important for management of community expectations and gives potentially impacted stakeholders prior notice of the associated hazards.

This CHRMAP includes an assessment of immediate to long term vulnerability of coastal assets, associated with predicted sea level rise. Long term adaptation pathways have been developed for all areas of the coast being assessed, as required by SPP2.6. Short term implementation plans have also been developed, focusing on areas where assets have been assessed as vulnerable by the 2030 planning timeframe. These short term implementation plans are designed such that they do not prevent the long term pathway from being realised.

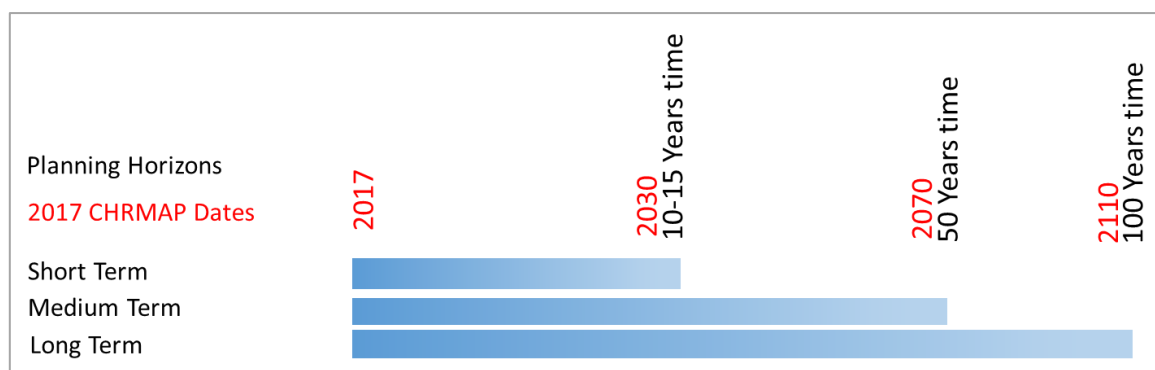


Figure 1-5 Coastal planning timeframes used in this report.

1.3.9 Spatial scales

In accordance with SPP2.6, the coastal hazards along the Shire's coastal zone have been identified at a coastal sediment cell scale (MRA, 2016; GHD, 2015). The policy requires assessment at this scale to account for the impact of existing controls and future management techniques on areas of the coast that are away from the direct area of interest (a common example of this is erosion down-current of a groyne or marina). For more information on the classification of coastal sediment cells, and their function, within the Shire see Stul et al., 2014.

Using the hard lines derived for the broader sediment cell scale, this CHRMAP then looks at finer spatial scales to assess the vulnerability of assets and to simplify management planning. 'Management units' have been defined based on the physical attributes of the coast. Within each management unit assets are considered individually or grouped according to the type of asset and in consideration of current land use. The risks and vulnerability of individual or groups of assets within each management unit have then been assessed.

1.3.10 Adaptive Management

'Adaptive management' is a term given to a structured, iterative process of robust decision making in the face of uncertainty (Allan & Stankey 2009). In the context of this CHRMAP, it allows for predictions of coastal hazards and the development of long term planning pathways to mitigate against risks, while at the same time acknowledging that predictions are likely to change over time. Management pathways have been developed based on predictions of present and future coastal erosion hazards, but implementation of management techniques should be driven by appropriate triggers (**Figure 1-6**). This approach ensures the timing of management (or changes in management) is appropriate to the actual sea level rise effects as and when they occur in the future (for example, if shoreline retreat is occurring faster than predicted, the management action to retreat may be implemented earlier than previously predicted).

The CHRMAP, therefore, recommends appropriate triggers to guide management. Monitoring programs are also recommended to identify when triggers have been reached, and to validate the current predictions of shoreline recession and the extent of coastal erosion hazards. Recommendations for further investigation and review are also made to better inform the refinement of management pathways in the future.

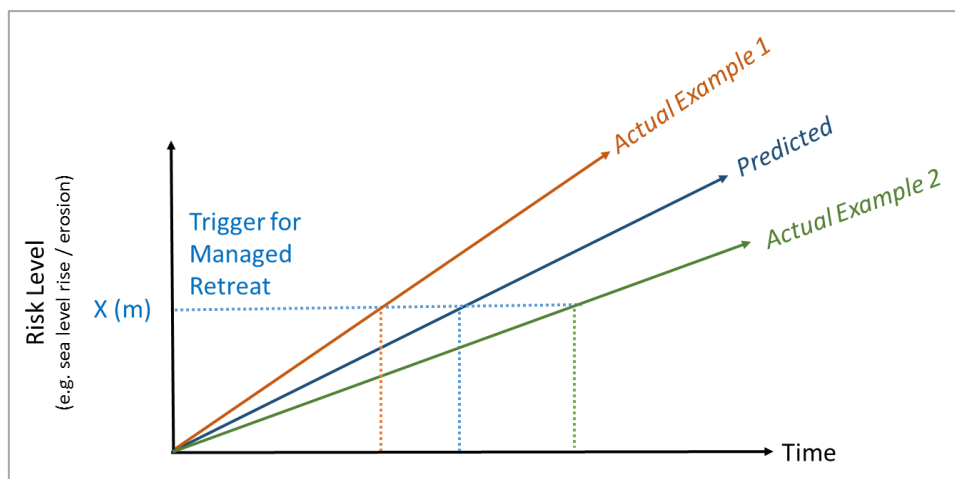


Figure 1-6 Conceptual timing for managed retreat in relation to predicted coastal hazards

1.4 Key Coastal Processes Concepts

A basic understanding of coastal processes is important for understanding the issues and constraints associated with managing the hazards of sea level rise and coastal erosion. **Figure 1-7 a)** illustrates the multiple processes involved in adding (accretion; yellow) and removing (erosion; red) sediment from the shoreline. The size of the arrows broadly represent the volume of sediment movement involved in each process. **Figure 1-7 b)** shows how a storm can remove sediment from the beach and reshape the shoreline profile, due to a combination of elevated water level and wave action. As mean sea level increases, storms can have a greater inland 'reach' and less of the removed sediment returns to the beach, leading to long term recession.

A key step in the coastal hazard identification is the definition of a horizontal shoreline datum (HSD) along the coastline, which "should define the active limit of the shoreline under storm activity" (WAPC, 2013a). Effectively the HSD is the shoreline at a particular point in time that can then be used as a bench mark or reference for assessing historic and future potential shoreline movement. For the Shire's predominantly sandy coastline, this has generally been determined from the 2012 LIDAR survey data as the point of intersection of the local peak still water level (determined at each town) with the beach/foredune surface level profile. This point is typically close to the seaward margin of coastal vegetation at the time of assessment (see MRA, 2016 and GHD, 2015). The HSD is the bench mark from which the extent of coastal hazards, at each planning timeframe, is measured. The HSD presented in hazard mapping for this CHRMAP has been defined for the 'present day' at the time that each coastal hazard assessment was undertaken (generally based on the 2012 LIDAR survey information). The HSD is constantly moving and its position, relative to assets and future monitoring of the shoreline position and determination a future HSD, is one of the key triggers for implementing management responses. It must be noted that future revisions of this CHRMAP will be based on new information, and the HSD and hazard lines will be recalculated accordingly.

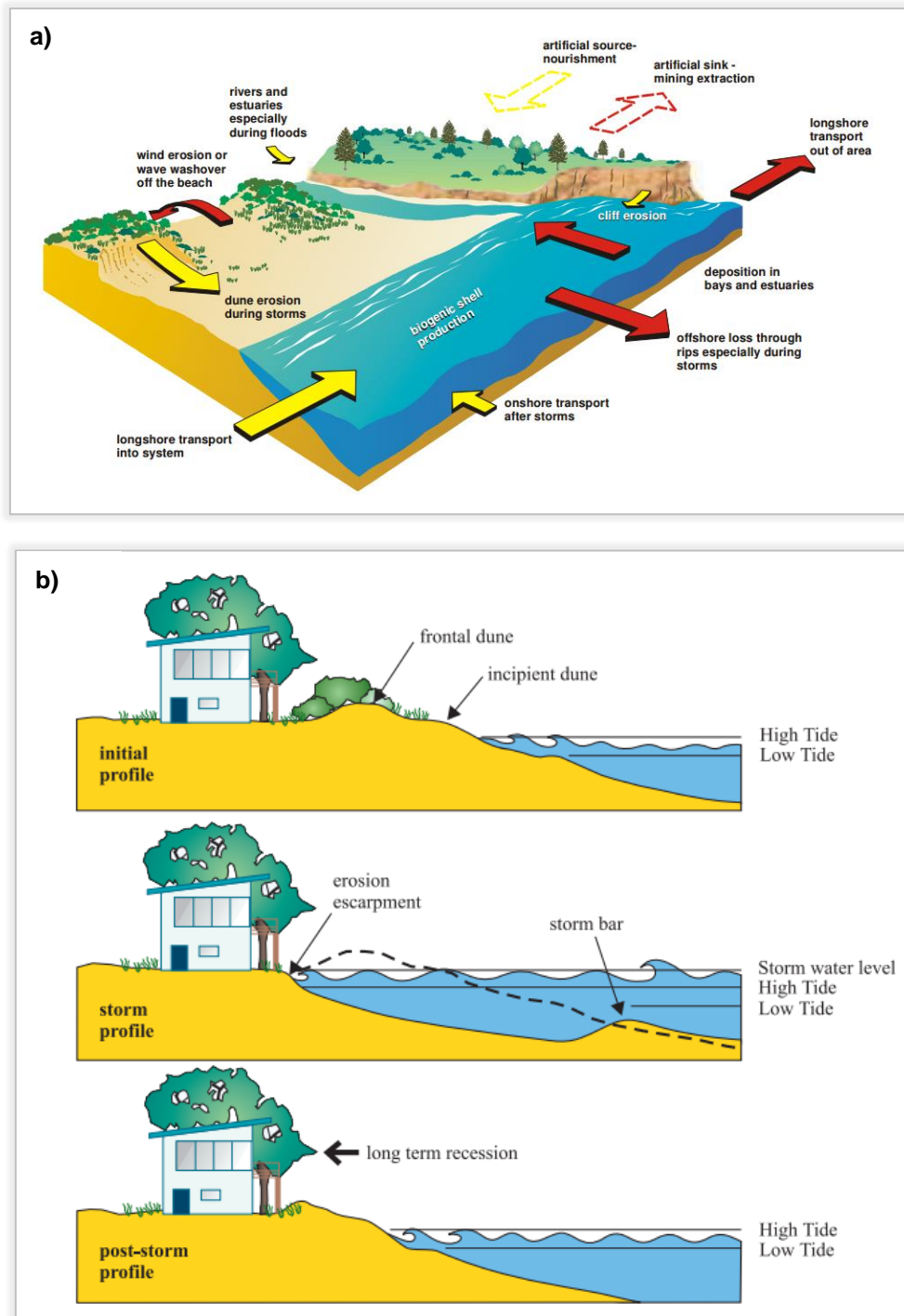


Figure 1-7 Conceptual representation of key coastal erosion concepts; a) sediment transport processes and b) long term beach recession due to permanent sand loss (source: NSW Department of Land and Water Conservation, 2001)

1.5 Previous Assessments

In 2012 the WA Department of Planning commissioned the study *The Coast of the Shires of Gingin and Dandaragan (WA): Geology, Geomorphology and Vulnerability* (Eliot et al, 2012). This study assessed the sensitivity and exposure of coastal landforms from Guilderton to North Head (north of Jurien Bay) and identified that all town sites along this stretch of coast are located on landforms that have a moderate or moderate to high vulnerability to changing coastal processes (winds, tides, currents, waves and sea levels). The study recommended detailed investigations to identify the potential extent of long term coastal erosion and inundation at priority locations.

In 2013 the Shire partnered with the Shire of Gingin and the Northern Agricultural Catchments Council (NACC) to identify the range of data and information required to undertake coastal hazard assessments at the priority locations outlined in the *Hill Primary Coastal Compartment Information and Data Gap Analysis* (Danese, 2013).

In 2014, in accordance with the recommendations made by Danese (2013), the Shire partnered with the Shire of Gingin, the NACC and the WA Department of Transport to undertake a preliminary assessment of coastal hazards at each town site in the study area. The preliminary findings of the assessment identified that:

1. Adaptation planning for coastal erosion is a priority at Seabird, Ledge Point, Lancelin, Cervantes and Jurien Bay town centre. Guilderton and South Jurien Bay (from Island Point south) were identified as low priority areas, mainly due to the relatively large coastal setback distance between the high water mark and built assets at these locations and, therefore, lack of a short term threat from coastal erosion;
2. Adaptation planning for coastal inundation is a priority at Lancelin, Cervantes and Jurien Bay. This is mainly due to the low lying nature of, and proximity of assets to, the shoreline at these locations;
3. Adaptation planning for coastal inundation at Guilderton requires a detailed investigation of the combined effects of inundation from the ocean and inland rainfall events, due to Guilderton's location on the Moore River estuary.

This current CHRMAP addresses the first of these recommendations with a focus on the areas identified at risk from coastal erosion hazards.

1.6 CHRMAP Format

This document has been designed to inform the community and provide direction to the Shire for planning for climate change induced coastal erosion risks facing the coastal townships of the Dandaragan Shire. An overview of the CHRMAP process and how it has been covered in the structure of this document is provided in **Figure 1-8**. The structure of the document also allows for the information base and planning context of individual assets or groups of assets to be separated from the main document with Appendices formatted as separate sheets provided for each of the coastal assets. The Appendices are as follows:

- > **Appendix A** – Hazard Maps by Management Unit
- > **Appendix B** – Value Maps
- > **Appendix C** – Asset Information for each of the Management Units
- > **Appendix D** – Technical Note on Risk Assessment Methods
- > **Appendix E** – Risk Assessment Ratings and Results
- > **Appendix F** – Multi-Criteria Analysis Results
- > **Appendix G** – Multi-Criteria Analysis Summary
- > **Appendix H** – Planning Controls Discussion
- > **Appendix I** – Long Term Pathways

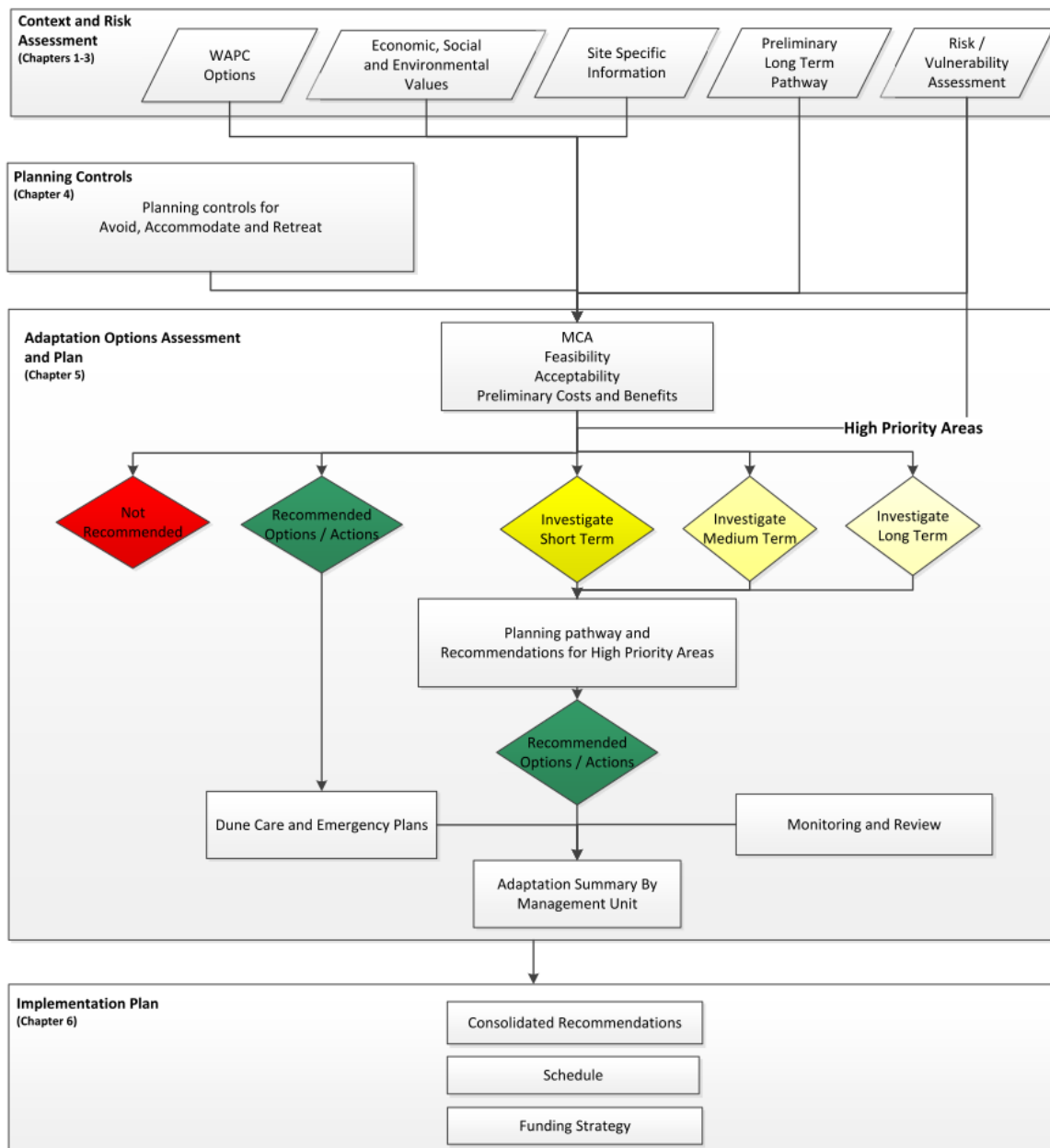


Figure 1-8 Overview of the CHRMAP process and its relationship to the chapters in this document.

2 ESTABLISHING THE CONTEXT

2.1 Shire of Dandaragan

The Shire of Dandaragan is located approximately 200 kilometres north of Perth. There are four townships within the Shire; the inland towns of Badgingarra and Dandaragan, and coastal towns of Jurien Bay and Cervantes (**Figure 1-2**).

The Shire of Dandaragan has an approximate population of 3,325. The major townships of Jurien Bay and Cervantes have estimated populations of 1,500 and 545 respectively (Shire of Dandaragan, 2016). The coastal areas encounter a large influx of people during the summer months and holiday periods, with the local population rising to approximately 4500-5000.

Mining is the largest industry sector in terms of gross value added to the local economy, however the agricultural, farming and fishing sectors are the major employers in the region. Tourism and hospitality have shown the fastest employment growth rates, but remain subject to the seasonal influx of the holiday periods (Shire of Dandaragan, 2016).

This CHRMAP focuses on the coastal zones within the existing gazetted town sites including future development areas, where the services from human-made and natural assets provide key social, economic and environmental values to the community. Coastal areas outside of the towns may also be exposed to the potential impacts of coastal hazards. Any future development outside of the study areas should avoid potential coastal hazards. The absence of human-made assets in these locations is likely to allow for the natural adaptation of the coastline to sea level rise. A brief description of each of the townships is provided in the following two sub-sections and a summary of their key attributes is presented in **Table 2-1** and the coastal management units boundaries and zoning of properties located seaward of the 2110 Hazard Line are presented in the maps shown in **Appendix A**.

Table 2-1 CHRMAP location key attributes

CHRMAP Area	Number of Ratepayers ¹	Estimate Number of Residents [#]	Approximate coastline length assessed (km)	Number of Management Units
Jurien Bay	990	1500	5.5	4
Cervantes	487	545	3.7	4

¹Estimated as the number of improved blocks, [#]Estimated

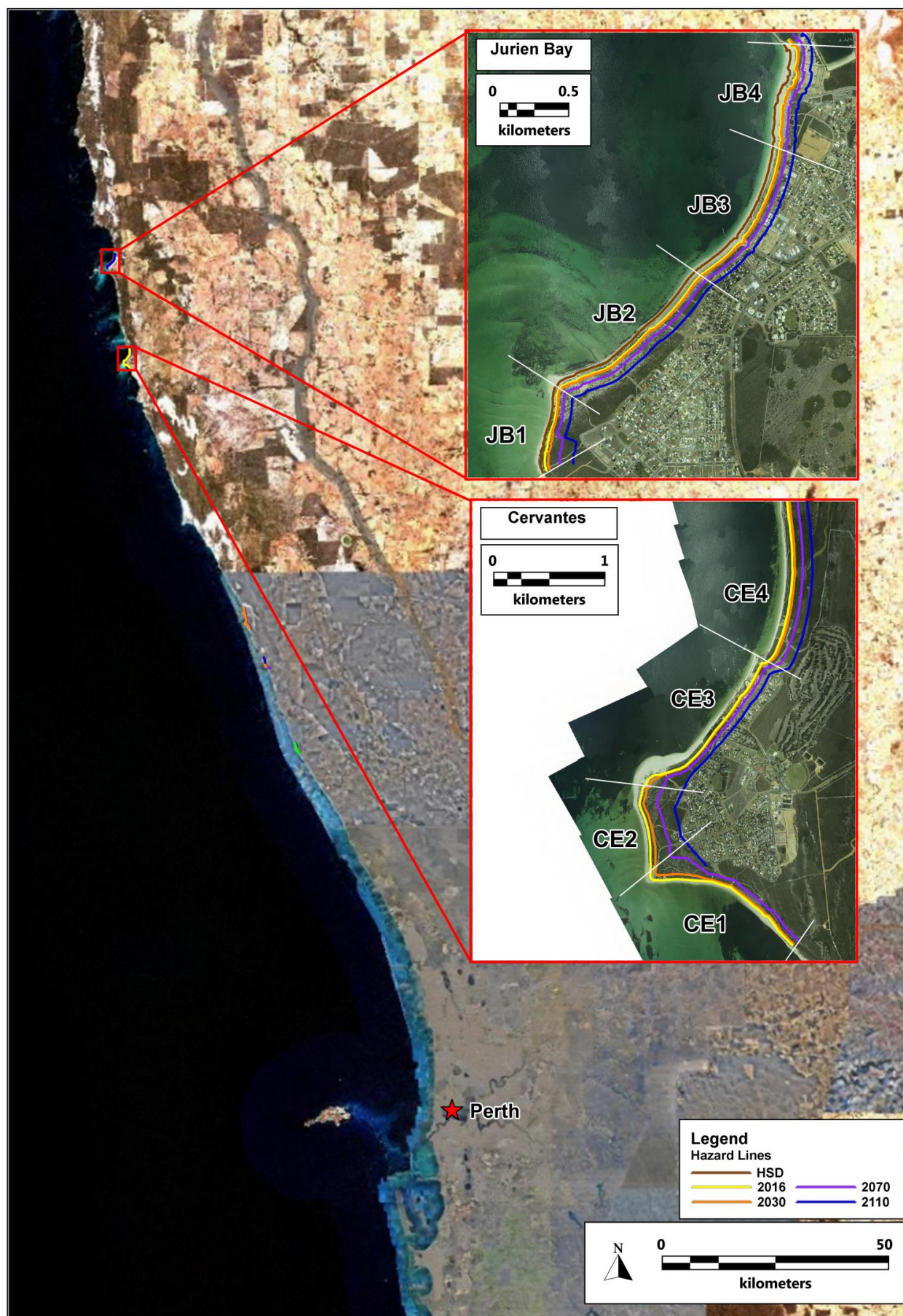


Figure 2-1 CHRMAP location map, townships and management unit boundaries

2.2 Cervantes

The township of Cervantes is located approximately 180 km north of Perth (**Figure 2-1**) and was gazetted in 1963. It is a regional centre that services the State's crayfishing industry. Tourism is also important for the town, located nearby the Pinnacles in Nambung National Park, and the saline Lake Thetis, which contains Stromatolites. The local population is around 550 (**Table 2-1**).

The townsite is located on a prominent sand foreland, called Thirsty Point (**Figure 2-2**), which protrudes over one km seaward from the general shoreline alignment and is situated in the lee of shallow offshore reefs (Short, 2006). Cervantes has a line of reef and the Cervantes Islands offshore, running parallel to the general shoreline alignment. These formations provide protection from wave energy to the Cervantes townsite. Sandy cusped forelands, such as Thirsty Point, often form in the lee of such offshore reefs and islands and it is quite common for the shorelines of these forelands to move over decadal time scales. Historical shoreline movement plots indicate that the shoreline of the Cervantes cusped foreland has changed substantially since 1943 (MRA, 2016).

Cervantes is located at the boundary between coastal sediment cells 25 and 26, both of which were assessed as having moderate vulnerability by Eliot et al (2012). Broad scale geological mapping covering the Cervantes townsite indicates Coastal Limestone may be present along the coast in this area; however, no rock was visible on the beach or in the dunes during a site visit undertaken in December 2015 (MRA, 2016). In the absence of detailed geotechnical information, the Cervantes area was classified as a sandy coast for the purpose of coastal hazard assessment (MRA, 2016).

Several man made coastal structures are present along the town's shoreline. A groyne was constructed at the northern end of the Cervantes townsite in 1992. A seawall was constructed in front of the Lobster Shack, and a jetty abutment was constructed approximately 120m south of the Lobster Shack (MRA, 2016).

The hazard assessment extended along approximately six km of the town's shoreline, and for risk assessment and adaptation planning purposes, the CHRMAP has divided this area into four management units (**Figure 2-1**).



Figure 2-2 Photographs of Cervantes coastline and jetty (source: NAA and DoT)

2.3 Jurien Bay

The township of Jurien Bay is located approximately 200 km north of the Perth Metropolitan area (**Figure 2-1**). It has an estimated population of around 1500 (**Table 2-1**). The first settlement was established in the mid-1850s and a jetty was constructed in 1885–87 due to the success of pastoralism at the time. The townsite was gazetted in 1956 (Landgate, 2017). It is a regional centre that has experienced substantial population growth in recent decades.

Island Point in Jurien Bay is a cusped foreland (**Figure 2-3**) that has formed in the lee of a chain of submerged reefs and island chains consisting of Escape, Whitlock, and Boulanger Islands (GHD, 2015). The long-term stability of the geomorphic landform at Island Point is dependent upon the stability provided by this island chain and the ongoing supply of sand that originates from the lee of these islands as 'sand slugs', which are currently connected to the accretion of the northern side of Island Point (GHD, 2015). Jurien Bay was identified as being located at the boundary between sediment cells 29 and 30, which were assessed as having moderate-high and moderate vulnerability, respectively, by Eliot et al (2012).

Coastal structures in the area include a curved jetty in management area JB3 and the Jurien Bay Marina, located at the northern boundary of the study area.

The hazard assessment extended along approximately four km of the town's shoreline, and for risk assessment and adaptation planning purposes, the CHRMAP has divided this area into four management units (**Figure 2-1**). The southern boundary of the study area is located at Island Point. Development within the coastal zone extends some 1.5 km south-east of Island Pt, including the recent development within about 200 m of the shore which is not included in this CHRMAP.



Figure 2-3 Aerial view of Jurien Bay (source: Jurien Bay Holiday, <http://www.jurienbayholidays.com/>)

2.4 Stakeholder and Community Engagement

2.4.1 Objectives

Community and stakeholder engagement is an important element of the CHRMAP process, as depicted in **Figure 1-3**. It is necessary to identify the values provided by the study area, to determine the tolerability of risks and to assess the acceptability of adaptation options designed to preserve the area's value.

The objectives of the community and stakeholder engagement process include:

- > To inform the community about the extent of potential coastal hazards, adaptation strategies available to respond to those hazards and the need for flexibility in response to future environmental, social and economic changes;
- > To explain the State and local governments' responsibilities and capacity to respond to potential coastal hazards;
- > To explain the benefits and challenges of each adaptation strategy, in terms of the meaning for residents and landowners, as well as the broader community;
- > To provide community members with multiple opportunities to provide input into proposed adaptation strategies, and to offer alternative strategies or to voice questions and concerns;
- > To receive and document feedback and concerns regarding each adaptation strategy from community members and affected residents and landowners; and
- > To report on the feedback, including analysis that highlights the level of community understanding, the principal concerns and preferences concerning the proposed adaptation strategies and funding mechanisms, and preferred methods of continued community engagement.

2.4.2 Methods

Since 2012, the Shire has worked closely with the Shire of Gingin, the NACC, State Government agencies, coastal specialists and the local community to investigate the hazards and risks to the Shire's coastline, and to develop strategies for adapting to them. In 2013 and 2014 the Shire provided opportunities for the community and stakeholder groups to learn about the Shire's CHRMAP process through workshops with government agencies and public information sessions.

Stakeholder and community engagement undertaken for this CHRMAP has focused on capturing the coastal values of the community, informing the public about coastal hazards and the CHRMAP process, and gauging attitudes towards various adaptation options. A community engagement session was facilitated by the Shire in Jurien Bay on the 27th of May 2017 (**Figure 2-4**). This was followed by an online survey that was conducted in June 2017.



Figure 2-4 Community engagement session at Jurien Bay in May 2017.

2.5 Social and Environmental Values

An ecosystems services approach has been used to identify the natural and social values of the coast (**Figure 2-5**). The results of recent community engagement highlighted the strong sentiment regarding the natural values of the beach. Respondents sometimes struggled to find words to describe the importance of the beach to them and their sense of health and wellbeing. When asked if there were any other values the coast provided them, an example answer was:

“Yes too many to list, e g aesthetics, relaxing, peacefulness, regeneration, good sources for juvenile aquatic animals, space for all animals including those pesky humans, preservation for, & adaptability for climate variability”

It is difficult to place an economic value on natural coastal assets such as the beach and dune systems. Identifying the value of natural assets through community engagement, and maintaining a focus on these values throughout the CHRMAP process is critical to its success. Maps showing social, cultural and environmental values for the CHRMAP study areas are provided in **Appendix B**. The maps provide a broad indication of threatened ecological communities, rare and endangered flora and fauna potentially present (noting that, as required by government agencies, the locations are only approximate to within the Management Unit).

While the results of the surveys are discussed in the following **Section 2.6** the general sentiment of the community may be summarised as follows:

- Strong disagreement that protection of private property should be prioritised over preservation of beaches,
- Strong support for relocation of assets and let nature take its course,
- Strong support for limiting intensity of development in hazard areas, and
- Strong support for informing landholders of hazard risk.



Figure 2-5 Ecosystem services approach to defining coastal values

2.6 Survey Results

2.6.1 Context

The coastal values survey was completed by 69 respondents. Contextual information results from the online survey are provided in **Figure 2-6**. The results show that more than 50% of respondents visit the beach on a daily or weekly basis, with the most common answer for which beach is visited being “Jurien Bay Main Beach”. Indicative beach usage by management unit based on the survey results is proved in **Table 2-2**.

Most respondents believed they either have some idea of the causes of coastal erosion (35%) or considered themselves to be well informed (35%). The majority of respondents (70%) had viewed the hazard maps, but there was moderate to high level of concern (33% very concerned and 43% somewhat concerned) about the coastal erosion.

The largest group of respondents were aged between 60 – 75, but other age groups were also well represented with around 20% aged from 30 – 39 and a further 25% aged 50 – 59. More than 10 % were aged less than 20, which suggests that the survey captured the sentiments of a wide demographic. Around 65% of respondents were landowners in the Shire, but a majority did not live in areas identified as being vulnerable to coastal erosion.

Of the 58 respondents who provided their postcode, 64% lived in Jurien Bay (6516) and 19% in Cervantes (6511). The majority of the remaining 17% of respondents were from outside the Dandaragan LGA. The inland area of Badgingarra (postcode 6521) had a total of three respondents. The concentration of response from the coastal areas being investigated within the Dandaragan LGA should be noted in interpreting the results of this

community engagement. It should also be considered prior to any funding for coastal management being sought from ratepayers in areas underrepresented in this community engagement process.

Table 2-2 Indicative beach usage by management unit based on survey results

Cervantes		Jurien Bay	
Management Unit	Number	Management Unit	Number
Cervantes 1 (CE1)	13	Jurien Bay 1 (JB1)	11
Cervantes 2 (CE2)	7	Jurien Bay 2 (JB2)	13
Cervantes 3 (CE3)	11	Jurien Bay 3 (JB3)	40
Cervantes 4 (CE4)	1	Jurien Bay 4 (JB4)	11

2.6.2 Coastal Values

The questions on coastal values showed strongest support for opportunities to use beaches for passive recreation, and ongoing provision of foreshore reserved for current and future generations (**Figure 2-7**). Opportunities for commercial enterprises and active recreations (i.e. boat ramps and jetties) received the least support, but the majority of respondents (around 70%) agreed that these opportunities should be provided.

2.6.3 Adaptation Options

The responses relating to adaptation options showed very strong support for retaining public access to beaches and foreshore reserves and preserving coastal dunes and vegetation for future generations (**Figure 2-7**). There was also strong support for not allowing more intensive development (such as units where there is a single house) in hazard areas. Respondents strongly agreed that private landowners should be informed about the risk of erosion when purchasing or developing in hazard areas.

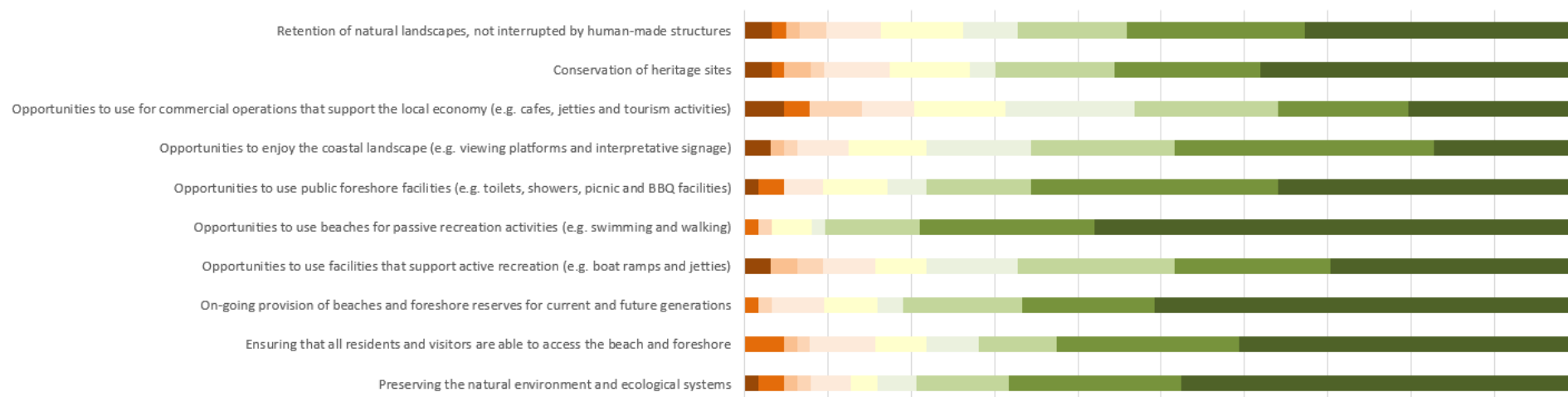
There was a high level of disagreement for protecting private property from erosion, when this results in the loss of the public foreshore reserve and beach access. There was also strong disagreement for allowing the continuation of approved land uses in developed areas until erosion becomes intolerable, suggesting that a “do-nothing” approach is not acceptable.

There was moderate support for allowing private land owners to protect their property where they have demonstrated there will be no impact on the adjoining coast, and moderate support also for relocating assets away from the coast and letting natural processes take their course. The responses to these questions have been taken into consideration in formulating the adaptation plans discussed in **Section 4**.



Figure 2-6 Summary charts of online survey questionnaire responses

Coastal Values



Adaptation Options

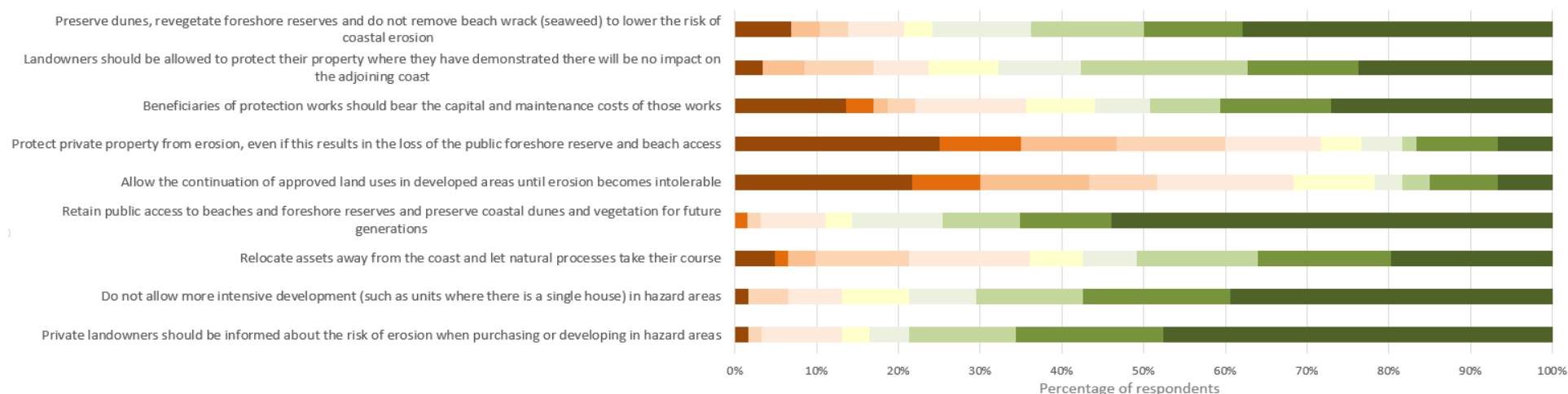


Figure 2-7 Responses to questions “what do you value about the coast” and “how strongly do you support the following erosion management approaches”. Generally, more green indicates more agreement and more red indicates more disagreement.

2.7 Planning Framework

Planning in Western Australia is guided by the *State Planning Framework*, that outlines the relationships and hierarchy of responsibilities of different levels of government and planning instruments, as summarised in **Figure 2-8**. Strategic plans at State, regional and local levels inform the development of statutory controls.

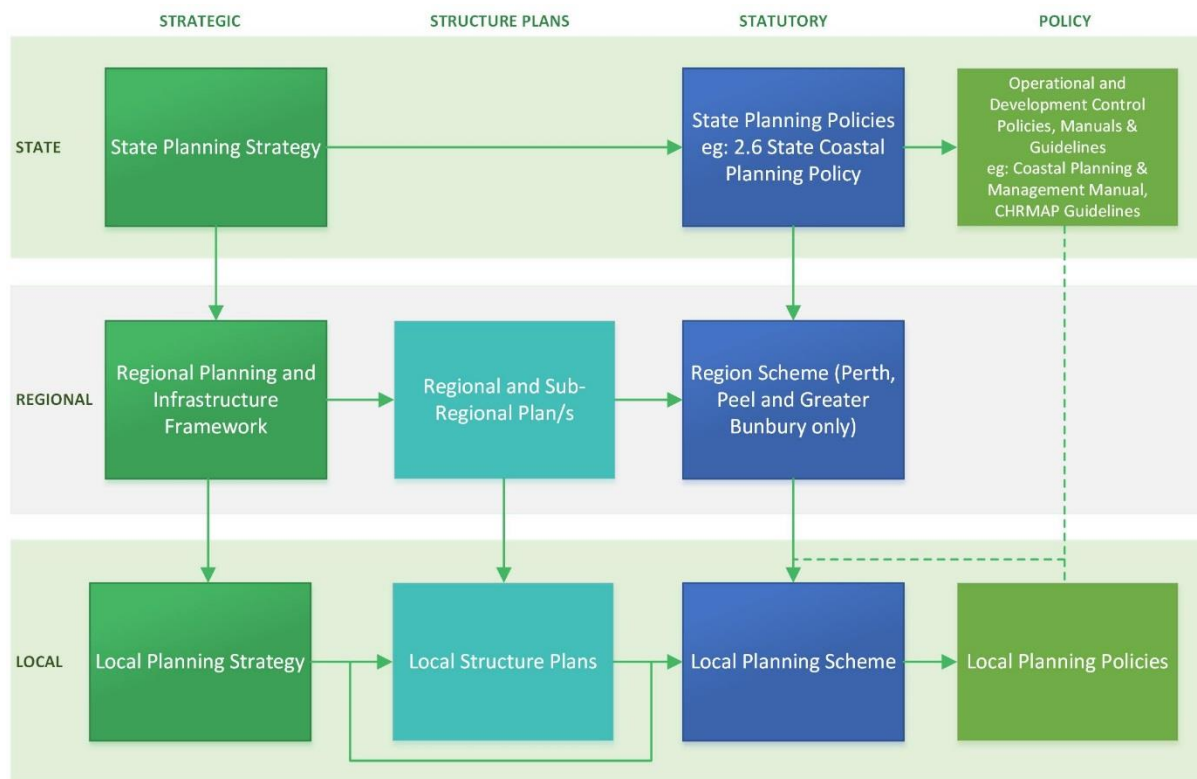


Figure 2-8 Planning context overview

The key strategic planning documents that have guided development of the coastal towns within the Dandaragan Shire are:

- State Planning Strategy 2050 (State)
- Wheatbelt Planning and Infrastructure Framework 2015 – (Regional)
- Local Planning Strategy – Rural land Use and Rural Settlement (Local)

In addition to these strategic guidance documents the following Plans and Policies provide the context for development in the local areas:

- Local Planning Scheme No. 7 (LPS 7)
- State Planning Policy: Coastal Planning Policy (SPP 2.6)
- Jurien Bay Regional Centre Growth Plan (Growth Plan)
- Jurien Bay City Centre Strategy Plan (Centre Plan)
- Local Tourism Planning Strategy (Tourism Strategy)

The requirement for Local governments to produce a CHRMAP is described in SPP2.6 and the WAPC (2014a) guidelines outline the steps for local government to develop the CHRMAP document. The CHRMAP is a local level policy document that can provide recommendations for implementation of local planning adjustments, if required and adopted by the Shire, to bring about change in line with mitigating the future effects of sea level rise and coastal erosion on coastal infrastructure.

The planning process, in relation to Dandaragan, is outlined in the following sections.

2.7.1 Strategic Plans

The *State Planning Strategy 2050* provides a strategic framework, principles, strategic goals and strategic directions for planning and development in Western Australia. In relation to climate change, this strategy identifies the Shire of Dandaragan coast as being at risk of coastal landform change. It makes key statements

that are fundamental to the approach taken to coastal hazard risk assessment and adaptation planning, including:

- > *Retaining natural bushland and coastal areas that are accessible is essential to human health and a sense of wellbeing, and*
- > *All decisions about sustained growth and prosperity must strike the appropriate balance between environmental issues, economic conditions and community wellbeing.*

At the regional level the *Wheatbelt Planning and Infrastructure Framework 2015* (Wheatbelt PIF) identifies the following key regional strategic planning initiative:

- > *Identification of required planning responses following completion of the Coastal Hazard Risk Management and Adaptation Planning Study being carried out by the shires of Dandaragan and Gingin, and*

The *Local Planning Strategy*, generally aligns with the Wheatbelt PIF strategy direction, however it is largely silent of the effects of climate change and the hazards associated with coastal processes and SLR.

The *Local Planning Strategy* identifies land along the coast west of Indian Ocean Drive and extending from Cervantes townsite in the south to the northern boundary of the Shire as 'Planning Unit 1 – Coastal Settlement'. A separate local planning strategy for this area was to be prepared for approval by the Minister for Planning. Although not expressly identified as such, the *Jurien Bay Regional Growth Centre Plan* prepared in 2012 as part of the Royalties for Regions SuperTown programme is essentially a planning strategy for Jurien Bay and its immediate surrounds.

A draft revised *Local Planning Strategy* (December 2016) draws together the planning framework for the whole Shire by considering the coastal settlement area and incorporating the substance of the Rural Land Use and Rural Settlement Strategy into a single document combined with the planning elements of the Growth Plan. Once approved, the current Local Planning Strategy (2012) will be superseded. The *draft Local Planning Strategy* (2016) addresses coastal processes, and identifies this CHRMAP as a document that will be modified over time as more detailed and updated scientific information is made available on the climate change and coastal impacts. The draft document acknowledges that appropriate coastal setbacks are important, and that engineering solutions to protect coastal infrastructure or residential/tourist development may be required (matters addressed by this CHRMAP).

The draft strategy includes the following strategic directions for Jurien Bay that are relevant to coastal land:

- Consolidate urban areas and support mixed use sites;
- Acknowledge that there are sufficient vacant lots and land zoned for residential use to satisfy demand beyond 15 years.

For Cervantes the draft strategy aims to recognise the town as a small and discrete town with a coastal character and a focus on tourism, and seeks to:

- Concentrate on development and intensification of existing zoned land; and
- Prevent ad-hoc or fragmented development of land to provide for long term consolidation of Cervantes.

Other strategies in the draft *Local Planning Strategy* include:

- Prepare a strategic plan for land north of the Cervantes townsite identified as that addresses coastal vulnerability, ground and surface water, servicing and infrastructure, conservation, fire management and linkages to the rural residential land (Marine Fields) to the north.
- New development and coastal facilities to be within areas that can be protected from coastal processes and hazards;
- Identify areas in which a detailed Coastal Hazard Risk Management and Adaptation Planning (CHRMAP) needs to be undertaken before rezoning, subdivision or development occur, such as areas that may be subject to coastal inundation and long-term erosion over the planning timeframe;
- Undertake coastal adaptation planning to identify assets, including infrastructure that may be at risk from coastal processes over the planning timeframe, and develop strategies to mitigate or manage risks where appropriate.

The draft *Local Planning Strategy* is expected to be adopted by the Shire in 2018.

2.7.2 Statutory Plans & Policies

State Planning Policies (SPPs) provide the highest level of planning policy control and guidance in Western Australia and are prepared under Part 3 of the Planning and Development Act 2005. The State Coastal Policy (SPP 2.6) is an environmental sector policy consistent with the higher order SPP 2 Environmental and Natural Resources Policy.

As there is no statutory region planning scheme applicable to the Shire of Dandaragan the key statutory planning document for the Shire of Dandaragan is *Local Planning Scheme No. 7* (LPS 7). This applies zones and reserves to land within the Shire and outlines the permissibility of land uses, the requirements for development and the processes for seeking approval for proposed development. LPS 7 was gazetted on 24 October 2006 and has been amended several times since.

One of the stated aims of LPS 7 set out in clause 1.6 and which can be inferred to relate to sensitive coastal planning is *“Protection and enhancement of the environmental values and natural resources and to promote ecologically sustainable land use and development.”*

Deemed provision 67 relates to matters to be considered by local government in considering an application for development approval. Clause 67 requires the local government is to have due regard to a number of matters to the extent that, in the opinion of the local government, those matters are relevant to the development the subject of the application. Amongst those matters, the following can be said to relate directly to matters of coastal planning and coastal hazards:

- (c) *any approved State planning policy;*
- (q) *the suitability of the land for the development taking into account the possible risk of flooding, tidal inundation, subsidence, landslip, bush fire, soil erosion, land degradation or any other risk;*
- (r) *the suitability of the land for the development taking into account the possible risk to human health or safety.*

The only direct reference to coastal hazard planning in LPS 7 at present is in Schedule 4 Special Use Zones, in relation to Special Use Zone No. 4 (SUZ 4). SUZ 4 relates to Lot 62 (No. 20) Roberts Street and a portion of Heaton Road road reserve, Jurien Bay. A range of tourism, recreation, residential and commercial activities are permitted in this zone. Two clauses in particular make reference to coastal hazards, as follows:

- 6. *Prior to the approval of development on the site a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) is to be prepared in accordance with State Planning Policy 2.6 State Coastal Policy and approved by the local government. The CHRMAP should include but not be limited to consideration of inundation, erosion, finished floor levels, setbacks and drainage. Relevant adaptation measures are to be implemented at the time of development.*
- 14. *A notification to the following effect is to be placed on the certificate(s) of title of any proposed lot(s) identified in the Coastal Hazard Risk Management and Adaptation Plan that may be affected by coastal hazards: Vulnerable coastal area – This lot is located in an area likely to be subject to coastal erosion/inundation over the next 100 years.*

2.7.3 Local Structure Plans

Local Structure Plans can be made under LPS 7 via the mechanisms provided in Part 4 of the Deemed Provisions set out in the *Regulations*. A structure plan is not a statutory document, but decision makers for applications for development or subdivision approval within a structure plan area must have regard to its content when deciding the application. Decision makers are not bound by the structure plan, but it would require compelling alternative considerations to ignore its intent.

The *Turquoise Coast Structure Plan* (2003) is a district structure plan that comprises approximately 2,000 hectares of land owned by Ardross Estates Pty. Ltd. It extends along the coast from the southern end of the Jurien Bay townsite to Hill River and is bordered by Indian Ocean Drive to the east. The structure plan indicates that foreshore reserves will be reviewed and refined at the development plan stage to address the provisions of the *State Coastal Policy*. Individual local structure plans are being prepared progressively for individual estates within the overall district structure plan area. To date, only one has been endorsed, which is adjacent to the coast.

It can be expected that adequate provision will be made for coastal processes within structure plans prepared on land that is currently undeveloped, with due regard being made to the recommendations of this CHRMAP.

2.7.4 Local Planning Policies

Local planning policies can be made under LPS 7 via the mechanisms provided in Division 2 of Part 2 of the Deemed Provisions set out in the *Planning and Development (Local Planning Scheme) Regulations 2015* (the *Regulations*).

The Shire of Dandaragan does not currently have any local planning policies that relate specifically to development of coastal land.

2.7.5 Local Planning Horizons

Local planning schemes require a review every five years to ensure the scheme remains current with respect to current issues, trends and policy and the strategy context. Local planning strategies, which provide the broader planning direction within which the local planning scheme operates, typically have a planning horizon of 10 to 15 years. The CHRMAP establishes strategy for adapting to sea level rise and coastal erosion over the next 100 years at a range of time scales from short term (next 5-10 years), medium term (10 to 40 years) and long term (40 to 100 years).

As development itself has a much longer horizon, coastal hazard assessment uses a 100-year horizon. Therefore, when assessments indicate zoned land may be impacted by coastal processes within the next hundred years (even if the likelihood of the hazard having an impact may be beyond the horizon of current planning instruments, including LPS 7) local government has a responsibility to the future community to direct new development away from high risk areas.

2.8 Risk Assessment Inputs

To effectively assess the risks and plan for the future management of the coastal zone, as illustrated in **Figure 2-9**, information is needed on:

- > Present and predicted future coastal hazards;
- > Existing assets, their value and lifecycles; and
- > Community and stakeholder values.

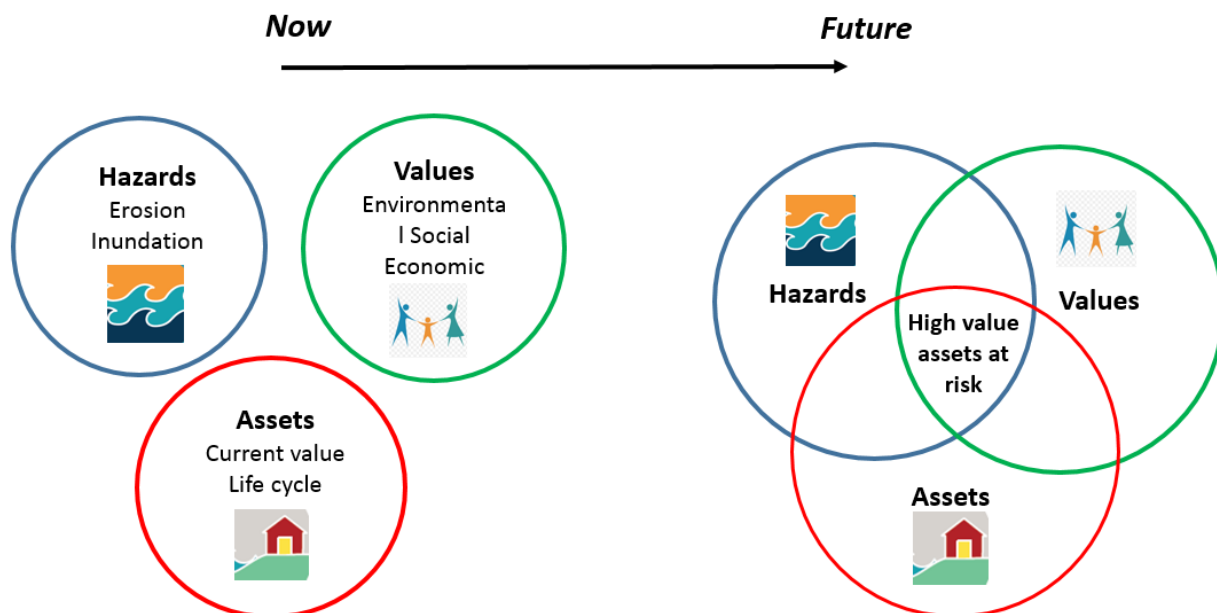


Figure 2-9 Conceptual relationship between key inputs to the coastal risk assessment process

The changing interrelationship between these components over time is the key to defining the priorities for future adaptation planning.

2.8.1 Hazards in each Management Unit

SPP2.6 Schedule One outlines the methodology for defining appropriate physical processes allowances, to ensure the use of coastal land accounts for coastal hazards over the next 100 years. Calculation of these allowances is based on a pragmatic approach to characterising coastal processes and includes four elements: storm erosion from a potential one in 100 year storm event (S1), historical erosion trends (S2) and predicted sea level rise (S3), and an allowance for uncertainty.

Coastal hazard assessments were undertaken for Cervantes by MRA (2016) and for Jurien Bay by GHD (2015). The assessments were reviewed and accepted for adaptation planning purposes by the WA Department of Transport and are available at the Shire's office. In accordance with SPP2.6, coastal erosion hazard lines have been collated for the present day (2016 at Cervantes; 2015 at Jurien Bay), 2030, 2070 and 2110 planning timeframes. The hazard maps are presented in **Appendix A**. A summary of the hazard assessment assumptions and calculated erosion allowances are presented in **Table 2-3** for each management unit. Erosion allowances and horizontal shoreline datum (HSD) were taken directly from the relevant coastal hazard report (MRA, 2016; GHD, 2015) or defined by Cardno where previously missing or incorrect.

Table 2-3 Coastal processes erosion allowance for present day and predicted conditions

Management Unit	HSD (m AHD)	S1 Erosion Allowance (m)	S2 Erosion Allowance (m/year)	Total Erosion Allowance (m)			
				Present-day (2016)	2030	2070	2110
Cervantes*							
CE1	+1.6	0 – 22	0.3 – 2.3	0 - 22	15 – 67	67 – 199	138 – 350
CE2	+1.6	22	1.8 – 2.3	22	59 - 67	171 – 199	302 – 350
CE3	+1.3	22 – 41	0 – 1.8^	22 - 41	48 – 78	80 – 190	131 – 321
CE4	+1.5	41 – 48	1	41 - 48	51 - 70	91 - 142	150 – 233
Jurien Bay#							
JB1	+1.6	30 – 40	1	30 - 40	40 - 55	81 – 136	139 – 234
JB2	+1.6	40 – 49	0	40 – 49	50 - 59	91 - 100	149 – 158
JB3	+1.6	49	0	49	59	100	158
JB4	+1.6	49	0	49	59	100	158

* Values for Cervantes are taken from MRA (2016)

Values for Jurien Bay are taken from a combination of GHD (2015) and values derived by Cardno

^ All but the southern boundary of this management area has an S2 erosion allowance of 0 m/year

2.8.2 Assets

As introduced in **Section 1.3.5**, assets include both natural and built features of coastal areas. Assets at risk of coastal erosion were identified by overlaying the hazard lines on aerial photomaps of each township. Residential property boundaries were drawn from the Shire's GIS cadastral layers, while all other assets were based on interpretation of aerial images only. A site visit was conducted to confirm asset classifications. Information on the assets at risk, existing coastal erosion controls and planning context/controls are provided for each management unit in **Appendix C**.

2.8.3 Values

It is clear that the community and visitors to the Shire place a high value on the natural coastal assets and foreshore amenities in each town. These values have been expressed on numerous occasions in the past through formal public consultations with the Shire, such as during the development of local planning documents and through feedback on development proposals. In establishing the values of assets and coastal areas for risk assessment, this social and environmental value has been fully considered, alongside economic value.

A summary of the values associated with assets at risk is provided for each management unit in **Appendix C**.

3 COASTAL HAZARD RISK ASSESSMENT

3.1 Risk Assessment Framework

To provide a transparent and logical basis for determining adaptation planning priorities, a risk assessment was undertaken based on the Australian Standard guideline *Climate change adaptation for settlements and infrastructure – A risk based approach* (AS5334-2013), and the CHRMAP guidelines (WAPC, 2014a). As illustrated in **Figure 3-1**, risk was assessed in relation to likelihood, consequence and adaptive capacity. Likelihood was assigned using the results of the hazard assessment and consequence ratings were informed by public consultation. Risk is considered to be the combination of likelihood and consequence, with consideration of adaptive capacity determining an asset's, or group of assets', overall vulnerability to climate change (as defined previously in **Section 2.8**).

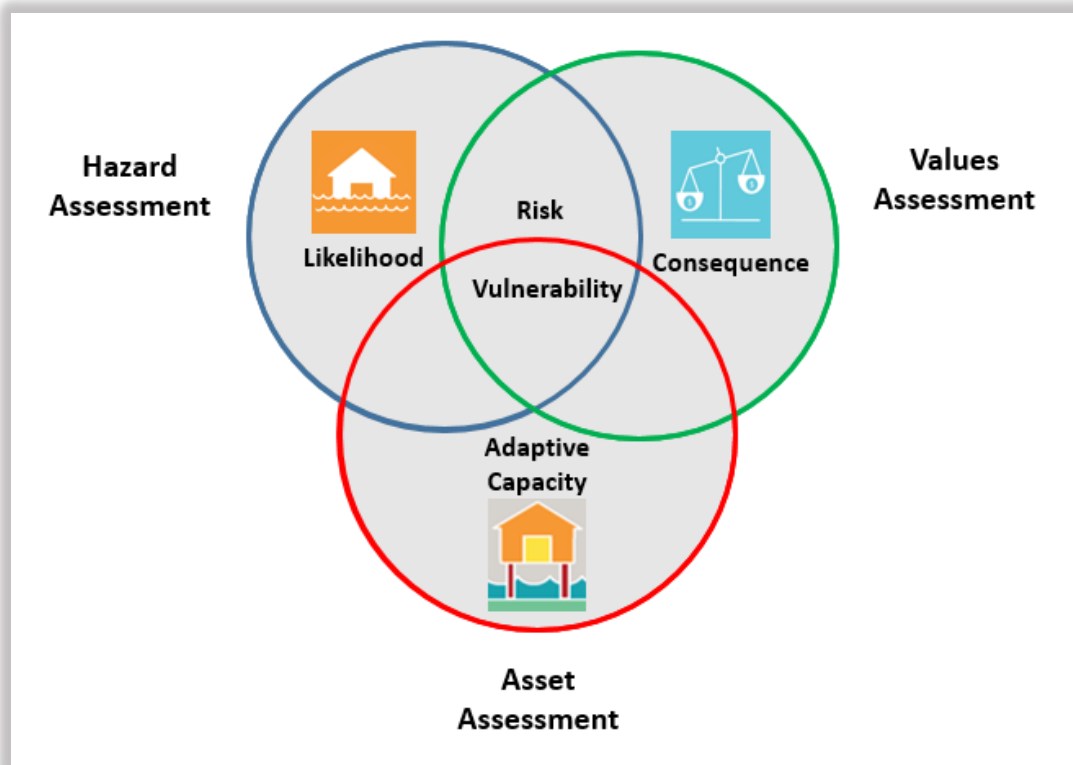


Figure 3-1 Conceptual relationship between risk assessment elements

Consequence and adaptive capacity criteria used in this assessment are presented in **0**. A full description of the risk assessment process is provided in **Appendix D**. A summary of the assigned likelihood, consequence and adaptive capacity ratings, as well as the resultant risk and vulnerability profiles over time are provided in **Appendix E** for assets within each management unit.

Table 3-1 Consequence and adaptive capacity criteria used in the risk assessment

Consequence			
Scale	Safety and Social	Economic	Environment and Heritage
Catastrophic	Loss of life and serious injury. Large long-term or permanent loss of services, public access/amenity, employment, wellbeing or culture. No suitable alternative sites exist within the LGA.	Permanent and/or entire loss or damage to property, plant and equipment, finances >\$10 million	Permanent loss of flora, fauna, conservation or heritage area (no chance of recovery).
Major	Serious injury. Medium term disruption to services, public access/amenity, employment, wellbeing or culture. Very limited suitable alternative sites exist within the LGA.	Permanent and/or large scale loss or damage to property, plant and equipment, finances > \$2 - \$10 million	Long-term and/or large scale loss of flora, fauna, conservation or heritage area (limited chance of recovery) with local impact.
Moderate	Minor injury. Major short term or minor long-term disruption to services/public access/amenity, employment, wellbeing or culture. Limited suitable alternative sites exist within the LGA.	Permanent loss or damage to property, plant and equipment, finances > \$100,000 - \$2 million	Medium-term and/or medium scale loss of flora, fauna, conservation or heritage area (recovery likely) with local impact.
Minor	Small to medium disruption to services, public access/amenity, employment, wellbeing or culture. Many suitable alternative sites exist within the LGA.	Permanent loss or damage to property, plant and equipment, finances > \$10,000 - \$100,000	Short-term and/or small scale loss of flora, fauna, conservation or heritage area (strong recovery) with local impact.
Insignificant	Minimal short term inconveniences to services, public access/amenity, employment, wellbeing or culture. Many suitable alternative sites exist within the LGA.	Permanent loss or damage to property, plant and equipment, finances < \$10,000	Negligible to no loss of flora, fauna, conservation or heritage area (strong recovery) with local impact.

Adaptive Capacity			
Scale	Physical / Engineering	Economic	Social and Environmental
Low	Little or no adaptive capacity. Potential impact would destroy all functionality. Not possible to relocate asset.	Cost to relocate or modify design of property, plant and equipment >\$10 million	Adaptation would significantly damage or negate current environmental and or social values
Moderate	Small amount of adaptive capacity. Difficult but possible to restore functionality through repair, redesign or relocation.	Cost to relocate or modify design of property, plant and equipment > \$2 - \$10 million	Limited natural adaptive capacity. Current environmental / social values would be negatively impacted.
High	Decent adaptive capacity. Functionality can be restored, although additional adaptive measures should still be considered. Natural adaptive capacity restored slowly over time under average conditions.	Cost to relocate or modify design of property, plant and equipment > \$100,000 - \$2 million	Current environmental / social values may be affected. Natural adaptive capacity restored over time under average conditions.
Very High	Good adaptive capacity. Functionality restored easily by repair, redesign or relocation.	Cost to relocate or modify design of property, plant and equipment > \$10,000 - \$100,000	Adaptation has little or no impact on current environmental and or social values.
Insignificant	Potential impact has insignificant effect on asset. Controls are re-established naturally or with ease before more damage would likely occur.	Cost to relocate or modify design of property, plant and equipment < \$10,000	Adaptation has may improve current environmental and or social values.

3.2 Risk Assessment Outcomes

The outcomes of the risk assessment are discussed for each management unit in the sub-sections below. The inputs to the risk assessment and the tabulated outcomes of the risk assessment process are presented in **Appendix E**.

3.2.1 CE1 – South of Thirsty Point

The South of Thirsty Point management unit contains predominantly natural assets such as the beach and vegetated dunes (**Figure 3-2**). Public infrastructure, including the Thirsty Point carpark and walk trail, lies seaward of the 2110 coastal hazard line. Recent erosion in the Thirsty Point area has necessitated the removal of a toilet block and retreat of the car park area. The Cervantes Lodge lies partially seaward of the 2110 hazard line. See **Appendix C** for more information on assets and their values in this management unit.

Existing physical controls associated with this management unit, which have been considered in the risk assessment process, include extensive offshore reefs, the Cervantes Islands and Thirsty Point at the northern boundary. The coastline has been treated as sandy for the purpose of coastal hazard assessment (MRA, 2016) and, subsequently, coastal hazard lines advance steadily landward over the assessed planning timeframes (see **Appendix A** and **Table 2-3**).

The Thirsty Point carpark and sections of the walk trail are predicted to be at risk by 2030, and Cervantes Lodge may be at risk by 2110. Due to the relatively low value and high adaptive capacity of the public assets at Thirsty Point, the vulnerability rating is generally low to medium for all assets across the planning timeframes (see **Appendix E**).

Key outcomes of the risk assessment for this management unit are as follows:

- > The Thirsty Point carpark has a medium vulnerability rating at present;
- > The coastal dunes/vegetation and the walk trail have medium vulnerability ratings towards the end of the century; and
- > Cervantes Lodge has a high vulnerability rating at the 2110 planning timeframe.



Figure 3-2 South of Thirsty Point CE1 management unit (source: RAC Parks & Resorts, <https://parksandresorts.rac.com.au/cervantes/park-info/things-to-do/>)

3.2.2 CE2 – Cervantes Township South

The Cervantes Township South management unit contains predominantly natural assets such as the beach and vegetated dunes. It contains 12 residential properties that are located partially or fully within the 2110 coastal hazard line, as well as roads and associated public infrastructure (**Figure 3-3**). Public infrastructure includes the carpark and ablution block at Ronsard Reserve. See **Appendix C** for more information on assets and their values in this management unit.

Existing controls associated with this management unit, which have been considered in the risk assessment process, include extensive offshore reefs, the Cervantes Islands and Thirsty Point at the southern boundary. The coastline has been treated as sandy for the purpose of coastal hazard assessment (MRA, 2016) and, subsequently, hazard lines advance steadily landward over the assessed planning timeframes (see **Appendix A** and **Table 2-3**).

Residential properties and Ronsard Reserve are predicted to be at risk of erosion by 2110. Due to the small number of properties, the consequences are rated as moderate and the properties have only medium vulnerability by 2070. Seville Street is highly vulnerable by 2070. Erosion is likely to lead to the degradation of dunes and the vegetated foreshore, impacting on the amenity of the beach and ecological values of the dunes in developed areas. These natural assets are considered to be highly vulnerable by 2110 (see **Appendix E**).

Key outcomes of the risk assessment for this management unit are as follows:

- > The beach and coastal dunes/vegetation have medium vulnerability ratings by 2070 and very high vulnerability ratings by 2110;
- > Seville Street has a medium vulnerability rating by 2030 and a high vulnerability rating by 2070; and
- > Residential properties and Thirsty Point carpark have high vulnerability ratings by 2110.



Figure 3-3 Cervantes Township South CE2 management unit (source: NACC)

3.2.3 CE3 – Cervantes Township Central

The Cervantes Township Central management unit contains 49 residential properties that are located partially or fully within the 2110 coastal hazard line, as well as roads and associated public infrastructure. Natural assets include the beach and foreshore reserve, which are bounded to various extents on the landward side by development, throughout the management unit. Commercial assets include the RAC Holiday Park, the light industrial area (Indian Ocean Lobsters and the Men's Shed) and the Seashells Café (**Figure 3-4**). It should be noted that the light industrial area is currently being rezoned to "Special Use – Tourism and Industry". The DoT-managed jetty and onshore fuel facilities lie at the northern end of the management unit. See **Appendix C** for more information on assets and their values in this management unit.

Existing physical controls associated with this management unit, which have been considered in the risk assessment process, include extensive nearshore and offshore reefs, the Cervantes Islands and the headland feature at the southern boundary. Manmade controls include the small seawall and jetty abutment near the crayfish factory, and a groyne at the northern boundary of the management unit. The coastline has been treated as sandy for the purpose of coastal hazard assessment (MRA, 2016) and, subsequently, hazard lines advance steadily landward over the assessed planning timeframes (see **Appendix A** and **Table 2-3**).

The beach, coastal dunes/vegetation and Light Industrial Area are all seen to be at high risk at present. For the Light Industrial Area this translates to a very high vulnerability rating at present. The beach and coastal dunes/vegetation are rated as highly vulnerable at present and have a very high vulnerability rating by 2070. The foreshore recreation area and residential areas west of Catalonia Street are at risk in 2070 and due to their high value and low adaptive capacity, they are considered to be very highly vulnerable by that time. Residences on Corunna Street and on the east side of Catalonia Street are at risk by 2070 (see **Appendix E**).

Key outcomes of the risk assessment for this management unit are as follows:

- > The Light Industrial Area has a very high vulnerability rating at present;
- > The beach and coastal dunes/vegetation have high vulnerability ratings at present and very high vulnerability ratings by 2070; and
- > All other assets or groups of assets in the management unit have high or very high vulnerability ratings by 2070.



Figure 3-4 Cervantes Township Central CE3 management unit and Catalonia Street (source: Western Australia for Everyone and view.com.au)

3.2.4 CE4 – Cervantes Township North

The Cervantes Township North management unit contains predominantly natural assets such as the beach and vegetated dunes. There are also unsealed tracks and a sailing club (which has recently been leased and taken over by the Fin Fishers Club) lying seaward of the 2110 coastal hazard line. There are also two residential properties at the southern end of the management unit, lying partially or fully seaward of the 2110 hazard line (**Figure 3-5**). See **Appendix C** for more information on assets and their values in this management unit.

Existing physical controls associated with this management unit, which have been considered in the risk assessment process, are extensive nearshore and offshore reefs, the Cervantes Islands and a groyne at the southern boundary of the management unit. The coastline has been treated as sandy for the purpose of coastal hazard assessment (MRA, 2016) and, subsequently, hazard lines advance steadily landward over the assessed planning timeframes (see **Appendix A** and **Table 2-3**).

Although the beach in its current state and the vegetated dune system is likely to be eroded over time, the lack of development landward of these areas means the consequence of the erosion is considered insignificant to minor. The adaptive capacity of these natural assets is also considered high through their ability to migrate inland. The risk profile and vulnerability of assets in this area are therefore low to medium across the planning timeframes. The medium rating is based on the assumption that inland migration of the dune habitat is likely, but it is not certain that all ecological functions will be retained (see **Appendix E**).

Key outcomes of the risk assessment for this management unit are as follows:

- > The beach has a low vulnerability rating across the planning timeframes and the coastal dunes/vegetation have a low vulnerability rating to 2030 and medium vulnerability rating by 2070;
- > Residential properties have a medium vulnerability rating by 2070; and
- > The Sailing Club has a medium vulnerability rating by 2030.



Figure 3-5 Cervantes Township North CE4 management unit (source: Peter Bellingham Photography)

3.2.5 JB1 – South of Island Point

The South of Island Point management unit contains predominantly natural assets such as the beach and vegetated dunes (**Figure 3-6**). As noted in Section 2.3 development within the coastal zone extends some 1.5 km south-east of Island Pt which is beyond the southern boundary of the study area and is not included in this CHRMAP. There is a sealed pedestrian trail running along the length of the management unit, that lies mostly seaward of the 2030 coastal hazard line. See **Appendix C** for more information on assets and their values in this management unit.

Existing physical controls associated with this management unit, which have been considered in the risk assessment process, include extensive offshore reefs and islands and the headland formations at both boundaries. The coastline has been treated as sandy for the purpose of coastal hazard assessment (MRA, 2016) and, subsequently, hazard lines advance steadily landward over the assessed planning timeframes (see **Appendix A** and **Table 2-3**).

Although the beach in its current state and the vegetated dune system is likely to be eroded over time, the lack of development landward of these areas means the consequence of the erosion is considered insignificant to minor. The adaptive capacity of these natural assets is also considered high through their ability to migrate inland. The risk profile and vulnerability of assets in this area are therefore low to medium across the planning timeframes. The medium rating is based on the assumption that inland migration of the dune habitat is likely, but it is not certain that all ecological functions will be retained (see **Appendix E**).

Key outcomes of the risk assessment for this management unit are as follows:

- > The beach and the coastal dunes/vegetation have a low vulnerability rating for the first half of the century, changing to a medium vulnerability later in the century; and
- > The pedestrian trail has a medium vulnerability rating by 2030 and a high vulnerability rating by 2070.



Figure 3-6 South of Island Point JB1 management unit (source: Ray White, <https://www.raywhite.com/wa/jurien-bay/1435853/>)

3.2.6 JB2 – Jurien Bay Township South

The Jurien Bay Township South management unit contains predominantly natural assets such as the beach and vegetated dunes. There is a sealed pedestrian trail running along the length of the management unit that lies mostly seaward of the 2030 coastal hazard line in the southern portion (**Figure 3-7**). Public assets include Casuarina Park and an unsealed carpark. See **Appendix C** for more information on assets and their values in this management unit. It is worth noting that a substantial portion of the Jurien bay township lies inland of the 2110 coastal hazard line in this area.

Existing physical controls associated with this management unit, which have been considered in the risk assessment process, include extensive offshore reefs and islands and a headland formation at the southern

boundary. The coastline has been treated as sandy for the purpose of coastal hazard assessment (MRA, 2016) and, subsequently, hazard lines advance steadily landward over the assessed planning timeframes (see **Appendix A** and **Table 2-3**).

Due to existing development landward of natural assets, the consequence of predicted erosion has been deemed moderate and the adaptive capacity decreases from very high to high over time. Erosion is predicted to degrade the dunes and foreshore vegetation in the north of the management unit over the planning timeframes, affecting the amenity of the beach and ecological functions of the dunes adjacent to developed areas. These natural assets are predicted to be highly vulnerable by 2070 (see **Appendix E**).

Key outcomes of the risk assessment for this management unit are as follows:

- > The beach has a medium vulnerability rating by 2070;
- > The coastal dunes/vegetation have a high vulnerability rating by 2070; and
- > The pedestrian trail and carpark have medium vulnerability ratings by 2030.



Figure 3-7 Jurien Bay Township South JB2 management unit (source: Birdseye View Photography)

3.2.7 **JB3 – Jurien Bay Township Central**

The Jurien Bay Township Central management unit contains 29 residential properties that are located partially or fully within the 2110 coastal hazard line, as well as roads and associated public infrastructure. Natural assets include the beach and vegetated dunes, which are bounded inland by development, along the length of the management unit (**Figure 3-8**). There are various public assets along the foreshore including recreation areas (such as Dobbyn Park), sealed walkway and jetty. Commercial assets include the Jurien Jetty Café and Jurien Bay Tourist Park. See **Appendix C** for more information on assets and their values in this management unit.

Existing controls associated with this management unit, which have been considered in the risk assessment process, are extensive offshore reefs and islands. The coastline has been treated as sandy for the purpose of coastal hazard assessment (MRA, 2016) and, subsequently, hazard lines advance steadily landward over the assessed planning timeframes (see **Appendix A** and **Table 2-3**).

Due to existing development landward of natural assets such as the beach and foreshore area, their vulnerability increases into the future as their adaptive capacity decreases, becoming very high by 2070. Residential properties, Dobbyn Park and the Snorkel and Dive Trail are all predicted to be highly vulnerable by 2070, due to their significant value and the increasing risk of erosion (see **Appendix E**).

Key outcomes of the risk assessment for this management unit are as follows:

- > The beach and foreshore area have very high vulnerability ratings by 2070;
- > Residential properties and Dobbyn Park have high vulnerability ratings by 2070 and very high vulnerability ratings by 2110;

- > The Snorkel and Dive Trail has a medium vulnerability rating by 2030 and a high vulnerability rating by 2070; and
- > Other assets such as Roads, Jurien Bay Tourist Park, Jurien Jetty Café and the pedestrian trail have low and/or medium vulnerability ratings across the planning timeframes.

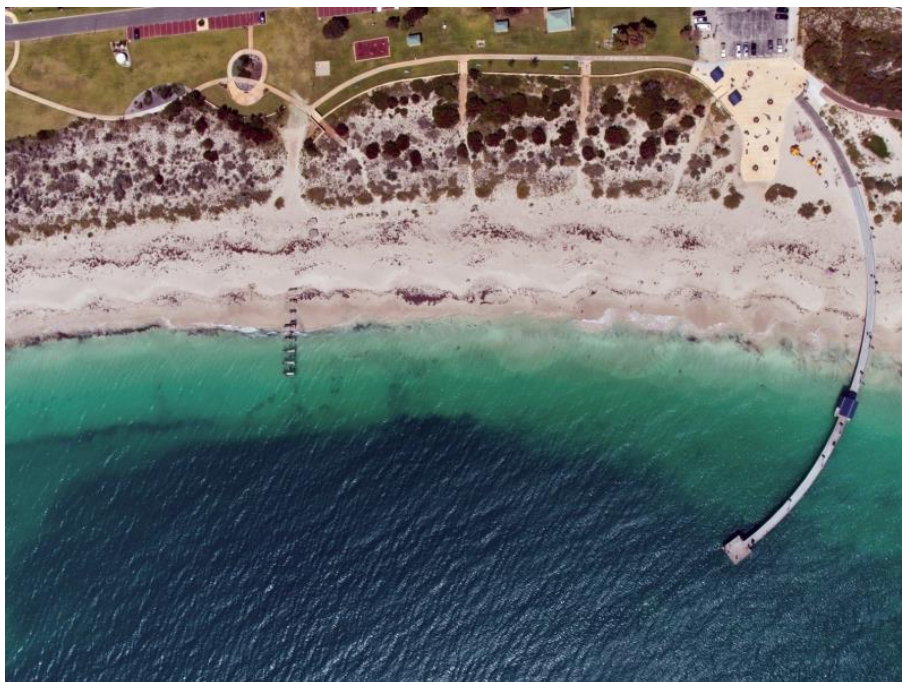


Figure 3-8 Jurien Bay Township Central JB3 management unit (source: Trails WA)

3.2.8 JB4 – Jurien Bay Township North

The northern end of the Jurien Bay Township North management unit contains residential land lying partially seaward of the 2110 coastal hazard line. Natural assets include the beach and vegetated dunes, which are bounded inland by development at the northern and southern ends of the management unit. Public assets include Federation Park and a sealed walkway extending along the length of the management unit (**Figure 3-9**). See **Appendix C** for more information on assets and their values in this management unit.

Existing physical controls associated with this management unit, which have been considered in the risk assessment process, include extensive offshore reefs and islands. Another significant existing control is the Jurien Bay Marina, which has its southern breakwater at the northern boundary of the management unit. The coastline has been treated as sandy for the purpose of coastal hazard assessment (MRA, 2016) and, subsequently, hazard lines advance steadily landward over the assessed planning timeframes (see **Appendix A** and **Table 2-3**).

Due to existing development landward of natural assets such as the beach and coastal dunes/vegetation in the north of the management unit, their vulnerability increases into the future as their adaptive capacity decreases, becoming very high by 2070. Residential properties at the north and south of the management unit have a high vulnerability rating by 2030 and very high vulnerability rating by 2070, as the risk of erosion increases over time (see **Appendix E**).

Key outcomes of the risk assessment for this management unit are as follows:

- > The beach and coastal dunes/vegetation have medium vulnerability ratings by 2030 and very high vulnerability ratings by 2070;
- > Residential properties have a high vulnerability rating by 2030 and very high vulnerability rating by 2070; and
- > The pedestrian trail and Federation Memorial Park have high vulnerability ratings by 2070.



Figure 3-9 Jurien Bay Township JB4 management unit (source: Domain Group)

3.3 Prioritisation of Assets based on Risk Assessment

The risk assessment process has resulted in predictions of vulnerabilities for the assets within each management unit at the two townships, discussed in the preceding sections.

Priority management units are those with assets assessed as having 'High' or 'Very High' present day vulnerability and/or 'Very high' vulnerability by 2030. Only one management unit within the Shire met these criteria and has been identified for prioritisation:

- > CE3: Cervantes Township Central (Light Industrial Area).

4 PLANNING CONTROLS

The risk assessment process highlighted the key areas vulnerable to coastal erosion over the next decade to 2030 as well the longer term threat to 2070 and 2110. The Shires Local Planning Strategy requires that development within the coastal zone follow the requirements of the SPP2.6 and the WAPC (2014a) guidelines for development of a CHRMAP that effectively focuses on two time scales:

- the long term strategic pathway over the next 100 years, and
- planning for implementation of management actions in the shorter term, the next decade, for priority management units.

As discussed in **Section 2.8** and in greater detail in **Appendix H** there exists a complex set of documents and rules that have influenced the evolution of the Shire's coastal townships. Historically, it was assumed that cadastral boundaries enclosed reasonably permanent areas suitable for developing residential and commercial assets ad-indefinitum. The notion that the land and assets within these boundaries is now subject to erosion and potentially becomes unusable triggered the establishment of SPP2.6 and the need for careful planning to determine future develop directions of coastal townships.

The essential aim of SPP2.6 is to recognise that sea level rise and coastal erosion are threatening currently fixed, coastal zone assets at an increasing rate, and to commence the process of adjusting community expectations about life in the future, diminishing coastal zone. Preliminary estimates of protecting property and beach amenity across the State into the future are prohibitively expensive and hence the SPP2.6 policy aims to implement responsible long term planning strategies to develop affordable solutions that satisfy a range of key drivers including intergenerational equity.

As per the SPP2.6 policy and WAPC (2014a) guidelines and recent *draft Planned or Managed Retreat Guidelines* (DoPLH, 2017c) the long term priority is to adopt a strategy hierarchy of:

- *Avoid*,
- *Managed Retreat*,
- *Accommodate* and as a last resort,
- *Protect* (to be funded under the beneficiary pays principle).

Ultimately, the aim is to manage the retreat of significant assets from threatened areas before damage occurs. This will require a shift in the strategy from, for example, initially protect to managed retreat. The *Protect* strategy proposes that protection be funded by the beneficiaries while the transition from a *Protect* to *Retreat* strategy may trigger funding for removal or relocation under the LA Act. A number of issues arise out of these strategies, for example;

- Who are the beneficiaries?
- What is a reasonable method for apportioning costs to the beneficiaries?
- Who is responsible for funding managed retreat, in accordance with the mechanisms described in the *draft Planned and Managed Retreat Guideline*?

It is recommended that a comprehensive analysis of each community and visitors be undertaken to identify beneficiaries of proposed protection areas, economic stimulus provided by tourism, mechanisms for recouping costs from beneficiaries (e.g. parking fees, visitor entry fee, increased Shire rates or levy and other options) be investigated to inform the future review of the strategies options outlined in this CHRMAP.

The following planning framework is similar to that outlined in the *draft Planned or Managed Retreat Guideline*, is to be adopted for this CHRMAP and can be modified as clarity around financial implications of options and funding arrangements evolve. This planning framework includes the following instruments and considerations:

Special Control Area, to ensure discretion over development proposed in hazard areas. The SCA will show on the scheme map, as required by the *Planning and Development (Local Planning Scheme) Regulations 2015*, Schedule 1, Part 5.

Notifications on Title, to inform current and future landholders of coastal hazard risk, as recommended by State Planning Policy 2.6: State Coastal Planning Policy.

Time Limited Planning Consent Conditions, to allow where appropriate, the temporary use of land in hazard areas until hazards materialise, while ensuring that Councils maintain a level of discretion over development in these areas. Time limits would be identified using coastal hazard mapping projections. If the consent expires before hazards materialise, the proponent may apply for an extension to the consent. If hazards materialise before the time limit expires, Council will consider requiring the demolition or removal of compromised structures under relevant legislative provisions.

Interim Coastal Protection, where development is proposed behind a protection structure, the design life of the protection structure would determine the time limit permitted on planning consents. Maintenance and capital costs of protection are to be funded by the beneficiaries of protection works. Protection would only be considered as a last resort where all other options have been considered, as per SPP2.6: State Coastal Planning Policy.

Assessment Criteria, to ensure consistency when assessing applications for development proposed in hazard areas, for inclusion into a Local Planning Policy.

Development applications for subdivision and zoning beyond existing scheme allowances, are not encouraged and will generally not be approved.

Ultimately the aim of the CHRMAP is to develop a plan for adapting to the effects of rising sea levels and coastal erosion. The general strategy shifts that are likely to be required in future, as assets currently situated in the eroding coastal zone become unviable, is outlined in **Figure 4.1**.

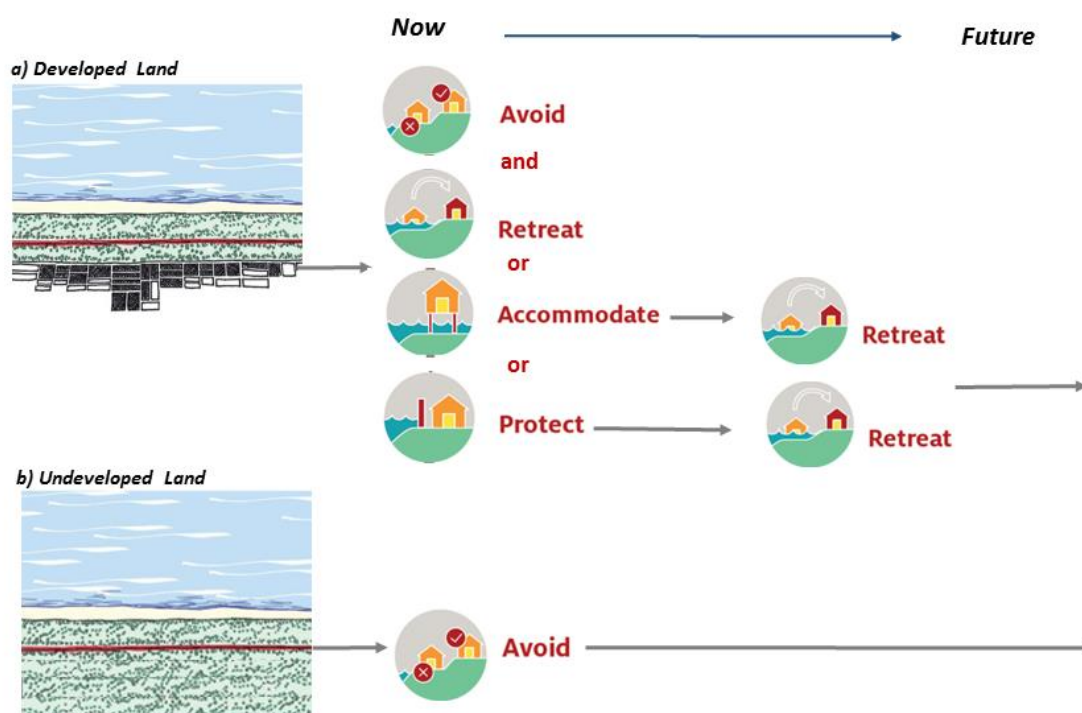


Figure 4-1 Long-term pathways for a) developed and b) undeveloped land

From a practical perspective implementation of managed retreat as suggested in the recent *Draft Planned or Managed Retreat Guidelines* (DoPLH, 2017c) would require the State or Commonwealth to provide the majority of funding to acquire property likely to be required under the compensation provisions of the LAA and/or PDA. Clearly, there is no obligation to adopt a policy that effectively forces government to compensate. The general public and landowners should be aware of the risks in any decisions they make about purchasing or developing lands in these coastal areas. The potential financial burden of a Managed Retreat policy are more likely to see Local Government adopt an 'Avoid' or 'Do Nothing' policy that effectively shifts the burden of costs of sea level rise and coastal erosion impacts to landowners and beach users.

The Planning Framework outlined above recognises the complexity of the issues surrounding the adaptation to sea level rise and coastal erosion. The framework:

- allows for the continued use of hazard areas,
- allows landholders to propose development to suit their own needs and recognise the future risks,
- limits future hazard and liability risk to the Shire and State government,
- considers the limited public funding available,
- largely accords with SPP2.6 Policy and Guidelines and the Planning & Development Regulations 2015, and
- is cognisant of community feedback and other local governments.

5 ADAPTATION OPTIONS

5.1 Adaptation Options Overview

Effective adaptation planning involves the identification, development and evaluation of options suitable to manage the risk of coastal hazards. Adaptation options were evaluated in relation to each of the management units, with multiple options identified as potentially suitable for implementation within each unit. For the longer term strategic planning options are discussed while options for the 3 priority managements units are considered in more detail.

In accordance with SPP2.6 and the CHRMAP guidelines (WAPC, 2014a), potential options have been identified under the risk management categories of 'Avoid', 'Managed retreat', 'Accommodate' and 'Protect' (**Table 5-1**). Note that the government has no obligation to protect private assets from coastal erosion and hence the Protect management category is deemed the least preferred option for implementation, as recommended by the guidelines (see **Flowchart** below, adapted from CoastAdapt, 2017). The range of adaptation and management options were based on WA's CHRMAP guidelines (WAPC, 2014a) and are described in **Table 5-1**.

'Avoid' is seen as the preferred option and is applicable to undeveloped coastal land and areas of the coast where intensification of development in hazardous areas might be proposed. This option is underpinned by the implementation of planning controls, which should prevent inappropriate use of land in areas identified as potentially at risk from coastal hazards.

'Managed retreat' is a preferred option for areas where there is existing development at risk and, ultimately, should be part of the long terms strategy for all such areas. Although it can involve significant expenditure during implementation, this option removes assets from the risk of coastal hazards and is economically responsible over the long term. The planning mechanisms around implementing 'avoid' and 'managed retreat options' have been discussed in detail in **Section 4**.



'Accommodate' options aim to re-design existing infrastructure to mitigate potential impacts as they occur, and allow for land use of a low risk (for example temporary) nature. This option is not applicable to all areas, assets and coastal hazards. The option has better applicability to areas prone to coastal inundation, where assets can be elevated above flooding to maintain land use in a hazardous area. The ability for substantial, built assets to be redesigned to accommodate coastal erosion hazards is generally limited.

'Protect' options range from temporary 'soft' protection, such as sand nourishment, to semi-permanent 'hard' protection options, such as groynes and seawalls. It should be noted that no protection option is considered permanent, and all have associated ongoing expense to implement or maintain. This ongoing expense and the inability of protection options to permanently mitigate the risks associated with coastal hazards are the primary reasons why these options are considered the least favourable in the preferential planning hierarchy. Hard protection options also have the potential to divert coastal erosion hazards elsewhere, increasing risk for other areas or assets and potentially creating liability for those responsible for the structures.

SPP2.6 Clause (5.5 (iii)) states that the employment of protection options should be sought where:

"sufficient justification can be provided for not avoiding the use or development of land that is at risk from coastal hazards and accommodation measures alone cannot adequately address the risks from coastal hazards, then coastal Protection works may be proposed for areas where there

is a need to preserve the foreshore reserve, public access and public safety, property and infrastructure that is not expendable.”

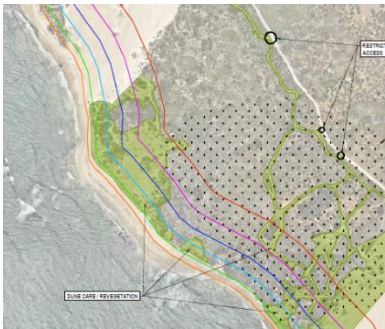
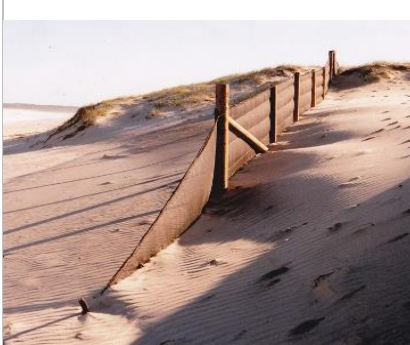




Although protection measures are the least favoured option, particularly as a long-term mitigation measure, they remain the most commonly employed coastal risk mitigation strategy globally. There are several effective protection techniques, that can be employed to manage the risks of coastal erosion in the short to medium term. **Table 5-2** below provides additional detail on protection options available.

Table 5-1 Adaptation and Management Options (adapted from WAPC, 2014a)

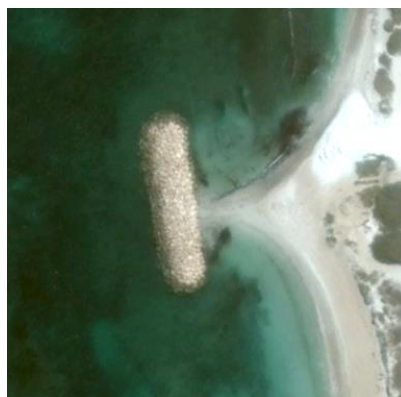
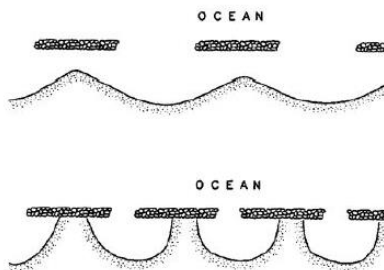
Option Category	Option Name	Option Code	Description
Avoid	Avoid development	AV	Avoidance of freehold residential or commercial development within the coastal foreshore reserve.
Managed Retreat	Leave unprotected / repair	MR1	Assets are left unprotected and loss is accepted following hazard event. Repairs may be implemented to extend life and for public safety in the short term. In the case of natural assets, such as beaches and vegetation, allow the impacts of hazards to occur.
	Remove / relocate	MR2	Assets located in the hazard zone are permanently removed or relocated. For residential and commercial property, this option may require voluntary or compulsory acquisition of land, transferrable development rights and land swaps.
	Planning controls for Managed Retreat	MR3	Use of planning controls to allow continued use of the current infrastructure until such time that impacts arise, but restrict the development of further infrastructure (densification) as the area/asset is known to be vulnerable. This option also includes mechanisms for ensuring that Local Government, land owners and prospective buyers are made aware of the risk.
Accommodate	Planning controls for accommodation	AC1	Indicates to current and future landholders that an asset is at risk from coastal hazards over the planning timeframe. Helps owners to make informed decisions about the level of risk they are/may be willing to accept and that risk management and adaptation is likely to be required at some stage.
	Emergency plans and controls	AC2	Implement plans for assets/areas that are at risk of coastal erosion. Have procedures in place for before, during and after the events for safety. E.g. signage/barriers to prevent access.
Protect	Dune care / sand management	PR1	Development of a long term program for revegetation and rehabilitation of the dune system. Sand fencing to manage wind-blown erosion also falls under this category (also see Table 5-2).
	Beach nourishment / sand management	PR2	Addition of sand to the beach, dune and/or nearshore area to replace lost material and/or create additional buffer. This option is a temporary measure and can be more effective in association with hard protection options, such as groynes. The sand may be from an external source or from a nearby part of that coastal area (i.e. via sand bypassing or back passing) (also see Table 5-2).
	Groyne	PR3	Construct groynes along the beach to restrict longshore sediment movement and stabilise sections of shoreline. This option is often accompanied by beach nourishment. Hard protection generally diverts erosion issues elsewhere, such as to the down drift side of a groyne, and can have significant impact on coastal ecosystems (also see Table 5-2).
	Nearshore reef / breakwater	PR4	Construct offshore reef(s)/breakwater(s) or raise existing natural nearshore reef structure to maintain level of protection as sea level rises. Hard protection generally diverts erosion issues elsewhere, such as to beaches either side of the nearshore structures, and can have significant impact on coastal ecosystems (also see Table 5-2).
	Seawall	PR5	Construct seawall in front of assets or along length of coastline to protect them from coastal hazards. Hard protection generally diverts erosion issues elsewhere, such as to beaches either side of, and directly in front of, a seawall. They can also have significant impact on coastal ecosystems (also see Table 5-2).

Option Category	Option Name	Option Code	Description
Do nothing	Do nothing	DN	Take no action. No limitations on development or implementation of adaptation planning. Accept risk.

Table 5-2 Overview of protection options considered in the CHRMAP

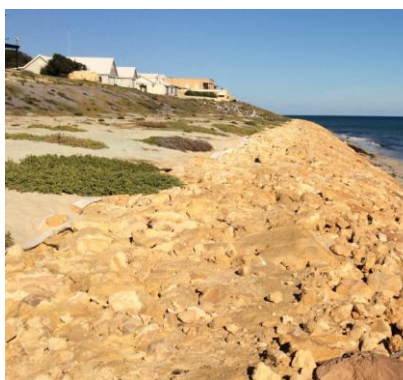
a) Dune Care		
		Dune care is a “soft” protection option that is relatively low cost and can assist by stabilising dune systems. It involves actively revegetating dunes or preventing degradation by restricting access, for example with fencing and signage. Dunes form a natural buffer to coastal erosion, which can protect areas and assets located behind them. Dune vegetation helps to prevent wind-blown erosion of dunes and stabilises the dune structure. Dune care is often undertaken by local volunteer groups.
b) Beach Nourishment		
		Beach nourishment is a “soft” protection option that provides temporary protection against coastal erosion. Sand can be sourced from another area of the beach, from an inland source, such as inland dunes or a sand quarry, or from offshore. Nourishment generally involves placement of sand on the upper beach face to act as a buffer during extreme events. Nourishment is often combined with other protection options such as groynes or offshore protection, which enhance its longevity. A nourished beach profile may provide protection for between 18 months and five years, before the beach returns to its original state. The cost of nourishment may vary from \$10/m ³ to \$50/m ³ , depending on the source and its location.
c) Groynes		
		Groynes are “hard” protection options that extend from above the high water mark, across the active shoreline and into the nearshore area. They are usually constructed perpendicular to the beach and can take various shapes such as T or L shapes. They can be constructed of rock, geotextile sand containers, timber or concrete. Groynes act to interrupt alongshore sediment transport which results in a build-up of sand on the up drift side of the groyne and an erosion on the down drift side. Groynes may be constructed as single groynes or in a groyne field to protect a larger area. Groynes have minimal impact on cross-shore sediment transport, such as that associated with storm-based erosion, outside of their immediate vicinity. Groynes are often complimented by additional beach nourishment, to increase the beach width on their up drift side. A rough estimate for the cost of a typical rock groyne is \$5000/m.

d) Nearshore Reef / Breakwater



Artificial nearshore reefs or breakwaters are “hard” protection options. They can be constructed of rock, concrete or geotextile sand containers. They function by diverting wave energy either side of the structure, which pushes sediment onto the shore inside of the structure. This results in the formation of a salient or even a tombolo in the lee of the structure, which results in an increase in beach width and an increased buffer against coastal hazards. Nearshore reefs or breakwaters affect both longshore and cross-shore sediment transport but do not fully interrupt either. Their feasibility is often determined by the nearshore water depth and the bottom type. They are generally more expensive to construct (per metre) than groynes, due to deeper water requiring a larger volume of construction material and leading to higher construction costs.

e) Seawall



A seawall is a “hard” protection option, which can be constructed of rock, geotextile sand containers or concrete, and can be either exposed or buried to improve visual amenity. A seawall is a solid barrier constructed parallel to the coast at the land-sea boundary, which functions by acting as a physical barrier to coastal erosion, protecting areas and assets on its landward side. Seawalls can also provide protection against inundation. Seawalls generally focus wave energy in front of them and to their sides, due to reflection off the structure. This usually leads to a more rapid loss of beach in the vicinity of the structure, leading to a “hardened” shoreline with poor useability and public amenity. The cost to construct a seawall may range from \$3000/m to \$6000/m, depending on a variety of factors, including construction material, required size and existing foundations.

5.2 Adaptation Option Assessment Process

Each of the adaptation options presented in **Table 5-1** has been considered for the Cervantes Township Central priority management unit. As recommended in the State's CHRMAP Guidelines, a multi-criteria analysis has been used as a preliminary step to identify potentially suitable adaptation options for each management unit, as well as to discount unviable options. The analysis uses a broad range of criteria and a simple 'traffic light' rating system to evaluate the acceptability of each option. The assessment considers the effectiveness of options at reducing risk and performing their function in relation to governance, environmental, social and economic aspects. Information gained through the stakeholder and community engagement process has been used to reflect the community's values in the assessment. Options have also been assessed in terms of their potential restriction on future planning and risk management opportunities, with options that allow for a wide range of future strategies considered more favourably. The analysis takes into consideration the following criteria:

Preliminary feasibility:

- > Effectiveness;
- > Governance, legal implications and approval risk; and
- > Reversibility / adaptability.

Preliminary acceptability:

- > Environmental and social impact; and
- > Community acceptability.

Preliminary financial implication:

- > Financial gain / avoidance of cost;
- > Capital cost; and
- > Ongoing cost.

The criteria and a description to guide the assignment of a rating for each criteria is presented in **Table 5-3**. Ratings have been assigned by taking into account information gathered prior to, and during, the CHRMAP process. This information includes feedback from ongoing stakeholder and community consultation, planning considerations (outlined in **Section 4**), previous investigations of the study areas and the outcomes of the coastal hazard assessments and risk assessment process. The analysis has also been guided by coastal engineering, management and planning expertise, and knowledge of other coastal management projects and techniques.

Based on the ratings assigned under each criteria for a particular adaptation option, a qualitative judgement is then made as to whether that option is recommended, not recommended or requires further investigation. It should be noted that red lights do not necessarily exclude an option, and it still may be recommended that such an option be investigated further. The outcomes of the multi-criteria analysis, for each management unit, are presented and discussed in **Section 5.3**, below.

For the priority management unit (as defined in **Section 3.3**) those options recommended for further investigation have been assessed in greater detail. This additional detail is discussed for the priority management unit in **Section 5.4**. Recommendations as to whether these options should be implemented and, if so, the details around this implementation are discussed in the Implementation Section (**Section 6**). Recommended options for long term pathways across all management units are also considered in **Section 6**.

Table 5-3 Multi-criteria assessment and qualitative cost benefit input ratings and assessment outcome categories

	Preliminary Feasibility			Preliminary Acceptability		Preliminary Financial Implication			Outcome
	Effectiveness	Governance / Legal / Approval Risk	Reversibility / Adaptability	Environmental / Social Impact	Community Acceptability	Financial Gain / Avoidance of Cost	Capital Cost	Ongoing Cost	Recommendation
Unlikely to be acceptable	Likely to be ineffective	Not likely to be approved / likely to result in legal risk /	Not likely to be reversible. Limits future options once implemented	Likely to have unacceptable negative impacts	Unlikely to meet most success criteria	No financial gain or avoidance of loss	Very expensive	Very expensive	Not Recommended
May be acceptable	May be effective	May not be approved / may present governance or legal risk	Likely to be reversible / adaptable at high costs	Some impacts that can be managed to an acceptable level	Mixed response, may meet some success criteria but not others	Some financial gain / small number of benefactors	Moderately expensive	Moderately expensive	Investigate / detailed option assessment
"No regrets"	Likely to be effective	Likely to be approved / minimal governance or legal risk	Easily reversible or adaptable for the future, no negative impacts in the future	Not likely to have negative impact, may have positive impacts	Likely to meet most acceptability criteria	Large financial gain / public benefit	Low cost	Low cost	Recommended
Not Applicable									

5.3 Multi-criteria Analysis Results

The detailed results of the multi-criteria analysis for each management unit are presented in **Appendix F**, with the final recommendations for each option in the prioritised management unit (CE3) summarised in tables presented in **Appendix G**. The following subsections discuss the outcomes of the analysis, with respect to the assets and their vulnerabilities, at each town site.

5.3.1 Cervantes

CE1 and CE4

South of Thirsty Point (CE1) and Cervantes Township North (CE4) management units are similar in containing predominantly natural assets. The outcomes of the multi-criteria analysis are consistent for the two management units. It is recommended that substantial residential and commercial development is avoided (AV) in the management units. Planning controls (MR3, AC1) are recommended for implementation to prevent inappropriate development. Low cost protection options such as dune care and sand management (PR1) are recommended for implementation within the management units. Beach nourishment (PR2) and hard protection options (PR3, PR4 and PR5) have been assessed as expensive and inappropriate with respect to the existing assets and nature of the risk in these management units, so have not been recommended.

CE2 and CE3

Cervantes Township Central (CE3) has been identified as a priority management unit through the risk assessment process. Therefore, identifying suitable adaptation options and determining an adaptation pathway for this management unit is considered urgent. The outcomes of the multi-criteria analysis are consistent for this management unit and the Cervantes Township South management unit (CE2).

The multi-criteria analysis has recommended that the process of implementing managed retreat of assets (MR2) be further investigated. The protection options of beach nourishment (PR2), groyne(s) (PR3), nearshore breakwater(s) (PR4) and a seawall (PR5) have all been recommended for further investigation to assess their suitability.

The options of avoiding further development (AV) in hazardous areas and implementing planning controls to facilitate future managed retreat (MR3) from these areas have both been recommended. Planning controls to accommodate risk (AC1) and the preparation of emergency plans and controls (AC2) have also been recommended. Low cost protection options such as dune care and sand management (PR1) are recommended for implementation.

An assessment of adaptation options recommended for further investigation within priority management unit CE3 is provided in **Section 5.4** below. Details around the implementation of adaptation options, for each management unit, are presented in **Section 6**.

5.3.2 Jurien Bay

JB1 and JB2

South of Island Point (JB1) and Jurien Bay Township South (JB2) management units are similar in containing predominantly natural assets. The developed area south of this CHRMAP study area boundary is located within 200m of the present day shoreline. This compares to the maximum 2110 hazard line width of 234 m (**Table 2-4**) at the southern boundary of the study area (southern boundary of JB1) and hence further investigation of this coastal area would be warranted. The outcomes of the multi-criteria analysis are consistent for the two management units. It is recommended that substantial residential and commercial development is avoided (AV) in the management units. Planning controls (MR3, AC1) are recommended for implementation to prevent inappropriate development. Low cost protection options such as dune care and sand management (PR1) are recommended for implementation within the management units. Beach nourishment (PR2) and hard protection options (PR3, PR4 and PR5) have been assessed as expensive and inappropriate with respect to the existing assets and nature of the risk in these management units, so have not been recommended.

JB3 and JB4

The outcomes of the multi-criteria analysis are consistent for Jurien Bay Township South management unit (JB3) and the Jurien Bay Township North management unit (JB4).

The multi-criteria analysis has recommended that the process of implementing managed retreat of assets (MR2) be further investigated. The protection options of beach nourishment (PR2), groyne(s) (PR3), nearshore breakwater(s) (PR4) and a seawall (PR5) have all been recommended for further investigation to assess their suitability.

The options of avoiding further development (AV) in hazardous areas and implementing planning controls to facilitate future managed retreat (MR3) from these areas have both been recommended. Planning controls to accommodate risk (AC1) and the preparation of emergency plans and controls (AC2) have also been recommended. Low cost protection options such as dune care and sand management (PR1) are recommended for implementation.

Details around the implementation of adaptation options, for each management unit, are presented in **Section 6**.

5.4 Adaptation Options – Cervantes Township Central (CE3)

5.4.1 Introduction

There are 49 residential properties lying seaward of the 2110 coastal hazard line in this management unit, with commercial property and public facilities also identified as vulnerable (**Appendix A**). The economic value associated with these properties has led to their high vulnerability rating at present, meaning immediate implementation of adaptation measures should be considered. The commercial property at highest risk is currently occupied by Indian Ocean Rock Lobsters which is a major employer in Cervantes and which requires access to seawater as it is a “live” facility. There is currently minimal beach buffer between the shoreline and commercial infrastructure and a lack of public access along the beach seaward of the commercial property.

As described in **Section 2.2**, a small section of seawall has been constructed adjacent to the existing jetty abutment in front of the commercial property which is shown in **Figure 5-1** below. The design basis and expected future performance of this seawall is uncertain. There are also existing groynes and jetty abutments along this section of coast which influence sediment transport processes in the area, particularly the Department of Transport groyne (built in 1992) which is the largest of the features and helps retain sand to its south.



Figure 5-1 Small section of seawall in front of Indian Ocean Rock Lobster property

The public park areas and residential property to the south of the commercial property lie behind a low-lying, narrow and relatively sparsely vegetated dune which is unlikely to provide a significant degree of protection during an extreme erosion event (e.g. the 100 year ARI event modelled to determine S1).

The S1 erosion allowance calculated for this area (MRA 2016) is 41 m as shown in **Figure 5-2** (reproduced from MRA, 2016) which highlights the low-lying nature of the land adjacent to the current shoreline and demonstrates how the infrastructure in the area is currently at risk of damage in a large erosion event. In addition to coastal erosion risk, the area is low-lying and is likely to be prone to coastal inundation, which will be included in the next revision of the CHRMAP in approximately 5 years.

The historical shoreline movement in management area CE3 was analysed in MRA (2016) and showed that the shoreline in this area typically experienced erosion between 1943 and the mid-1990s but then stabilised and has accreted since, most likely in response to the construction of the DoT groyne in 1992.

The Indian Ocean Rock Lobster facility has been in operation since 2008. It contains holding tanks for live lobsters and also operates as a tourism attraction showcasing the live facility and selling seafood products (including a fast food outlet). Recently the decision was made by the Shire to amend the Local Planning Scheme to rezone the area used by the facility from “Residential/Industry” to “Special Use – Tourism and Industry”. Conditional to the rezoning is that the development have due regard to coastal hazards (as per SPP2.6) and be responsive to measures identified in this CHRMAP.

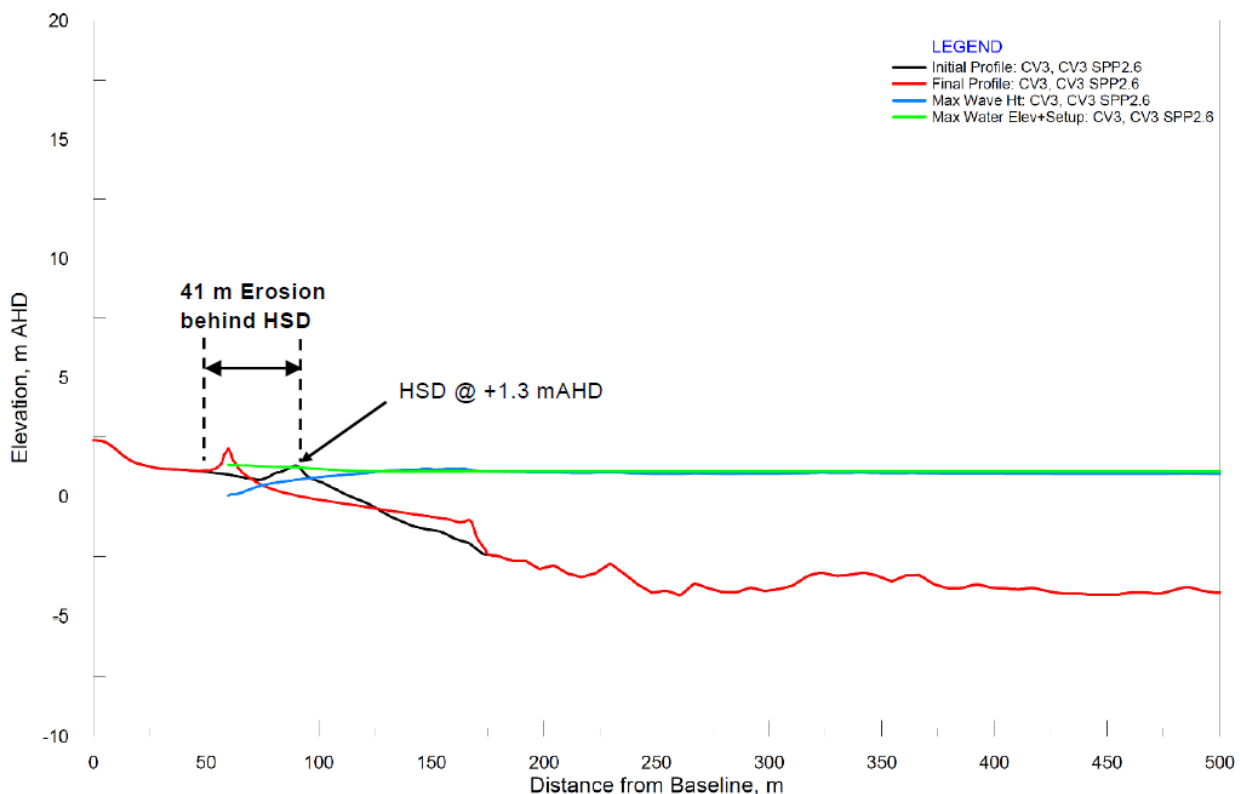


Figure 5-2 S1 results for CE3 (MP Rogers and Associates 2016, Cervantes Zone 3)

5.4.2 Value of Assets at Risk

An estimate of the economic value in 2015 dollars (2015 \$) of built assets lying seaward of the 2030 coastal hazard line is presented in **Table 5-4**. Note that this table only includes assets in CE3. To provide context for subsequent discussion of the application of a beneficiary pays system to fund future coastal management the Shire’s revenue base (2015 \$) for the 15-year period (2015 to 2030) is also estimated in **Table 5-4**.

Table 5-4 Summary of estimated value (2015 \$) of vulnerable built assets in Cervantes

Asset type	unit	Rate(\$)	2030	
			#	value (\$)
Roads (main)	m	800	0	-
Roads (secondary)	m	500	96	\$ 48,000
Footpaths / Cycleways / Beach Access	m	350	560	\$ 196,000
Carpark	m ²	70	11304	\$ 791,280
Private properties: residential				
- land vacant	#	250,000	1	\$ 250,000
- houses and improvements	#	250,000	0	-
Private properties: commercial, holiday accommodation				
- land	m ²	150	3000	\$ 450,000
- improvements (chalets)	#	180,000	0	-
Total				\$ 1,735,280
Rate Base Revenue over 15 years, 2015 to 2030 (in 2015 \$)				
Affected properties	#	\$1000 [#]	49	\$735,000
Township	#	\$1000 [#]	990	\$14,850,000
Shire	#	\$1000 [#]	2000 [#]	\$30,000,000

[#]Estimated

5.4.3 Accommodate (AC2)

Redevelopment of the Indian Ocean Rock Lobster facility offers the opportunity to ensure that the erosion and inundation risks are accommodated as far as is practicable. It is easier to accommodate inundation through development controls, such as ensuring finished floor heights are adequate for expected flood levels, than it is to accommodate erosion. However, as part of the development, the company hopes to build and maintain a private jetty in addition to the informal seawall and jetty abutment which have already been put in place. Any plans to accommodate coastal hazards through the redevelopment should be underpinned by the investigations undertaken as part of the CHRMAP process, as well as other scientific investigations in the area.

5.4.4 Remove and Relocate (MR2)

Removal or relocation of properties at risk of erosion is an option for management area CE3.

There are currently no specific mechanisms for government funded managed retreat in the CHRMAP context, however voluntary or compulsory acquisition may be implemented under the provisions the LAA or the P&D Act (See **Section 4.1**).

It is reasonable to assume that triggers for retreat might include:

- > Distance of the asset from the HSD is less than S1 (i.e. 41m for CE 3);
- > Loss of legal access to property; or
- > Loss of essential services.

The distance of the commercial infrastructure from the HSD datum is less than 10 m for this area, so the need for retreat in relation to S1 (and possibly in relation to a set distance) would already be triggered as these structures could be impacted by a single storm event. The adjacent residential buildings are located further from the HSD (generally 50-60m) so would not currently trigger the need for retreat in relation to S1. The public park areas are located closer to the HSD (generally 10-20m) however the nature of these assets means they should remain in place until unserviceable.

The majority of infrastructure within the 2030 hazard line is public infrastructure, however in the event of voluntary or compulsory acquisition of private properties, this could be estimated as costing up to around \$1 M.

R_CE3.1: It is recommended that a comprehensive economic study, including detailed economic analysis and proposed costs apportionment to identified beneficiaries, be undertaken by the Shire and the State to guide eventual managed retreat from hazardous areas.

5.4.5 Beach Nourishment (PR2)

Sand nourishment aimed at increasing the width of the beach and increasing the buffer against coastal erosion in management area CE3 is an option for reducing the risk of erosion, but may be of limited value without being used in conjunction with groynes as outlined below. Although sand nourishment as a standalone option has not been costed, nourishment providing an offset for shoreline recession has been estimated by MP Rogers in 2015 as 144,000 m³. At a unit rate of \$35/m³ from terrestrial sources this equates to a cost of approximately \$5 million. It appears the DoT groyne at the northern end of this management area may already be saturated at present and either the nourishment may be scheduled for a period following the erosion of sand from the groyne area, or if extending the beach buffer zone is desired then the groyne structure may be extended further offshore.

Sand nourishment of a much smaller scale is also an option, particularly as an interim short term solution in response to erosion events or to protect infrastructure at risk while long term solutions are investigated and implemented.

5.4.6 Groynes (PR3)

A preliminary costing of structural protection options for Cervantes was undertaken for the Shire by MP Rogers in 2015 (MRA, 2016). A best practice approach was adopted which recommended the following groyne and nourishment characteristics for protection of Cervantes (not just CE3) up to 2030:

- > 2 additional groynes;
- > Additional width of beach profile required: 20 m;
- > Total length of 140 m; and
- > Sand nourishment volume 144,000 m³.

The total cost of using groynes as a protection measure for the 15 year period was estimated at approximately \$9 million. Note that the above approach and costing is of a preliminary nature and that detailed design would need to be carried out based on site specific data (assuming this is available), and the impacts on adjoining areas would need to be investigated. The above costings are also representative of “best practice” and it is possible that more cost effective options may be adequate for shorter term protection of assets.

In addition to the capital cost, the cost of maintenance of the groynes was estimated by MP Rogers to be approximately \$200,000 per decade.

5.4.7 Seawall (PR5)

A preliminary costing for construction of a seawall at Cervantes was undertaken for the Shire by MP Rogers in 2015 (MRA, 2016). A best practice approach was adopted which recommended a 600 m long rock seawall. The estimated cost of constructing a seawall was \$2.3 million. Additionally, ongoing seawall monitoring and maintenance costs need to be considered, and these are likely to be between \$100,000 and \$300,000 per decade.

The installation of a seawall is likely to be seen as unacceptable to many members of the community, due to the likely loss of beach access and amenity in the area it is installed. The potential to divert and exacerbate erosion issues elsewhere will likely lead to additional coastal management costs, which have not been accounted for in estimating the cost implications of the seawall protection method.

R_CE3.2: Unless significant sources of external funding become available, it would not be recommended that hard protection options are implemented to manage coastal erosion hazards in this area. Available funding should be directed at managing the retreat of built infrastructure from this area as it becomes vulnerable.

R_CE3.3: It is recommended that major coastal management investment decisions are reserved until the hazards associated with coastal inundation have been incorporated into the CHRMAP.

6 IMPLEMENTATION

A range of options for addressing the challenges of coastal erosion and its effects on the coastal zone over the next decade and century have been outlined in the preceding chapters. In general, the threat to significant assets is predicted to occur only after 2030 and become progressively more severe into the latter part of the century. While it is natural that local communities would prefer to protect and preserve the current features of the coastal zone, the reality is that unless some new and innovative protection methods are developed, the costs of maintaining current features will likely become prohibitively expensive at some point in the future. The interim nature of protect options needs to be recognised across the community and, the adaption options developed and solutions optimised for social, environmental and economic (affordability) drivers. This section first discusses the issues around funding and equity, then addresses the plan for implementation of recommended adaptation options up to the 2030 timeframe with a strategic view on the likely adjustments over the next century, to 2110.

6.1 Funding and Equity

In accordance with the CHRMAP guidelines, equity implications are considered with a particular focus on identifying who may benefit and who may be disadvantaged by proposed management options. This then raises the question of who would be expected to bear the cost of implementation.

6.1.1 Cervantes CE3

As introduced in **Section 2.2**, a small section of seawall has been constructed adjacent to the existing jetty abutment in front of the Indian Ocean Rock Lobsters property, providing temporary protection. There is currently minimal beach buffer between the shoreline and commercial infrastructure and a lack of public access along the beach seaward of the commercial property. Redevelopment of the Indian Ocean Rock Lobster facility should be explored to accommodate erosion and inundation risks. The facility provides benefits to the local community, being a major employer in the town and, as such, the equitable apportionment of costs across beneficiaries will require further investigation.

The complex coastal processes around Cervantes and its offshore reefs will need to be monitored to inform the need for sand nourishment in future within CE3. Both the local community and visitors to the township would benefit from sand nourishment and it is recommended that the mechanisms available to generate revenue from these beneficiaries be investigated. The cost for sand nourishment is estimated at around \$5M, but would likely only be considered in conjunction with the construction of additional groynes costing an estimated \$9M. These items would provide protection for some 15 years only. For the longer term, and given current day knowledge of coastal processes and protection measures, the implementation plan aims to exercise the retreat option and it is recommended that detailed implementation of the draft Guidelines for Planned or Managed Retreat (DoPLH, 2017c) be investigated.

6.1.2 Jurien Bay

One row of housing, Grigson St and Heaton St fall within the 2110 hazard line in JB3. Should a protect strategy be adopted then the capital cost for a seawall or groynes may be spread over a larger group of beneficiaries within the local community. If adopted, it is likely that a protect strategy would transition to retreat at the end of the design life of the seawall/groynes around 2070, by which point the removal/relocation of the streets and utility infrastructure would need to be considered.

The complex coastal processes around Jurien Bay and its offshore reefs will need to be monitored to inform the need for sand nourishment in future, within JB3 and JB4. Sand management would benefit the local community and visitors to the township. It is recommended that the mechanisms available to generate revenue from these beneficiaries be investigated.

6.2 Long Term Pathways and Short Term Implementation

The information collated through the various stages of the CHRMAP process, including outcomes of the risk assessment and subsequent analyses summarised in the preceding sections, have been used to define priority actions for implementation by the Shire and other stakeholders. The proposed implementation

actions are intended to reduce the risk posed by coastal hazards in the immediate to short term (up to 2030), with consideration of the long term 100 year planning horizon.

The implementation plan has been structured to group actions in accordance with the WAPC (2014a) adaptation hierarchy. In addition, adaptation responses can be defined as being related to either, planning and development or to engineering as discussed by the Planning Institute of Australia's (PIA) National Land Use Planning Guidelines for Disaster Resilient Communities (2015).

The long-term pathway for each management unit is both an input and an output to the adaptation option assessment. For example, in a management unit containing few built assets the long term strategic pathway is one of avoiding development. By contrast, in areas containing built assets under threat in the long term decisions about when to transition from a protect strategy to a retreat strategy need to be made.

It is clear that planning decisions made decades and even centuries in the past, prior to understanding the implications of sea level rise and coastal erosion, are a key contributor to the current situation where assets are now at risk.

R1 - It is recommended that a comprehensive investigation of each community and visitors be undertaken to identify beneficiaries of proposed protection areas. The investigation should assess the economic stimulus provided by tourism and mechanisms for recouping costs from identified beneficiaries (e.g. parking fees, visitor entry fee, increased shire rates or levies, etc.) to inform the future review of the strategies and options outlined in this CHRMAP.

In the shorter term, roughly the next decade up to 2030, there are a number of specific recommendations that may be implemented. These range from investigations to provide more detailed analyses to inform balanced decisions, monitoring to assess whether the predicted threats of coastal erosion actually occur, community consultation to better educate the community about the impending threats and need to plan for their eventuality and consequences.

6.3 Triggers

The Draft Guidelines for Planned or Managed Retreat (DoPHL, 2017c) provide a guidance on the appropriate triggers or criteria to commence actioning a particular management response. The guidelines suggest the following:

Planned retreat allows development to remain and be safely used until the coastal hazard risk becomes unacceptable. Initiation of the process to remove at risk development can be controlled by triggers such as:

Trigger 1. Where the most landward part of the Horizontal Shoreline Datum (HSD) is within 40 metres of the most seaward point of a development or structure.

Trigger 2. Where a public road is no longer available or able to provide legal access to the property.

Trigger 3. When water, sewage or electricity to the lot is no longer available as they have been removed/ decommissioned by the relevant authority due to coastal hazards.

The trigger distance determines when planned retreat is activated for a particular development.

For the specific sites within The Shire the criterion outlined in Trigger 1 has already been exceeded. Triggers 2 and 3 are relevant to sections of management units CE3 and JB3 where public roads and potentially utilities services are located seaward of the 2110 Hazard line, but landward of the 2070 hazard line. Given that the projected risk to these assets is half a century away, and there appear to be more pressing issues in the shorter term, it is prudent to adopt a set of triggers based on the immediate term recommendations and around the HSD shoreline movement criteria. For the purpose of this CHRMAP the following triggers have been adopted and applied to each management unit (**Appendix I**):

Trigger 1: CHRMAP recommendation

Trigger 2: HSD plus S1 reaches 2030 vulnerability line

Trigger 3: HSD plus S1 reaches 2070 vulnerability line

Trigger 4: Minor Infrastructure becomes damaged or unsafe

In the above triggers it is assumed that the HSD line will be determined annually or at least soon after major storm erosion events to inform the ongoing assessment of the Trigger criteria. Hazard line estimates for interim planning horizons at 2050 and 2090 have also been generated. Finer temporal resolution of the triggers may be implemented using these lines during future revision of the CHRMAP, each 5-10 years. At this time it is important to agree the concepts and implementation process before getting too detailed on the trigger values.

Specific long term pathways and short term implementation recommendations for the priority management units are discussed in the following sections.

6.4 Cervantes

6.4.1 Long Term Pathway

The long term pathway for the Cervantes Township should aim for the eventual managed retreat and accommodation of built infrastructure, as it becomes vulnerable to coastal hazards and/or interferes with the maintenance of an appropriate coastal foreshore reserve (as defined in Section 5.9 of SPP2.6). The development of emergency plans and controls should occur for the management of coastal hazards. For major infrastructure, such as residential and commercial property, managed retreat should occur when the risk to infrastructure becomes intolerable and it is no longer viable or acceptable to the Shire's community to implement protection measures. For undeveloped areas, the long term pathway should focus on avoiding inappropriate development, to prevent unnecessary future cost and potential liability for the Shire.

Proposed long term pathways for the individual Management Units within Cervantes (CE1, CE2, CE3 and CE4) are provided in **Appendix I**. The key tools that will underpin the achievement of these long term pathways are planning controls, which were discussed in **Section 4**. Protection mechanisms using hard structures for the Township should be carefully assessed and guided by appropriate triggers to determine their suitability for implementation, particularly given they are likely to provide interim protection only.

6.4.2 Short Term Implementation – Cervantes Township Central (CE3)

The following adaptation pathway is proposed:

Short to Medium term: Protect in a manner that maintains existing social values and within budgetary constraints, until such time as triggers for retreat are exceeded following which the planned retreat strategy be implemented.

Recommendations arising from the above assessment for CE3 are provided in **Table 6-1**.

Table 6-1 Recommendations and adaptation planning recommendations for CE3

ID	Recommendation
R_CE3.1	The Shire and State to undertake a comprehensive economic study, including detailed economic analysis and proposed costs apportionment to identified beneficiaries, to guide eventual managed retreat from hazardous areas.
R_CE3.2	Unless significant sources of external funding become available, it would not be recommended that hard protection options are implemented to manage coastal erosion hazards in this area. Available funding should be directed at managing the retreat of built infrastructure from this area as it becomes vulnerable.
R_CE3.3	Major coastal management investment decisions are reserved until the hazards associated with coastal inundation have been incorporated into the CHRMAP.
R_CE3.4	Avoid further residential or commercial development within the 100 year hazard line.
R_CE3.5	Ensure that coastal hazard management commitments in the redevelopment application for the Indian Ocean Lobster facility are consistent with this CHRMAP.

R_CE3.6	Ensure that conditions of re-zoning re-development of the Indian Ocean Lobster facility are met and independently audited.
R_CE3.7	Ensure that any coastal protection structures gain appropriate environmental approvals, are designed by appropriately qualified engineers and the decommissioning at end of design life is consistent with the long term plan of this CHRMAP.
R_CE3.8	Allow ongoing use of public park, pathway and picnic facilities until it is unsafe to continue to do so.
R_CE3.9	Major investment decisions with regards to coastal infrastructure should be reserved until after coastal inundation projections have been incorporated into the CHRMAP.

6.5 Jurien Bay

6.5.1 Long Term Pathway

The long term pathway for the Jurien Bay Township should aim for the eventual managed retreat of built infrastructure, as it becomes vulnerable to coastal hazards and/or interferes with the maintenance of an appropriate coastal foreshore reserve (as defined in Section 5.9 of SPP2.6). For major infrastructure, such as residential and commercial property, this retreat should occur when the risk to infrastructure becomes intolerable and it is no longer viable or acceptable to the Shire's community to implement protection measures. For undeveloped areas, the long term pathway should focus on avoiding inappropriate development, to prevent unnecessary future cost and potential liability for the Shire.

Proposed long term pathways for the individual Management Units within Jurien Bay (JB1, JB2, JB3 and JB4) are provided in **Appendix I**. The key tools that will underpin the achievement of these long term pathways are planning controls, which were discussed in **Section 4**. Protection mechanisms using hard structures for the Township should be carefully assessed and guided by appropriate triggers to determine their suitability for implementation.

6.5.2 Short Term Implementation

The following adaptation pathway is proposed:

Short to Medium term: Investigate hard protection options ensuring that it maintains existing social values and within budgetary constraints; investigate the mechanism for planned retreat of vulnerable assets; and implement planning changes to avoid future development in currently undeveloped areas.

6.6 Shire of Dandaragan Monitoring Plan

Monitoring of the ongoing changes in actual shoreline movements and the response to storm erosion events is critical to assess compliance with trigger criteria for the management actions, to inform the future revisions of hazard lines and the CHRMAP. A monitoring plan should be developed for the townships, prioritising monitoring activities based on available funding. The *Seabrid, Ledge Point, Lancelin – Coastal Monitoring Action Plan* (Seashore Engineering, 2017) provides a high level of detail on coastal monitoring techniques. It is applicable to different areas than those assessed in this CHRMAP, but deals with similar coastal environments and the proposed monitoring is generally transferable to sites within the Shire. In general the monitoring, data collation and analysis may include:

- > Annual Beach Profile Surveys;
- > Horizontal Shoreline Datum determination from aerial photos;
- > Post wave erosion event (>2 yr ARI wave) beach profiles;
- > Cyclone storm surge flooding event inundation levels; and
- > Seawall, groyne and shoreline protection devices condition monitoring.

The Shire may also require data from updates from the State and Federal programs providing offshore wave data, winds and rainfall, ecological community information and threatened species registers and other data sets. This information needs to be collated to inform the updates to hazard line projections and revise CHRMAP adaptation strategies as appropriate.

6.7 Shire of Dandaragan Implementation Plan (to 2030)

The implementation plan for the next decade up to 2030 is shown in the Gantt chart presented in **Figure 6-1** and Tasks listed below in **Table 6-2**.

Table 6-2 Tasks for Implementation up to 2030, schedule start and end dates and approximate costs

Task Name	Start	Finish	Cost Estimate \$1,000s
Planning and Development Controls Review	1 Jan '18	28 Oct '20	\$155
Review Planning and Development Controls and Recommend Amendments as required	1 Mar '18	27 Sep '19	\$80
Amend current zone and SCA boundaries	1 May '18	31 Oct '18	\$15
Update SCA special provisions	29 Nov '18	30 Jan '19	\$20
Dandaragan LPS 7 Update and Endorsement by WAPC	17 Jan '20	30 Jun '20	\$40
Monitoring	1 May '18	14 May '29	\$410
Horizontal Shoreline Datum (Aerial Photo Analysis)	1 May '18	2 May '22	\$70
Annual Beach Profile Surveys	4 May '18	14 May '29	\$300
Post wave erosion Event (>2 yr ARI wave) Beach Profiles	11 Jan '19	17 Jan '19	\$30
Cyclone storm surge flooding Event	15 Mar '20	18 Mar '20	\$10
Specialist Investigations	4 Feb '19	28 Jul '26	\$415
Comprehensive investigation of each community and visitors be undertaken to identify beneficiaries of proposed protection areas	4 Feb '19	8 Nov '19	\$150
Investigate allowance for coastal foreshore reserve width to extend the 2110 Hazard line a sufficient distance to accommodate future relocation of foreshore assets	15 Mar '19	2 Jul '19	\$15
Assess Current and Future Sediment Budget in the Secondary Cell	1 Jul '19	30 Jun '22	\$80
Analysis of Storm Surge Inundation and Erosion event monitoring	14 May '20	5 Aug '20	\$40
Investigate Storm Surge and Coastal Processes Interactions to reassess triggers, set FFL, CHRMAP, Water Management Plans and Emergency Management Plan overlaps	25 Mar '26	28 Jul '26	\$50
Undertake economic analysis of options	17 May '20	17 Sep '20	\$80
Operational	1 Feb '18	28 Apr '20	\$80
Establish Data Management and GIS system (time series, spot levels and remote sensing) relating to shoreline monitoring and general flooding in each Township to allow identification of trends over time, and Trigger assessment	1 Feb '18	26 Mar '19	\$50
Update Asset database to incorporate end of life date to facilitate future management of assets	1 Feb '19	30 Sep '19	\$20
Notifications on property titles - Potentially affected land owners to be contacted directly	2 Jul '18	28 Apr '20	\$10
CHRMAP Review and Update (2023)	18 Feb '22	30 Nov '23	\$210
Review Hazard line estimates (S1, S2, S3 and S4)	18 Feb '22	21 Apr '22	\$25
Review Risk Assessment and Future Pathway Options	29 Apr '22	30 Jun '22	\$40
Community and Stakeholder Consultation	1 May '22	30 Jan '23	\$50
Update CHRMAP	24 Jun '22	2 Mar '23	\$80
CHRMAP 2022 Endorsement by WAPC	7 Jul '23	30 Nov '23	\$15
CHRMAP Review and Update (2028)	1 Feb '28	23 Nov '29	\$210
Review Hazard line estimates (S1, S2, S3 and S4)	1 Feb '28	27 Mar '28	\$25
Review Risk Assessment and Future Pathway Options	1 May '28	1 Nov '28	\$40
Community and Stakeholder Consultation	1 Feb '28	9 Oct '28	\$50
Update CHRMAP	10 Jul '28	16 Mar '29	\$80
CHRMAP 2027 Endorsement by WAPC	23 Jul '29	23 Nov '29	\$15

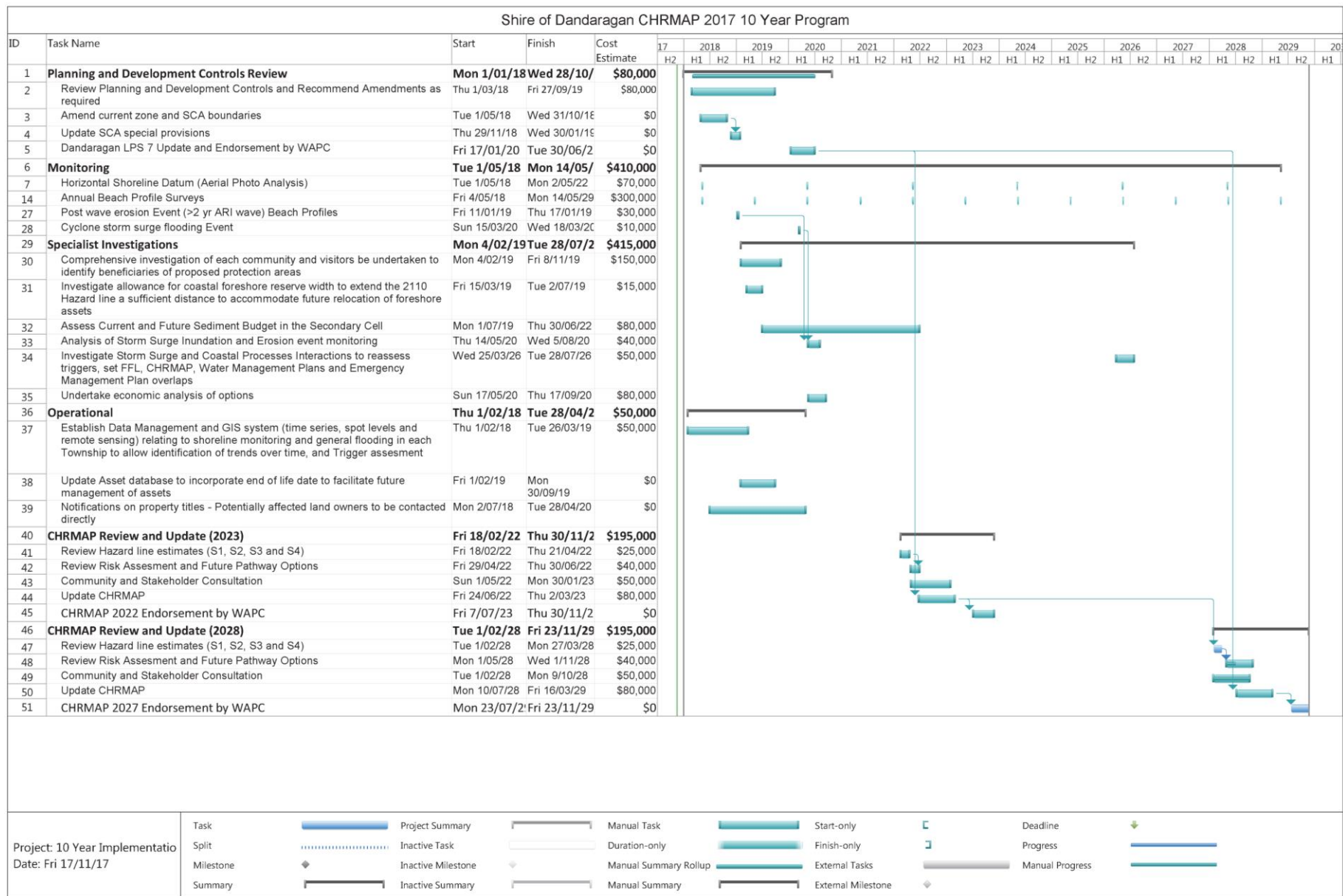


Figure 6-1 Shire of Dandaragan CHRMAP 2017: 10 year suggested program of work

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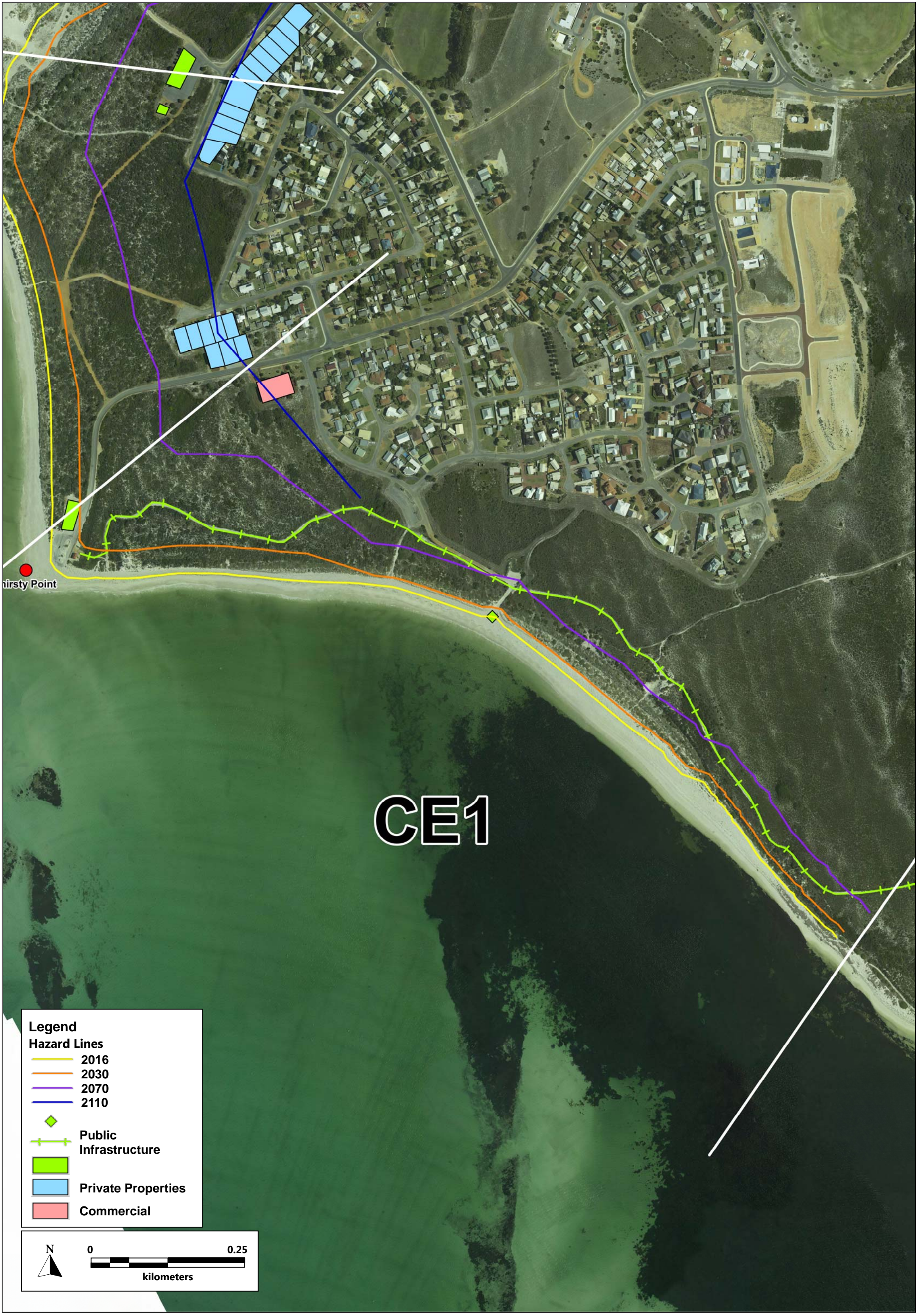
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Shire of Dandaragan
Coastal Hazard Risk Management
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APPENDIX

A

HAZARD MAPS BY
MANAGEMENT UNITS



thirsty Point

CE1

Legend

Hazard Lines

- 2016
- 2030
- 2070
- 2110

Public Infrastructure

Private Properties

Commercial

N

0 0.25

kilometers

CE2

Thirsty Point

Legend

Hazard Lines

- 2016
- 2030
- 2070
- 2110

Public Infrastructure

- Private Properties
- Commercial



0 0.2
kilometers

CE

CE3

Legend

Hazard Lines

- 2016
- 2030
- 2070
- 2110

Public Infrastructure

Private Properties

Commercial

N

0 0.25


kilometers


CE4


Legend

Hazard Lines

- 2016
- 2030
- 2070
- 2110

 Public Infrastructure

 Private Properties

 Commercial



JB1

Island Point

Legend

Hazard Lines

- HSD
- 2016
- 2030
- 2070
- 2110

Public Infrastructure

- Private Properties
- Commercial



0 0.2
kilometers

JB2

Legend

Hazard Lines

- HSD
- 2016
- 2030
- 2070
- 2110

Public Infrastructure

Private Properties

Commercial



JB3

Legend

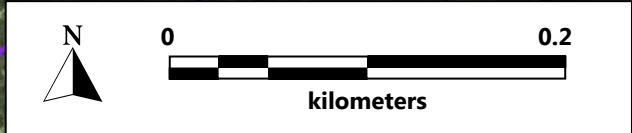
Hazard Lines

- HSD
- 2016
- 2030
- 2070
- 2110

Public Infrastructure

Private Properties

Commercial



JB4

Legend

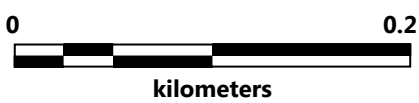
Hazard Lines

- HSD
- 2016
- 2030
- 2070
- 2110

Public Infrastructure

Private Properties

Commercial



Shire of Dandaragan
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APPENDIX

B

VALUE MAPS AND LIST OF KEY STAKEHOLDERS



Please help us understand what you value about the
Lancelin coast, where do you like to work, rest and play?

Data Source: Department of Parks & Wildlife (2017) Threatened and Priority Flora/Fauna Database.
Search for Cervantes accessed on 8 May 2017. Prepared by the Species and Communities Branch for Cardno for the
Shire of Dandaragan CHRMAPS.

Legend

- Recreational
- Enviromental
- Commercial
- Infrastructure
- Civic
- Heritage

- Threatened Flora, Fauna;
Ecological Communities

Our Coastal Values

Cervantes





Please help us understand what you value about the
Lancelin coast, where do you like to work, rest and play?

Legend

- Recreational
- Environmental
- Commercial
- Infrastructure
- Civic
- Heritage
- Threatened Flora, Fauna;
Ecological Communities

Our Coastal Values

Jurien Bay



Key stakeholders for engagement in the CHRMAP process

Internal Stakeholders	Community Groups	Impacted stakeholders	Interested External Stakeholder Groups
<ul style="list-style-type: none"> CHRMAP Steering Group Elected members and Executive Lead Team Shire planning and development departments Communications and marketing departments Emergency management departments Infrastructure / Asset Management Section Community Development 	<ul style="list-style-type: none"> Community and Ratepayers Associations: Kwelena Mambakort Aboriginal Corporation (Yued) Cervantes Ratepayers Association and Coastcare Group Jurien Bay Progress Association Jurien Bay Regional Herbarium Group Local Chamber of Commerce 	<ul style="list-style-type: none"> Traditional Owners Residents, business owners and property owners located in areas vulnerable to coastal hazards. Residents, business owners and property owners who live in parts of the LGA that are not vulnerable to coastal hazards (e.g. ratepayers who may be subject to charges to fund adaptation works). Community members that are indirectly impacted by coastal hazards (e.g. users of coastal roads, parks, and other amenities). Agencies involved in the emergency response immediately prior to, during or after a storm/erosion event (incl. SES, WA Police, Fire Service and Ambulance Service). 	<ul style="list-style-type: none"> Department of Planning, Lands and Heritage (formerly the Departments of Planning, Lands, State Heritage Office and the Aboriginal heritage and land functions of the Department of Aboriginal Affairs) Department of Transport Northern Agricultural Catchments Council Department of Biodiversity, Conservation and Attractions (formerly Department of Parks and Wildlife) Western Australian Planning Commission Other WA State Government entities: (for example Main Roads, Department of Aboriginal Affairs, Department of Water, Department of Environmental Regulation, Department of State Development) Service providers: St Johns Ambulance, Local Police Stations, Bush Fire Brigade, Volunteer Marine Rescue, SES, SLSCs Utilities (e.g. Synergy, Water Corporation, Telstra) WA Local Government Association (WALGA) Local Government Insurers (LGIS) Developers Landcorp Wheatbelt Development Commission Moore Catchments Council City of Wanneroo Shire of Coorow Insurance Industry Representatives (TBA) WA Tourism WA Conservation Council






Shire of Dandaragan
Coastal Hazard Risk Management
and Adaptation Plan

APPENDIX



C

ASSET INFORMATION FOR EACH OF
THE MANAGEMENT UNITS







CE1: South of Thirsty Point

		Values	Assets at Risk	
 	  	Environmental	Beach Coastal/dune vegetation	
		Social	Beach Carpark (Thirsty Point) Thirsty Point Walk Trail	
		Economic - Private	Cervantes Lodge	
		Economic - Public	Beach Carpark (Thirsty Point) Thirsty Point Walk Trail	
		Existing Coastal Controls		
		Numerous small offshore islands and reefs		
		Existing Planning Controls		
		District Planning Scheme No.7 (DPS7) Reserves and Zoning Parks and Recreation Reserve Tourist Zone and Public Purpose Utility (cnr Barcelona Drive & Seville St) Low-density residential Coastal Plan - Walk trail identified		





CE2: Cervantes Township South

		Values	Assets at Risk
 	Environmental	Beach Coastal/dune vegetation	
	Social	Beach - dog and fishing beach Carpark (sealed) Coastal path (unsealed) Ronsard Reserve	
	Economic - Private	Residential - 13 properties	
	Economic - Public	Beach Road (Seville St) Carpark (sealed) Ronsard Reserve	
		Existing Coastal Controls	
		Numerous small offshore islands and reefs	
		Existing Planning Controls	
		District Planning Scheme No.7 (DPS7) Reserves and Zoning Parks and Recreation Reserve Low-density residential 1999 Coastal Plan: Promenade and bike network	





CE3: Cervantes Township Central

		Values	Assets at Risk
 	   	Environmental Beach Coastal/dune vegetation	Assets at Risk Beach Coastal/dune vegetation
		Social	Beach Jetty Foreshore Recreation Café (Seashells) Light Industrial Area
		Economic - Private	Caravan Park (RAC Holiday Park) Light Industrial Area Residential - 66 properties
		Economic - Public	Beach Jetty & Refuelling Station Road (Calatonia St) Foreshore Recreation Light Industrial Area
		Existing Coastal Controls	
		Numerous small offshore islands and reefs	
		Existing Planning Controls	
		District Planning Scheme No.7 (DPS7) Reserves and Zoning Parks and Recreation Reserve Tourist Zone and Public Purpose Utility Low-density residential Harbour Industrial 1999 Coastal Plan: "Major foreshore improvements", " Waterside tourism and recreation focus", "Marine Services Park (Cervantes Keys)"	





CE4: Cervantes Township North

		Values	Assets at Risk	
 	 	Environmental	Beach Coastal/dune vegetation	
		Social	Beach Fishing Club	
		Economic - Private	Residential - 2 properties	
		Economic - Public	Beach	
		Existing Coastal Controls		
		Numerous small offshore islands and reefs		
		Existing Planning Controls		
		District Planning Scheme No.7 (DPS7) Reserves and Zoning Parks and Recreation Reserve Marine Services Unvested Crown Land Conservation 1999 Coastal Plan: "Proposed tourist development"		




JB1: South of Island Point

		Values	Assets at Risk
   		Environmental	Beach Coastal/dune vegetation Marine Park - Sanctuary Zone
		Social	Beach Turquoise Way Trail
		Economic - Private	
		Economic - Public	Beach Turquoise Way Trail
		Existing Coastal Controls	
		Witlock / Boullanger Island and surrounding reefs	
		Existing Planning Controls	
		District Planning Scheme No.7 (DPS7) Reserves and Zoning Parks and Recreation Reserve Special Use Zone	



JB2: Jurien Bay Township South

		Values	Assets at Risk
 	 	Environmental Beach Coastal/dune vegetation Marine Park - Sanctuary Zone	Beach Coastal/dune vegetation Marine Park - Sanctuary Zone
		Social	Beach - dogs allowed on south-west side of Shingle Ave and no dogs on north-east side Carpark (unsealed) Casuarina Park Turquoise Way Trail
		Economic - Private	
		Economic - Public	Beach Turquoise Way Trail
		Existing Coastal Controls	
		Witlock / Boullanger Island and surrounding reefs	
		Existing Planning Controls	
		District Planning Scheme No.7 (DPS7) Reserves and Zoning Parks and Recreation Reserve Low-density residential	

JB3: Jurien Bay Township Central

		Values	Assets at Risk
 		Environmental	Beach Snorkel and Dive Trail
		Social	Beach Snorkel and Dive Trail (Reef Balls / Jetty) Café (Jurien Jetty) Dobbyn Park Foreshore Recreation Turquoise Way Trail
		Economic - Private	Residential Café (Jurien Jetty)
		Economic - Public	Beach Jetty Roads (Grigson St and Heaton St) Jurien Bay Tourist Park Dobbyn Park Turquoise Way Trail Foreshore Recreation
		Existing Coastal Controls	
		Witlock / Boulanger / Favourite Island and surrounding reefs	
		Existing Planning Controls	
		District Planning Scheme No.7 (DPS7) Reserves and Zoning Parks and Recreation Reserve Low density residential Tourist zone Special Use Zone 3 1999 Coastal Plan: Town centre link to beach, Major foreshore park, Vibrant	

JB4: Jurien Bay Township North

	<u>Values</u>	<u>Assets at Risk</u>
 	Environmental	Beach Coastal/dune vegetation
	Social	Beach Turquoise Way Trail Federation Memorial Park
	Economic - Private	Residential Jurien Challeys
	Economic - Public	Beach Turquoise Way Trail
<u>Existing Coastal Controls</u>		
Witlock / Boullanger Island and surrounding reefs		
<u>Existing Planning Controls</u>		
District Planning Scheme No.7 (DPS7) Reserves and Zoning Parks and Recreation Reserve Low density residential Tourist zone Harbour zone 1999 Coastal Plan Sea search and rescue facility, Major gardens/War Memorial Park Coast Link Road to Harbour		



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APPENDIX

D

TECHNICAL NOTE ON RISK
ASSESSMENT METHODS

APPENDIX D RISK ASSESSMENT METHODOLOGY

1.1 Overview

The risk assessment process uses the outcomes of Part 1 of the CHRMAP to characterise the risk and vulnerability of assets over the planning time frame. An overview of the framework adopted in this assessment is presented in Figure 1-1.

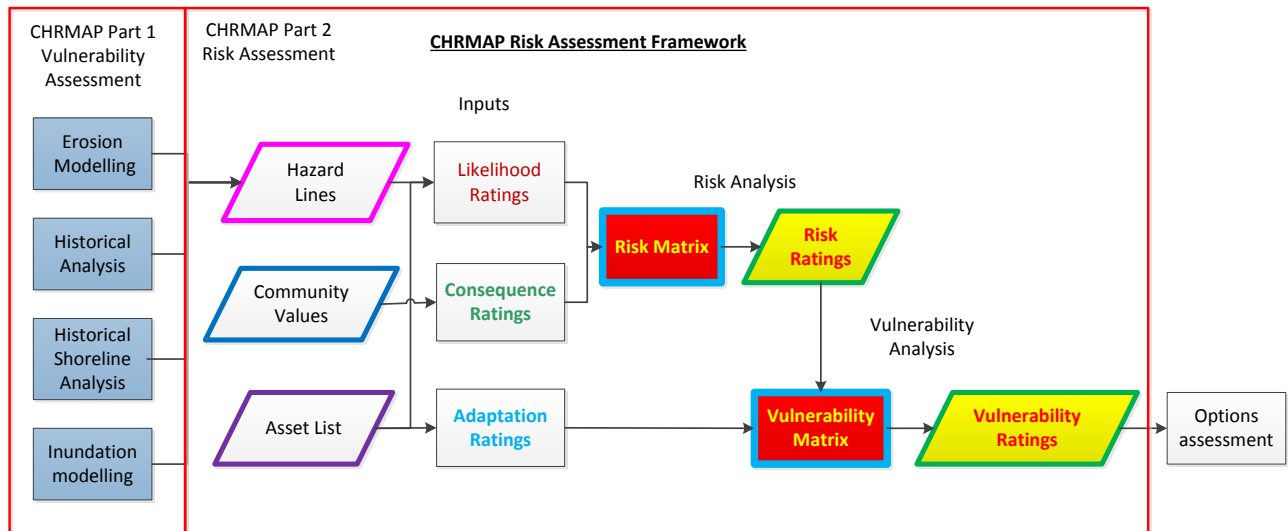


Figure 1-1 Schematic representation of the risk assessment process

There are a number of steps involved in the risk assessment process:

1. Define likelihood categories (ratings)
2. Allocate the likelihood of the risk occurring to specific assets for a particular planning timeframe based on the results of the hazard assessment;
3. Define consequence categories (ratings)
4. Allocate the consequence of the risk occurring to specific assets for a particular planning timeframe based on CHRMAP guidance, AS 5334-2013 and the project specific Success Criteria;
5. Define risk categories (ratings) based on the acceptability (or tolerability); and
6. Allocate the risk ratings for combinations of likelihood and consequence.

The process aims to be objective, logical and transparent. All steps call for interpretation, and allocation of consequence in particular may be based on subjective judgement. However, once the framework has been adopted, specific outcomes can be clearly traced to inputs. The inputs can be updated in response to new information or stakeholder input, and the risk assessment outcomes will be revised accordingly. Additional details on how the input parameters were derived, and the ratings were developed is provided below.

1.2 Risk Analysis

To assess the level of risk, or potential impact, posed to the assets by the identified coastal hazards, this CHRMAP has employed risk analysis techniques outlined in AS 5334-2013. The risk assessment entails the combination of likelihood and consequence of exposure to coastal hazard to produce the risk level, or potential impact, for each asset, as presented in Figure 1-2 below.

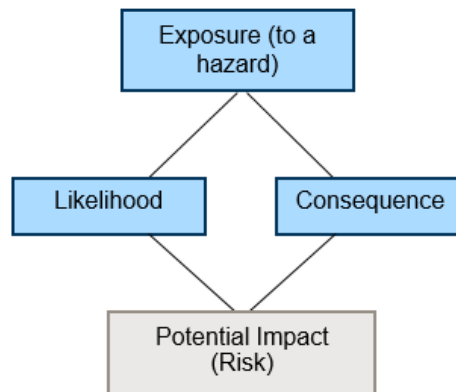


Figure 1-2 Risk analysis structure

The potential impact (risk) has been assessed for each asset at each of the planning timeframes:

- > Present Day (2016)
- > 2030
- > 2070
- > 2110

This allows risk prioritisation and assessment of each asset's risk level over the 100 year planning horizon as required by SPP2.6.

For the purposes of this report 'short-term' refers to the period between 2015 and 2030, 'medium-term' refers to the period between 2030 and 2050, and long-term refers to the period beyond 2050. The 'immediate-term' or 'immediately' may also be used, generally referring to within the next 5 years.

1.2.2 Likelihood

According to WAPC (2014) and for the purposes of this study, likelihood is defined as the chance of erosion and storm surge inundation impacting on existing and future assets and their values. The likelihood scale that has been applied at each timeframe is presented in Error! Reference source not found.

Table 1-1 CHRMAP likelihood ratings

Rating	Description
Almost Certain	High possibility of impact to asset shoreline for a given planning timeframe
Likely	Impact to asset shoreline for a given planning timeframe is likely
Possible	Impact to asset shoreline for a given planning timeframe is possible
Unlikely	Impact to asset shoreline for a given planning timeframe is unlikely
Rare	May occur in exceptional circumstances

As outlined in Section 3, the erosion risk is made up of a number of components. Each of these is based on a suite of assumptions and each has a degree of uncertainty which may influence the likelihood of the predicted level of erosion occurring at each planning horizon. For instance, S1 assumes that the probability of a coastal hazard event occurring is the same each year, which is not necessarily the case when considering the effects of climate change and the rise in sea level over time, which underpins the future planning scenarios assessed in this study.

There is considerable scope for confusion in defining and allocating likelihood in terms of recurrence frequency / probability (as per AS 5334) for the purposes of risk assessment, since this terminology has specific meaning in the coastal context. Cardno has therefore adopted the approach presented in Figure 1-3, which is generally consistent with guidance in WAPC (2014). An example of the likelihood rating input format for assets in a particular study site is provided in Table 1-2.

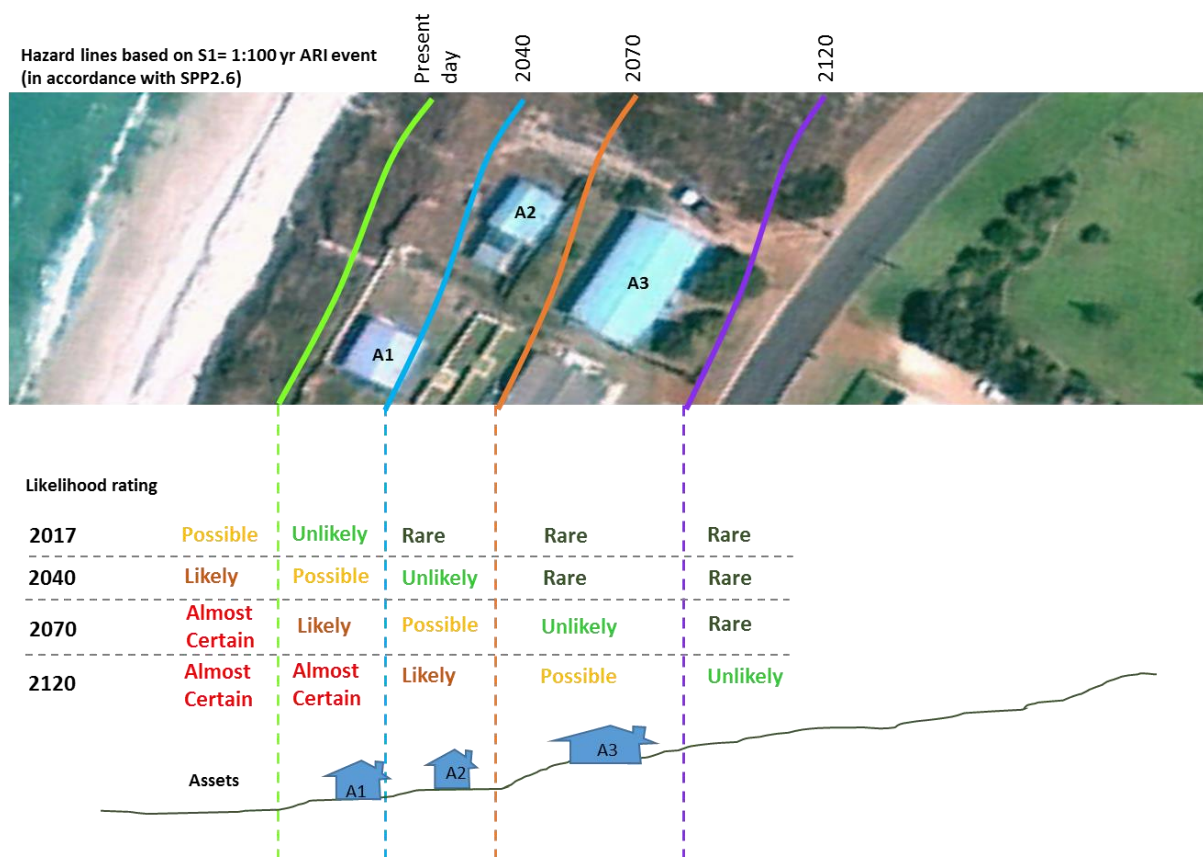


Figure 1-3 Representation of method used to assign likelihood ratings to individual assets for each planning timeframe

Table 1-2 Example likelihood rating inputs table

Asset	Planning timeframe			
	Present Day	2030	2070	2110
Asset	Likelihood			
Beach	Unlikely	Possible	Almost Certain	Almost Certain
Car Park	Rare	Rare	Possible	Almost Certain
Road	Rare	Rare	Possible	Almost Certain
Residential Lots	Rare	Rare	Unlikely	Likely

1.2.3 Consequence

Consequence is the result of a hazard impacting an area or asset. For this analysis, consequence has been divided into five ratings ranging from catastrophic to insignificant (Table 1-3). The consequence ratings for this risk assessment have been adapted from those presented in AS 5334-2013, and WAPC (2014), which focus on the social, economic and environmental consequences.

A heritage component has been incorporated alongside environmental impacts to ensure impacts to heritage sites are accounted for in the risk assessment process. The consequence descriptions have also been scaled to be applicable to the local context in which this study is being undertaken, where as previously their higher ratings were associated with consequences on a global scale. Generally, the consequence categories incorporate all of the values outlined by the success criteria and align comparatively between categories with the level of response to these success criteria.

Unless otherwise stated, the consequence ratings are generally associated with the impact of coastal erosion. Generally coastal inundation and coastal erosion will occur at the same time during a storm event. In the majority of circumstances and locations for the City's coastline, the impacts of coastal erosion on infrastructure will be more severe and long-lasting than the impacts of coastal inundation. There are circumstances where coastal erosion will not occur (e.g. where the shoreline is rock) and in these instances only the consequences of coastal inundation are considered

Table 1-3 Consequence ratings (adapted from AS 5334-2013)

Rating	Safety and Social	Economic	Environment and Heritage
Catastrophic	Loss of life and serious injury. Large long-term or permanent loss of services, public access/amenity, employment, wellbeing or culture. No suitable alternative sites exist within the LGA.	Permanent and/or entire loss or damage to property, plant and equipment, finances >\$10 million	Permanent and entire loss of flora, fauna conservation or heritage area (no chance of recovery)
Major	Serious injury. Medium term disruption to services, public access/amenity, employment, wellbeing or culture. Very limited suitable alternative sites exist within the LGA.	Permanent and/or large scale loss or damage to property, plant and equipment, finances > \$2 - \$10 million	Long-term and/or large scale loss of flora, fauna or heritage area (limited chance of recovery) with local impact.
Moderate	Minor injury. Major short term or minor long-term disruption to services, public access/amenity, employment, wellbeing, or culture. Limited suitable alternative sites exist within the LGA.	Permanent and/or medium scale loss or damage to property, plant and equipment, finances > \$100,000 - \$2 million	Medium-term and/or medium scale loss of flora, fauna or heritage area (recovery likely) with local impact.
Minor	Small to medium disruption to services, public access/amenity, employment, wellbeing, or culture. Many suitable alternative sites exist within the LGA.	Permanent and/or small scale loss or damage to property, plant and equipment, finances > \$10,000 - \$100,000	Short-term and/or small scale loss of flora, fauna or heritage area (strong recovery) with local impact.
Insignificant	Minimal short-term inconveniences to services, public access/amenity, employment, wellbeing, or culture. Many suitable alternative sites exist within the LGA.	Permanent loss or damage to property, plant and equipment, finances < \$10,000	Negligible to no loss of flora, fauna or heritage area (strong recovery) with local impact.

Consequence was allocated for each asset within a vulnerable area, and for each of the planning timeframes. It was possible for the severity of consequence to increase over time, assuming that impacts could be greater as well as more likely to occur. An example of the format of consequence rating inputs is provided in Table 1-4.

Table 1-4 Example consequence ratings applied to a vulnerable area

Asset	Planning timeframe			
	Present day	2030	2070	2110
Asset	Consequence			
Impact on Beach	Major	Major	Catastrophic	Catastrophic
Impact on Car Park	Moderate	Moderate	Moderate	Moderate
Impact on Road	Moderate	Moderate	Major	Major
Impact on Residential Lots	Minor	Minor	Minor	Major

1.3 Risk Evaluation

1.3.1 Potential Impact (Risk Rating)

The CHRMAP uses a risk assessment matrix which is based on that provided in AS5334-2013 (Table 1-5). Risk ratings are defined by risk acceptability / tolerance and the urgency of required action (Table 1-6). This will help to prioritise multiple identified risks within the study area. It also provides a mechanism to compare the level of risk after a preferred adaptation option is determined, for example, at present a risk may be “extreme” in the short term, after the implementation of adaption option ‘X’ the risk level is re-evaluated and reduces to “medium”.

Table 1-5 Risk matrix (Based on AS5334-2013)

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	L	M	H	E	E
Likely	L	M	M	H	E
Possible	L	L	M	H	E
Unlikely	L	L	M	M	H
Rare	L	L	L	M	M

Table 1-6 Risk levels and tolerances

Risk Level	Action Required	Acceptance / Tolerance
Extreme (E)	Immediate action required to eliminate or reduce risk to acceptable levels.	Unacceptable
High (H)	Immediate to short-term action required to eliminate or reduce risk to acceptable levels.	Tolerable / Unacceptable
Medium (M)	Short to medium term action to reduce risk to acceptable levels, or accept risk.	Tolerable
Low (L)	Accept risk.	Acceptable

The risk evaluation process utilises the outcomes of the risk analysis as inputs. Likelihood and consequence allocated for assets, under each scenario, are combined to derive a risk rating for each asset within each of vulnerable areas. Examples of the derived risk ratings for a particular study site are provided in Table 1-7.

Table 1-7 Example of risk rating results by asset and planning timeframe

	Planning Timeframe			
	Present Day	2030	2070	2110
Asset	Risk			
Beach	Medium	Medium	Extreme	Extreme
Car Park	Low	Low	Medium	High
Road	Low	Low	High	Extreme
Residential Lots	Low	Low	Medium	High

1.4 Vulnerability Analysis

As per AS 5334-2013, detailed risk analysis should include a vulnerability analysis to thoroughly examine how coastal hazards and climate change may affect the asset.

Vulnerability analysis involves assessing the asset's existing capacity to adapt to a potential impact; a flow chart for the process of establishing the vulnerability is presented in Figure 1-4. Adaptive capacity and vulnerability are detailed in the following sections

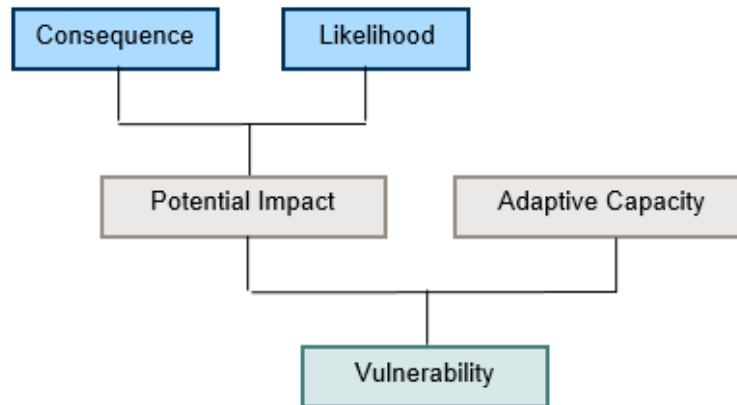


Figure 1-4 Vulnerability assessment structure

1.4.2 Adaptive Capacity

The adaptive capacity (Table 1-8) is based upon the potential for the system to be modified or acclimatise to cope with the impacts of identified hazards. The system of existing controls, such as the dune system and reef, all have an influence on the ability of hazards to affect a study site. The aim of the CHRMAP is to develop options that realise the potential adaptive capacity through techniques such as managed retreat, accommodation, and protection. An asset or group of assets with a high adaptive capacity is one that can easily (i.e. at low cost) be adapted or one that has some capacity to self-adapt with changing conditions (e.g. beaches and dune systems can migrate across shore as the mean sea level (MSL) changes). Assets with a high risk level and low adaptive capacity are deemed vulnerable and management options should be investigated. Examples of the adaptive capacity ratings allocated for a particular study site are provided in Table 1-9.

Table 1-8 CHRMAP adaptive capacity ratings

Rating	Adaptive Capacity
Low	Little or no adaptive capacity. Potential impact would destroy all functionality.
Moderate	Small amount of adaptive capacity. Difficult but possible to restore functionality through repair and redesign.
High	Decent adaptive capacity. Functionality can be restored, although additional adaptive measures should still be considered. Natural adaptive capacity restored slowly over time under average conditions.
Very High	Good adaptive capacity. Functionality restored easily. Adaptive systems restored at a relatively low cost or naturally over time.

Table 1-9 Example of adaptive capacity ratings applied to assets and timeframes

	Planning Timeframe			
	Present Day	2030	2070	2110
Asset	Adaptive Capacity			
Beach	High	High	Moderate	Low
Car Park	Moderate	Moderate	Moderate	Moderate
Road	Moderate	Low	Low	Low
Residential Lots	Low	Low	Low	Low

1.4.3 Vulnerability

Vulnerability is the potential for a system to suffer damage or ill effects as a result of coastal hazards or climate change. Vulnerability is a function of the likelihood of an event occurring, the consequences of the event and the capacity to adapt and change. In a similar fashion to the risk methodology, potential impact and adaptive capacity can be combined using a customised matrix (Table 1-10) with the significance of the vulnerability rating listed in relation to acceptability and tolerances provided in Table 1-11. An example outcome from the analysis is provided in Table 1-12.

Table 1-10 Vulnerability Analysis Matrix

Risk Level (Potential Impact)	Adaptive Capacity			
	Very High	High	Moderate	Low
Extreme	H	H	VH	VH
High	M	H	H	VH
Medium	M	M	M	H
Low	L	L	L	L

Table 1-11 Vulnerability levels and tolerances

Vulnerability Level	Action Required	Acceptance / Tolerance
Very High (VH)	Significant further adaption required to ensure asset is not lost. Reconsideration of design if vulnerability cannot be reduced.	Unacceptable
High (H)	Further adaption required. All stakeholders should be fully aware of risks if vulnerability cannot be reduced.	Tolerable / Unacceptable
Medium (M)	Further adaption should be investigated, acceptable in certain circumstances. Monitoring programs recommended.	Tolerable
Low (L)	Acceptable; adaption and monitoring may be required over the asset's lifetime.	Tolerable / Acceptable

Table 1-12 Example of outcome from vulnerability analysis

	Planning Timeframe			
	Present Day	2030	2070	2110
Asset	Vulnerability			
Beach	Low	Low	Medium	High
Car Park	Low	Low	Medium	High
Road	Low	Low	Low	Medium
Residential Lots	Low	Low	Low	High

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APPENDIX

E

RISK ASSESSMENT RATINGS
AND RESULTS

CE1: South of Thirsty Point

Assessment Inputs				
	2016	2030	2070	2110
<u>Asset</u>	<u>Likelihood</u>			
Beach	Unlikely	Possible	Likely	Almost Certain
Coastal/dune vegetation	Unlikely	Possible	Likely	Almost Certain
Cervantes Lodge	Rare	Rare	Unlikely	Possible
Carpark (Thirsty Point)	Unlikely	Possible	Likely	Almost Certain
Thirsty Point Walk Trail	Unlikely	Possible	Likely	Almost Certain

<u>Asset</u>	<u>Consequence of Erosion</u>			
Impact on beach amenity	Insignificant	Insignificant	Insignificant	Insignificant
Impact on ecological buffer	Insignificant	Insignificant	Minor	Minor
Impact on Cervantes Lodge	Insignificant	Insignificant	Insignificant	Moderate
Impact on Thirsty Point Carpark	Minor	Minor	Minor	Minor
Impact on Thirsty Point Walk Trail	Minor	Minor	Minor	Minor

<u>Asset</u>	<u>Adaptive capacity</u>			
Beach	Very high	Very high	Very high	Very high
Coastal/dune vegetation	Very high	Very high	Very high	Very high
Cervantes Lodge	Low	Low	Low	Low
Carpark (Thirsty Point)	High	High	Moderate	Moderate
Thirsty Point Walk Trail	High	High	Moderate	Moderate

Risk Assessment				
	2016	2030	2070	2110
	<u>Risk</u>			
Beach	Low	Low	Low	Low
Coastal/dune vegetation	Low	Low	Medium	Medium
Cervantes Lodge	Low	Low	Low	Medium
Carpark (Thirsty Point)	Low	Low	Medium	Medium
Thirsty Point Walk Trail	Low	Low	Medium	Medium

	<u>Vulnerability</u>			
Beach	Low	Low	Low	Low
Coastal/dune vegetation	Low	Low	Medium	Medium
Cervantes Lodge	Low	Low	Low	High
Carpark (Thirsty Point)	Low	Low	Medium	Medium
Thirsty Point Walk Trail	Low	Low	Medium	Medium

CE2: Cervantes Township South

Assessment Inputs				
	2016	2030	2070	2110
<u>Asset</u>	<u>Likelihood</u>			
Beach	Possible	Likely	Almost Certain	Almost Certain
Coastal/dune vegetation	Possible	Likely	Almost Certain	Almost Certain
Road (Seville St)	Rare	unlikely	Possible	Almost Certain
Residential	Rare	Rare	unlikely	Possible
Thirsty Point Carpark (sealed)	unlikely	Possible	Likely	Almost Certain
Ronsard Reserve	Rare	Rare	unlikely	Possible

<u>Asset</u>	<u>Consequence of Erosion</u>			
Impact on beach amenity	Insignificant	Insignificant	Minor	Moderate
Impact on ecological buffer	Insignificant	Insignificant	Minor	Moderate
Impact on Seville St	Minor	Minor	Moderate	Moderate
Impact on carpark	Minor	Minor	Minor	Moderate
Impact on beach access road	Minor	Minor	Minor	Moderate
Impact on Ronsard Reserve	Minor	Minor	Minor	Moderate

<u>Asset</u>	<u>Adaptive capacity</u>			
Beach	Very High	Very High	Moderate	Low
Coastal/dune vegetation	High	High	Moderate	Low
Road (Seville St)	High	High	High	High
Residential	Low	Low	Low	Low
Thirsty Point Carpark (sealed)	High	High	High	High
Ronsard Reserve	High	High	High	Moderate

Risk Assessment				
	2016	2030	2070	2110
	<u>Risk</u>			
Beach	Low	Low	Medium	High
Coastal/dune vegetation	Low	Low	Medium	High
Road (Seville St)	Low	Low	Medium	High
Residential	Low	Low	Low	Medium
Thirsty Point Carpark (sealed)	Low	Low	Medium	High
Ronsard Reserve	Low	Low	Low	Medium

	<u>Vulnerability</u>			
Beach	Low	Low	Medium	Very High
Coastal/dune vegetation	Low	Low	Medium	Very High
Road (Seville St)	Low	Low	Medium	High
Residential	Low	Low	Low	High
Thirsty Point Carpark (sealed)	Low	Low	Medium	High
Ronsard Reserve	Low	Low	Low	Medium

CE3: Cervantes Township Central

	Assessment Inputs			
	2016	2030	2070	2110
<u>Asset</u>	<u>Likelihood</u>			
Beach	Possible	Likely	Almost Certain	Almost Certain
Coastal/dune vegetation	Possible	Likely	Almost Certain	Almost Certain
Jetty	Possible	Likely	Almost Certain	Almost Certain
Road (Calatonia St)	Rare	Unlikely	Possible	Likely
Caravan Park (RAC Holiday Park)	Rare	Rare	Unlikely	Possible
Foreshore recreation	Possible	Likely	Almost Certain	Almost Certain
Café (Seashells)	Rare	Rare	Unlikely	Possible
Light Industrial Area (Lobster Shack)	Possible	Likely	Almost Certain	Almost Certain
Residential	Unlikely	Possible	Likely	Almost Certain

<u>Asset</u>	<u>Consequence of Erosion</u>			
Impact on beach amenity	Major	Major	Major	Major
Impact on ecological buffer	Major	Major	Major	Major
Impact on jetty	Minor	Minor	Moderate	Moderate
Impact on Calatonia St	Insignificant	Minor	Moderate	Moderate
Impact on RAC Holiday Park	Insignificant	Minor	Moderate	Moderate
Impact on park facilities	Insignificant	Minor	Moderate	Moderate
Impact on Seashells Café	Insignificant	Minor	Moderate	Moderate
Impact on fishing industrial area	Major	Major	Catastrophic	Catastrophic
Residential	Minor	Moderate	Catastrophic	Catastrophic

<u>Asset</u>	<u>Adaptive capacity</u>			
Beach	High	High	Moderate	Low
Coastal/dune vegetation	High	High	Moderate	Low
Jetty	Moderate	Moderate	Moderate	Moderate
Road (Calatonia St)	Moderate	Low	Low	Low
Caravan Park (RAC Holiday Park)	Low	Low	Low	Low
Foreshore recreation	Moderate	Low	Low	Low
Café (Seashells)	Low	Low	Low	Low
Light Industrial Area	Low	Low	Low	Low
Residential	Low	Low	Low	Low

	Risk Assessment			
	2016	2030	2070	2110
	<u>Risk</u>			
Beach	High	High	Extreme	Extreme
Coastal/dune vegetation	High	High	Extreme	Extreme
Jetty	Low	Medium	High	High
Road (Calatonia St)	Low	Low	Medium	Medium
Caravan Park (RAC Holiday Park)	Low	Low	Medium	Medium
Foreshore recreation	Low	Medium	High	High
Café (Seashells)	Low	Low	Medium	Medium
Light Industrial Area	High	High	Extreme	Extreme
Residential	Low	Medium	Extreme	Extreme

	<u>Vulnerability</u>			
Beach	High	High	Very High	Very High
Coastal/dune vegetation	High	High	Very High	Very High
Jetty	Low	Medium	High	High
Road (Calatonia St)	Low	Low	High	High
Caravan Park (RAC Holiday Park)	Low	Low	High	High
Foreshore recreation	Low	High	Very High	Very High
Café (Seashells)	Low	Low	High	High
Light Industrial Area	Very High	Very High	Very High	Very High
Residential	Low	High	Very High	Very High

CE4: Cervantes Township North

Assessment Inputs				
	2016	2030	2070	2110
<u>Asset</u>	<u>Likelihood</u>			
Beach	Possible	Likely	Almost Certain	Almost Certain
Coastal/dune vegetation	Possible	Likely	Almost Certain	Almost Certain
Residential	Rare	Unlikely	Possible	Likely
Sailing Club (currently inactive)	Possible	Likely	Almost Certain	Almost Certain

<u>Asset</u>	<u>Consequence of Erosion</u>			
Impact on beach amenity	Insignificant	Insignificant	Insignificant	Insignificant
Impact on ecological buffer	Insignificant	Insignificant	Minor	Minor
Impact on residential lots	Minor	Minor	Moderate	Moderate
Impact on sailing club	Minor	Minor	Minor	Minor

<u>Asset</u>	<u>Adaptive capacity</u>			
Beach	Very High	Very High	Very High	Very High
Coastal/dune vegetation	High	High	High	High
Residential	High	High	High	High
Sailing Club (currently inactive)	High	High	High	High

Risk Assessment				
	2016	2030	2070	2110
	<u>Risk</u>			
Beach	Low	Low	Low	Low
Coastal/dune vegetation	Low	Low	Medium	Medium
Residential	Low	Low	Medium	Medium
Sailing Club (currently inactive)	Low	Medium	Medium	Medium

	<u>Vulnerability</u>			
Beach	Low	Low	Low	Low
Coastal/dune vegetation	Low	Low	Medium	Medium
Residential	Low	Low	Medium	Medium
Sailing Club (currently inactive)	Low	Medium	Medium	Medium

JB1: South of Island Point

Assessment Inputs				
	2016	2030	2070	2110
<u>Asset</u>	<u>Likelihood</u>			
Beach	Possible	Likely	Almost Certain	Almost Certain
Coastal/dune vegetation	Possible	Likely	Almost Certain	Almost Certain
Turquoise Way Trail	Possible	Likely	Almost Certain	Almost Certain

<u>Asset</u>	<u>Consequence of Erosion</u>			
Impact on beach amenity	Insignificant	Insignificant	Insignificant	Minor
Impact on ecological buffer	Insignificant	Insignificant	Minor	Minor
Impact on Turquoise Way Trail	Minor	Moderate	Moderate	Moderate

<u>Asset</u>	<u>Adaptive capacity</u>			
Beach	Very high	Very high	Very high	High
Coastal/dune vegetation	Very high	Very high	High	High
Turquoise Way Trail	High	High	High	High

Risk Assessment				
	2016	2030	2070	2110
	<u>Risk</u>			
Beach	Low	Low	Low	Medium
Coastal/dune vegetation	Low	Low	Medium	Medium
Turquoise Way Trail	Low	Medium	High	High

	<u>Vulnerability</u>			
Beach	Low	Low	Low	Medium
Coastal/dune vegetation	Low	Low	Medium	Medium
Turquoise Way Trail	Low	Medium	High	High

JB2: Jurien Bay Township South

Assessment Inputs				
	2016	2030	2070	2110
<u>Asset</u>	<u>Likelihood</u>			
Beach	Possible	Likely	Almost Certain	Almost Certain
Coastal/dune vegetation	Possible	Likely	Almost Certain	Almost Certain
Turquoise Way Trail	Possible	Likely	Almost Certain	Almost Certain
Casuarina Park	rare	Unlikely	Possible	Likely
Carpark (unsealed)	rare	rare	Unlikely	Possible

<u>Asset</u>	<u>Consequence of Erosion</u>			
Impact on beach amenity	Insignificant	Insignificant	Minor	Moderate
Impact on ecological buffer	Insignificant	Insignificant	Minor	Moderate
Impact on Turquoise Way Trail	Minor	Minor	Minor	Minor
Impact on Casuarina park	Minor	Minor	Minor	Minor
Impact on beach carpark	Minor	Minor	Minor	Minor

<u>Asset</u>	<u>Adaptive capacity</u>			
Beach	Very High	Very High	Very High	Very High
Coastal/dune vegetation	Very High	Very High	High	High
Turquoise Way Trail	High	High	High	High
Casuarina Park	High	High	High	High
Carpark (unsealed)	High	High	High	High

Risk Assessment				
	2016	2030	2070	2110
	<u>Risk</u>			
Beach	Low	Low	Medium	High
Coastal/dune vegetation	Low	Low	Medium	High
Turquoise Way Trail	Low	Medium	Medium	Medium
Casuarina Park	Low	Low	Low	Medium
Carpark (unsealed)	Low	Low	Low	Low

	<u>Vulnerability</u>			
Beach	Low	Low	Medium	Medium
Coastal/dune vegetation	Low	Low	Medium	High
Turquoise Way Trail	Low	Medium	Medium	Medium
Casuarina Park	Low	Low	Low	Medium
Carpark (unsealed)	Low	Low	Low	Low

JB3: Jurien Bay Township Central

Assessment Inputs				
	2016	2030	2070	2110
Asset	Likelihood			
Beach	Possible	Likely	Almost Certain	Almost Certain
Snorkel and Dive Trail	Possible	Likely	Almost Certain	Almost Certain
Jetty	Possible	Likely	Almost Certain	Almost Certain
Roads	rare	Unlikely	Possible	Likely
Caravan Park (Jurien Bay Tourist Park)	rare	rare	Unlikely	Possible
Residential	rare	Unlikely	Possible	Likely
Café (Jurien Jetty)	rare	rare	Unlikely	Possible
Dobbyn Park	Unlikely	Possible	Likely	Almost Certain
Turquoise Way Trail	Possible	Likely	Almost Certain	Almost Certain
Foreshore Recreation	Unlikely	Possible	Likely	Almost Certain

Asset	Consequence of Erosion			
Impact on beach amenity	Minor	Moderate	Major	Major
Impact on Underwater Interpretive Snorkel	Minor	Moderate	Moderate	Moderate
Impact on jetty	Minor	Minor	Moderate	Moderate
Impact on Heaton St and Grigson St	Moderate	Moderate	Moderate	Moderate
Impact on Jurien Bay Tourist Park	Minor	Minor	Moderate	Moderate
Impact on residential lots	Minor	Minor	Major	Catastrophic
Impact on Jurien Jetty Café	Moderate	Moderate	Moderate	Moderate
Impact on Dobbyn Park and facilities	Moderate	Moderate	Moderate	Moderate
Impact on Turquoise Way Trail	Minor	Minor	Minor	Minor
Impact on foreshore recreation area	Minor	Minor	Major	Major

Asset	Adaptive capacity			
Beach	High	High	Moderate	Low
Snorkel and Dive Trail	High	High	High	High
Jetty	Moderate	Moderate	Moderate	Moderate
Roads	Moderate	Moderate	Moderate	Moderate
Caravan Park (Jurien Bay Tourist Park)	High	High	High	High
Residential	Low	Low	Low	Low
Café (Jurien Jetty)	High	High	High	High
Dobbyn Park	Moderate	Moderate	Low	Low
Turquoise Way Trail	High	High	High	High
Foreshore Recreation	Moderate	Moderate	Low	Low

Risk Assessment				
	2016	2030	2070	2110
	Risk			
Beach	Low	Medium	Extreme	Extreme
Snorkel and Dive Trail	Low	Medium	High	High
Jetty	Low	Medium	High	High
Roads	Low	Medium	Medium	Medium
Caravan Park (Jurien Bay Tourist Park)	Low	Low	Medium	Medium
Residential	Low	Low	High	Extreme
Café (Jurien Jetty)	Low	Low	Medium	Medium
Dobbyn Park	Medium	Medium	Medium	High
Turquoise Way Trail	Low	Medium	Medium	Medium
Foreshore Recreation	Low	Low	High	Extreme

	Vulnerability			
Beach	Low	Medium	Very High	Very High
Snorkel and Dive Trail	Low	Medium	High	High
Jetty	Low	Medium	High	High
Roads	Low	Medium	Medium	Medium
Caravan Park (Jurien Bay Tourist Park)	Low	Low	Medium	Medium
Residential	Low	Low	Very High	Very High
Café (Jurien Jetty)	Low	Low	Medium	Medium
Dobbyn Park	Medium	Medium	High	Very High
Turquoise Way Trail	Low	Medium	Medium	Medium
Foreshore Recreation	Low	Low	Very High	Very High

JB4: Jurien Bay Township North

Assessment Inputs				
	2016	2030	2070	2110
<u>Asset</u>	<u>Likelihood</u>			
Beach	Possible	Likely	Almost Certain	Almost Certain
Coastal/dune vegetation	Possible	Likely	Almost Certain	Almost Certain
Turquoise Way Trail	Possible	Likely	Almost Certain	Almost Certain
Federation Memorial Park	Rare	Rare	Unlikely	Possible
Residential	Rare	Unlikely	Possible	Likely

<u>Asset</u>	<u>Consequence of Erosion</u>			
Impact on beach amenity	Insignificant	Minor	Moderate	Major
Impact on ecological buffer	Minor	Moderate	Major	Catastrophic
Impact on Turquoise Way Trail	Minor	Minor	Minor	Minor
Impact on Federation Memorial P	Insignificant	Minor	Moderate	Moderate
Impact on residential lots	Minor	Moderate	Major	Catastrophic

<u>Asset</u>	<u>Adaptive capacity</u>			
Beach	High	High	Moderate	Low
Coastal/dune vegetation	High	High	Moderate	Low
Turquoise Way Trail	Moderate	Moderate	Low	Low
Federation Memorial Park	Moderate	Moderate	Low	Low
Residential	Low	Low	Low	Low

Risk Assessment				
	2016	2030	2070	2110
	<u>Risk</u>			
Beach	Low	Medium	High	Extreme
Coastal/dune vegetation	Low	Medium	Extreme	Extreme
Turquoise Way Trail	Low	Medium	Medium	Medium
Federation Memorial Park	Low	Low	Medium	Medium
Residential	Low	Medium	High	Extreme

	<u>Vulnerability</u>			
Beach	Low	Medium	High	Very High
Coastal/dune vegetation	Low	Medium	Very High	Very High
Turquoise Way Trail	Low	Medium	High	High
Federation Memorial Park	Low	Low	High	High
Residential	Low	High	Very High	Very High

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APPENDIX

F

MULTI-CRITERIA ANALYSIS RESULTS

CE1: South of Thirsty Point



Asset types

Social, Environmental

Preliminary long term pathway

Avoid and Accommodate, then Managed Retreat OR Protect

Vulnerability ranking and timeframe

	2016	2030	2070	2110
Vulnerability				
Beach	Low	Low	Low	Low
Coastal/dune vegetation	Low	Low	Medium	Medium
Cervantes Lodge	Low	Low	Low	High
Carpark (Thirsty Point)	Low	Low	Medium	Medium
Thirsty Point Walk Trail	Low	Low	Medium	Medium

Option Category	Option Code	Option Name	Preliminary Feasibility			Preliminary Acceptability		Preliminary Financial Implication			Recommendation
			Effectiveness	Legal / Approval Risk	Reversibility / Adaptability	Environmental / Social Impact	Community Acceptability	Economic gain / Avoidance of Cost	Capital Cost	Ongoing Cost	
Avoid	AV	Avoid development									Recommended
Managed Retreat	MR1	Leave unprotected / repair									Recommended
	MR2	Remove / relocate									Recommended
	MR3	Planning controls for retreat									Recommended
Accommodate	AC1	Planning controls to accommodate risk									Recommended
	AC2	Emergency plans and controls									Recommended
	AC3	Re-design to withstand impact	N/A								
Protect	PR1	Dune care / sand management									Recommended
	PR2	Beach nourishment									Not recommended
	PR3	Groyne									Not recommended
	PR4	Nearshore reef / breakwater									Not recommended
	PR5	Seawall									Not recommended
Do Nothing	DN	Do nothing									Not recommended

CE2: Cervantes Township South



Asset types

Social, Environmental

Preliminary long term pathway

Avoid and Accommodate, then Managed Retreat OR Protect

Vulnerability ranking and timeframe

	2016	2030	2070	2110
Vulnerability				
Beach	Low	Low	Medium	Very High
Coastal/dune vegetation	Low	Low	Medium	Very High
Road (Seville St)	Low	Low	Medium	High
Residential	Low	Low	Low	High
Thirsty Point Carpark (sealed)	Low	Low	Medium	High
Ronsard Reserve	Low	Low	Low	Medium

Option Category	Option Code	Option Name	Preliminary Feasibility			Preliminary Acceptability		Preliminary Financial Implication			Recommendation
			Effectiveness	Legal / Approval Risk	Reversibility / Adaptability	Environmental / Social Impact	Community Acceptability	Economic gain / Avoidance of Cost	Capital Cost	Ongoing Cost	
Avoid	AV	Avoid development									Recommended
Managed Retreat	MR1	Leave unprotected / repair									Not recommended
	MR2	Remove / relocate									Investigate
	MR3	Planning controls for retreat									Recommended
Accommodate	AC1	Planning controls to accommodate risk									Recommended
	AC2	Emergency plans and controls									Recommended
	AC3	Re-design to withstand impact	N/A								
Protect	PR1	Dune care / sand management									Recommended
	PR2	Beach nourishment									Investigate
	PR3	Groyne									Investigate
	PR4	Nearshore reef / breakwater									Investigate
	PR5	Seawall									Investigate
Do Nothing	DN	Do nothing									Not recommended

CE3: Cervantes Township Central



Asset types

Social, Environmental

Preliminary long term pathway

Avoid and Accommodate, then Managed Retreat OR Protect

Vulnerability ranking and timeframe

	2016	2030	2070	2110
	Vulnerability			
Beach	High	High	Very High	Very High
Coastal/dune vegetation	High	High	Very High	Very High
Jetty	Low	Medium	High	High
Road (Calatonia St)	Low	Low	High	High
Caravan Park (RAC Holiday Park)	Low	Low	High	High
Foreshore recreation	Low	High	Very High	Very High
Café (Seashells)	Low	Low	High	High
Light Industrial Area	Very High	Very High	Very High	Very High
Residential	Low	High	Very High	Very High

Option Category	Option Code	Option Name	Preliminary Feasibility			Preliminary Acceptability		Preliminary Financial Implication			Recommendation
			Effectiveness	Legal / Approval Risk	Reversibility / Adaptability	Environmental / Social Impact	Community Acceptability	Economic gain / Avoidance of Cost	Capital Cost	Ongoing Cost	
Avoid	AV	Avoid development									Recommended
Managed Retreat	MR1	Leave unprotected / repair									Not recommended
	MR2	Remove / relocate									Investigate
	MR3	Planning controls for retreat									Recommended
Accommodate	AC1	Planning controls to accommodate risk									Recommended
	AC2	Emergency plans and controls									Recommended
	AC3	Re-design to withstand impact	N/A								
Protect	PR1	Dune care / sand management									Recommended
	PR2	Beach nourishment									Investigate
	PR3	Groyne									Investigate
	PR4	Nearshore reef / breakwater									Investigate
	PR5	Seawall									Investigate
Do Nothing	DN	Do nothing									Not recommended

CE4: Cervantes Township North



Asset types

Social, Environmental

Preliminary long term pathway

Avoid then Managed Retreat

Vulnerability ranking and timeframe

	2016	2030	2070	2110
	Vulnerability			
Beach	Low	Low	Low	Low
Coastal/dune vegetation	Low	Low	Medium	Medium
Residential	Low	Low	Medium	Medium
Sailing Club (currently inactive)	Low	Medium	Medium	Medium

Option Category	Option Code	Option Name	Preliminary Feasibility			Preliminary Acceptability		Preliminary Financial Implication			Recommendation
			Effectiveness	Legal / Approval Risk	Reversibility / Adaptability	Environmental / Social Impact	Community Acceptability	Economic gain / Avoidance of Cost	Capital Cost	Ongoing Cost	
Avoid	AV	Avoid development									Recommended
Managed Retreat	MR1	Leave unprotected / repair									Recommended
	MR2	Remove / relocate									Recommended
	MR3	Planning controls for retreat									Recommended
Accommodate	AC1	Planning controls to accommodate risk									Recommended
	AC2	Emergency plans and controls									Recommended
	AC3	Re-design to withstand impact	N/A								
Protect	PR1	Dune care / sand management									Recommended
	PR2	Beach nourishment									Not recommended
	PR3	Groyne									Not recommended
	PR4	Nearshore reef / breakwater									Not recommended
	PR5	Seawall									Not recommended
Do Nothing	DN	Do nothing									Not recommended

JB1: South of Island Point



Asset types Social, Environmental
Preliminary long term pathway Avoid
Vulnerability ranking and timeframe

	2016	2030	2070	2110
	Vulnerability			
Beach	Low	Low	Low	Medium
Coastal/dune vegetation	Low	Low	Medium	Medium
Pedestrian trail (sealed)	Low	Medium	High	High

Option Category	Option Code	Option Name	Preliminary Feasibility			Preliminary Acceptability		Preliminary Financial Implication			Recommendation
			Effectiveness	Legal / Approval Risk	Reversibility / Adaptability	Environmental / Social Impact	Community Acceptability	Economic gain / Avoidance of Cost	Capital Cost	Ongoing Cost	
Avoid	AV	Avoid development									Recommended
Managed Retreat	MR1	Leave unprotected / repair									Recommended
	MR2	Remove / relocate									Recommended
	MR3	Planning controls for retreat									Recommended
	MR3	Planning controls for retreat									Recommended
Accommodate	AC1	Planning controls to accommodate risk									Recommended
	AC2	Emergency plans and controls									Recommended
	AC3	Re-design to withstand impact	N/A								
Protect	PR1	Dune care / sand management									Recommended
	PR2	Beach nourishment									Not recommended
	PR3	Groyne									Not recommended
	PR4	Nearshore reef / breakwater									Not recommended
	PR5	Seawall									Not recommended
Do Nothing	DN	Do nothing									Not recommended

JB2: Jurien Bay Township South



Asset types Social, Environmental
Preliminary long term pathway Avoid and Accommodate, then Managed Retreat OR Protect
Vulnerability ranking and timeframe

	2016	2030	2070	2110
	Vulnerability			
Beach	Low	Low	Medium	Medium
Coastal/dune vegetation	Low	Low	Medium	High
Pedestrian trail (sealed)	Low	Medium	Medium	Medium
Casuarina Park	Low	Low	Low	Medium
Carpark (unsealed)	Low	Low	Low	Low

Option Category	Option Code	Option Name	Preliminary Feasibility			Preliminary Acceptability		Preliminary Financial Implication			Recommendation
			Effectiveness	Legal / Approval Risk	Reversibility / Adaptability	Environmental / Social Impact	Community Acceptability	Economic gain / Avoidance of Cost	Capital Cost	Ongoing Cost	
Avoid	AV	Avoid development									Recommended
Managed Retreat	MR1	Leave unprotected / repair									Recommended
	MR2	Remove / relocate									Recommended
	MR3	Planning controls for retreat									Recommended
	MR3	Planning controls for retreat									Recommended
Accommodate	AC1	Planning controls to accommodate risk									Recommended
	AC2	Emergency plans and controls									Recommended
	AC3	Re-design to withstand impact	N/A								
Protect	PR1	Dune care / sand management									Recommended
	PR2	Beach nourishment									Not recommended
	PR3	Groyne									Not recommended
	PR4	Nearshore reef / breakwater									Not recommended
	PR5	Seawall									Not recommended
Do Nothing	DN	Do nothing									Not recommended

JB3: Jurien Bay Township South



Asset types

Social, Environmental

Preliminary long term pathway

Avoid and Accommodate, then Managed Retreat OR Protect

Vulnerability ranking and timeframe

	2016	2030	2070	2110
Vulnerability				
Beach	Low	Medium	Very High	Very High
Snorkel and Dive Trail	Low	Medium	High	High
Jetty	Low	Medium	High	High
Roads	Low	Medium	Medium	Medium
Caravan Park (Jurien Bay Tourist Park)	Low	Low	Medium	Medium
Residential	Low	Low	Very High	Very High
Café (Jurien Jetty)	Low	Low	Medium	Medium
Dobbys Park	Medium	Medium	High	Very High
Pedestrian trail (sealed)	Low	Medium	Medium	Medium
Foreshore Recreation	Low	Low	Very High	Very High

Option Category	Option Code	Option Name	Preliminary Feasibility			Preliminary Acceptability		Preliminary Financial Implication			Recommendation
			Effectiveness	Legal / Approval Risk	Reversibility / Adaptability	Environmental / Social Impact	Community Acceptability	Economic gain / Avoidance of Cost	Capital Cost	Ongoing Cost	
Avoid	AV	Avoid development									Recommended
Managed Retreat	MR1	Leave unprotected / repair									Not recommended
	MR2	Remove / relocate									Investigate
	MR3	Planning controls for retreat									Recommended
Accommodate	AC1	Planning controls to accommodate risk									Recommended
	AC2	Emergency plans and controls									Recommended
	AC3	Re-design to withstand impact	N/A								
Protect	PR1	Dune care / sand management									Recommended
	PR2	Beach nourishment									Investigate
	PR3	Groyne									Investigate
	PR4	Nearshore reef / breakwater									Investigate
	PR5	Seawall									Investigate
Do Nothing	DN	Do nothing									Not recommended

JB4: Jurien Bay Township North



Asset types

Social, Environmental

Preliminary long term pathway

Avoid and Accommodate, then Managed Retreat OR Protect

Vulnerability ranking and timeframe

	2016	2030	2070	2110
Vulnerability				
Beach	Low	Medium	High	Very High
Coastal/dune vegetation	Low	Medium	Very High	Very High
Pedestrian trail (sealed)	Low	Medium	High	High
Federation Memorial Park	Low	Low	High	High
Residential	Low	High	Very High	Very High

Option Category	Option Code	Option Name	Preliminary Feasibility			Preliminary Acceptability		Preliminary Financial Implication			Recommendation
			Effectiveness	Legal / Approval Risk	Reversibility / Adaptability	Environmental / Social Impact	Community Acceptability	Economic gain / Avoidance of Cost	Capital Cost	Ongoing Cost	
Avoid	AV	Avoid development									Recommended
Managed Retreat	MR1	Leave unprotected / repair									Not recommended
	MR2	Remove / relocate									Investigate
	MR3	Planning controls for retreat									Recommended
Accommodate	AC1	Planning controls to accommodate risk									Recommended
	AC2	Emergency plans and controls									Recommended
	AC3	Re-design to withstand impact	N/A								
Protect	PR1	Dune care / sand management									Recommended
	PR2	Beach nourishment									Investigate
	PR3	Groyne									Investigate
	PR4	Nearshore reef / breakwater									Investigate
	PR5	Seawall									Investigate
Do Nothing	DN	Do nothing									Not recommended

Shire of Dandaragan
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APPENDIX

G

MULTI-CRITERIA ANALYSIS SUMMARY

Table G1 Summary of multi-criteria analysis

Description	Avoid	Managed Retreat			Accommodate			Protect					Do Nothing	Risk Priority	Preliminary long term pathway	Decision Timeframe
	AV	MR1	MR2	MR3	AC1	AC2	AC3	PR1	PR2	PR3	PR4	PR5	DN			
CE1: South of Thirsty Point	R	R	R	R	R	R	N/A	R	NR	NR	NR	NR	NR	Low	Avoid and Accommodate	Not required
CE2: Cervantes Township South	R	NR	I	R	R	R	N/A	R	I	I	I	I	NR	Medium	Managed Retreat or Protect	Medium term
CE3: Cervantes Township Central	R	NR	I	R	R	R	N/A	R	I	I	I	I	NR	High	Managed Retreat or Protect	Short term
CE4: Cervantes Township North	R	R	R	R	R	R	N/A	R	NR	NR	NR	NR	NR	Low	Avoid and Accommodate	Not required
JB1: South of Island Point	R	R	R	R	R	R	N/A	R	NR	NR	NR	NR	NR	Low	Avoid and Accommodate	Not required
JB2: Jurien Bay Township South	R	R	R	R	R	R	N/A	R	NR	NR	NR	NR	NR	Low	Avoid and Accommodate	Not required
JB3: Jurien Bay Township Central	R	NR	I	R	R	R	N/A	R	I	I	I	I	NR	Medium	Managed Retreat or Protect	Medium term
JB4: Jurien Bay Township North	R	NR	I	R	R	R	N/A	R	I	I	I	I	NR	Medium	Managed Retreat or Protect	Medium term

AV: Avoid development
MR1: Leave unprotected / repair
MR2: Remove / relocate
MR3: Planning controls for retreat
AC1: Planning controls to accommodate risk
AC2: Emergency plans and controls
AC3: Re-design to withstand impact

PR1: Dune care / sand management
PR2: Beach Nourishment
PR3: Groyne
PR4: Nearshore Reef / Breakwater
PR5: Seawall
DN: Do Nothing

NR Not recommended
I Investigate (High Priority Areas - see Adaptation Options in Chapter 4)
R Recommended (See Implementation Plan - Chapter 6)

Table G2 CE3: Cervantes Township Central

	Sand Nourishment (only)	MR2 Remove / relocate	PR3 Groynes	PR5 (Seawall)
Effectiveness	May reduce risk but residual risk from extreme events would remain. Ongoing nourishment would likely be required.	Removal of commercial property and residential housing at risk would reduce the consequences of erosion.	Additional groynes are likely to be effective if sand renourishment is also carried out.	Construction of a seawall would be effective in lowering the risk of erosion impacts to assets landward of the seawall.
Legal / Approval Risk	This option is expected to have minimal legal risk.	At present the mechanisms for implementing managed retreat are not well understood, and may involve legal risk.	Implementing groynes may increase the risk of long term erosion in adjoining areas, potentially posing a legal risk.	Construction of a seawall may increase risk of long term erosion in management unit CE4, thereby exposing responsible entities to future legal action in the event of injurious affection.
Reversibility / Adaptability	This option is highly reversible.	Managed retreat preserves future options for adaptation.	This option is difficult to reverse and limits future adaptation options.	This option is difficult to reverse and limits future adaptation options.
Environmental / Social Impact	Environment impacts are likely to be minimal. Social impacts on beach use may be experienced during construction and may alter the nature of the beach.	Managed retreat may be considered to have the best environmental outcomes since this is the most natural course of action. Removal of assets and creation of a foreshore reserve would increase public access to the beach.	The potential environmental impacts from groynes would need to be assessed in greater detail.	Increased erosion of CE4 would be a negative environmental impact. Construction of a seawall would reduce the public amenity of the coast in front of the seawall.
Community Acceptability	High acceptability unless current beach use is significantly impacted.	Unlikely to be unacceptable to the specific landowners required to remove assets / relocate, and be of limited acceptability to broader Cervantes community.	This option is likely to be acceptable so long as existing use of the beach can be maintained.	This option may be acceptable so long as existing use of the beach can be maintained.
Financial Gain / Avoidance of Cost	Minimal financial gain anticipated.	This option avoids the cost of coastal protection works.	Provides financial gain for landowners of commercial and residential properties at risk. Does not provide immediate financial gain to the broader community, but may raise property values.	This option provides financial gain primarily for landowners of commercial and residential properties at risk.
Capital Cost	\$5.04m for same volume as with groynes but could be less if no groynes constructed.	Around \$1M.	Estimated to be \$ 8.92 M for 2 additional groynes and sand renourishment.	Estimated \$2.34 M for 600 m long rock seawall.

Ongoing Cost	Estimated \$19,500 p/a.	Expected to be negligible.	Estimated \$19,500 p/a.	Estimated \$25,600 p/a.
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APPENDIX

H

PLANNING CONTROLS DISCUSSION

H PLANNING CONTROLS DISCUSSION

H1 When Planning Controls are Required

As climate change and sea level rise are not 100% predictable, risk assessments are based on likelihood rather than certainty. The clear challenge for responsible planning near the coast is managing development in a way that does not prematurely sterilise otherwise suitable land from being sensitively used. At the same time, the local government must not create a future legal or financial liability by permitting development that is likely to become vulnerable to damage from erosion or inundation.

Planning controls are particularly important for locations affected by coastal processes where avoidance or managed retreat responses are recommended.

The classification of land in a local planning scheme is one of the key planning tools available to manage the use of land. Through the classification of land, land uses and land use intensity can be controlled.

Local planning schemes zone or reserve land for various purposes, and may additionally incorporate 'overlays' that indicate special requirements applicable to affected land regardless of the zone or reserve.

Most land within scheme areas is zoned. Depending on the zone applied, certain land uses may be permitted or excluded, and different development standards or other requirements may apply. Land is generally only 'reserved' in planning schemes to serve some public purpose. For example, foreshore reserves and parks will usually be reserved, as will civic and community uses and important infrastructure such as service utilities and major transport corridors. Reservation of land in a local planning scheme doesn't necessarily mean it is or will ever be publicly owned, although it often is.

The classification of land in a local planning scheme creates expectations for owners and the wider community about what may be permitted to be developed on that land. Therefore, it is preferable for planning schemes to classify land in a way that makes it clear that any further development of land at risk from coastal processes can only occur if the local government considers it to be acceptable in the light of the policy of planned (or managed) retreat. Hence it is important to indicate on scheme maps those areas that are considered to be at risk.

The draft Planned or Managed Retreat Guidelines (WAPC 2017) provide guidance for the preparation of policy for planned or managed retreat, which is based on the principles of social, environmental and economic sustainability and the objectives of the State Coastal Planning Policy. The principles underpin the planning response for coastal risk management and adaptation. The principles are:

- a) To ensure land in the coastal zone is continuously provided for coastal foreshore management, public access, recreation and conservation;
- b) To ensure public safety and reduce risk associated with coastal erosion and inundation;
- c) To avoid inappropriate land use and development of land at risk from coastal erosion and inundation; and
- d) To ensure land use and development does not accelerate coastal erosion or inundation risks, or have a detrimental impact on the functions of public reserves.

Not all adaptation and management responses require a planning control. It is necessary to understand that local planning schemes and other planning mechanisms can only address some matters, including those that fall within the definition of 'development' as defined by the Planning and Development Act 2005, that is:

"development or use of any land, including:

- (a) any demolition, erection, construction, alteration of or addition to any building or structure on the land;
- (b) the carrying out on the land of any excavation or other works;

- (c) in the case of a place to which a Conservation Order made under section 59 of the Heritage of Western Australia Act 1990 applies, any act or thing that —
- (i) is likely to change the character of that place or the external appearance of any building; or
- (ii) would constitute an irreversible alteration of the fabric of any building.”

Planning controls include provisions in the local planning scheme relating to certain land use designations and/or development types, preferably supported by appropriate local planning policy or policies to describe the Shire’s intentions and the principles that will guide decision making on the matters covered.

H2 Types of Planning Control

Planning controls that may be considered include:

- > Zoning or reservation of land in the Local Planning Scheme;
- > Special Control Areas;
- > Local Planning Policies;
- > Structure Plans;
- > Approval Conditions.

H2.1 Zones and Reserves

Zones allow for private land uses within the development parameters permitted by the local planning scheme and any related planning policies. Typical zones adjacent to the coast are Residential, Tourism, and Commercial.

Ideally, land at risk from coastal hazards would be contained within a foreshore reserve classified in the local planning scheme for either Parks and Recreation, or Environmental Conservation. However, in practice this may not be appropriate over privately-owned land because local planning schemes reserves typically preclude development for private purposes, and refusal of an application for private development would trigger a claim for compensation that the Shire could ill afford. Furthermore, prohibiting development in the short-term may not be necessary if the risk is forecast to be longer term and beyond the economic life of the proposed development.

Therefore, rather than reserving vulnerable land, the planning recommendations in this CHRMAP seek to facilitate appropriate development on private land according to the applicable zone, for as long as the land and the development can exist without adversely impacting public amenity and safety, and without unacceptable risk to the users of the development or neighbouring developments and land. The most appropriate way of doing this is through the application of a special control area (see **H2.2**), which is an ‘overlay’ to the zone (and/or reserve).

H2.2 Special Control Areas

Where land has been assessed as being vulnerable to coastal processes, a Special Control Area (SCA) is the most appropriate classification of land to facilitate land use change and development control, and is preferred by the WAPC as outlined in the draft Planned or Managed Retreat Guidelines.

Special Control Areas apply to land that is significant for some reason (in this case, vulnerability to coastal processes) and where special provisions in the scheme may need to apply. An SCA is shown on the scheme map as an overlay to the zones and reserves, and the special provisions related to the issue apply in addition to the provisions of the underlying zones and reserves. The provisions set out the purpose and objectives of the SCA, any specific development requirements, the process for referring applications to relevant agencies, and matters to be considered in determining development proposals.

Within an SCA the Shire can mandate that all development requires approval including development that is normally exempt from planning approval (e.g.: ordinarily single houses don’t require planning

approval). This ensures that only development that the Shire considers to be acceptable to the assessed risk can take place.

An SCA can also provide for time limited planning approvals (ie: temporary approval), which is discussed further in **H2.4**.

The draft Planned or Managed Retreat Guidelines provide recommended wording for scheme text relating to a SCA.

H2.3 Structure Plans

A structure plan is a plan for the coordination of future subdivision and zoning of an area of land. If comprehensive redevelopment of land is an option, a structure plan should be required before subdivision or development can take place.

Part 4 of the deemed provisions sets out the procedure for preparing structure plans. Structure plans consider a range of matters including land requirements to accommodate coastal risks in compliance with the requirements of the State Coastal Planning Policy.

In LPS 7, structure plans are required on land zoned 'Future Development'. Local structure plans typically indicate future proposed zones and reserves. A foreshore reserve of adequate dimensions to accommodate coastal processes can be identified, to ensure that there will still be a public foreshore reserve even when the extent of forecast erosion is reached.

Structure plans are not statutory documents but the deemed provisions of local planning schemes in the Planning and Development (Local Planning Schemes) Regulations 2015 set out the way they are to be prepared and adopted, and confer a requirement on decision makers to have due regard to them when determining development under the planning scheme.

Structure plans have a life of 10 years from the date of approval (or until 19 October 2025 if they were approved before the Planning and Development (Local Planning Schemes) Regulations 2015 came into force). In due course and as the structure plan is implemented it is expected that reserves and zones shown in the structure plan will be reflected in the local planning scheme via a scheme amendment.

H2.4 Approval Conditions

Provided they are justified and reasonable in relation to the proposal, the decision maker can apply conditions to approvals for subdivision or development. The WAPC is responsible for determining applications for subdivision and in doing so will consult with the local government and consider relevant State Planning Policies including the State Coastal Policy. Applications for development approval are the responsibility of the local government or, where the value of the proposed development exceeds the defined threshold, by the Mid-West/Wheatbelt (Central) Joint Development Assessment Panel (JDAP).

Two possible types of condition of particular relevance to land at risk from coastal processes are to require a notification to be placed on the Title of the land, and to place a time limit on the approval (so that the approval will expire after a defined period).

Notifications on Title

Notifications on Title are made to alert owners and potential purchasers of something that applies to the land but which may not be apparent from inspection of the land. The threat of future coastal hazards is a matter that would not be apparent on land unless it had already been eroded.

A notification on the Certificate of Title will ensure that existing and any future landowners (Successors in Title) are made aware of the risk of possible impacts on the land from coastal processes. Owners and potential purchasers would then be able to make an informed decision about the level of risk they are prepared to take on. The notification would also inform them that some form of adaptation or management is likely to be required.

There are two mechanisms by which a notification can be placed on a Certificate of Title:

- > Section 165 of the Planning and Development Act 2005; and
- > Section 70A of the Transfer of Land Act 1897.

Under Section 165 of the Planning and Development Act 2005 it is the WAPC's responsibility to determine the need for a notification, and to place a condition on a subdivision proposal if necessary. New titles could not then be created until the notification had been placed.

Alternatively, under Section 70A of the Transfer of Land Act 1897 a notification may be lodged to the benefit of a local government or public authority. Such a notification must include the signature of the registered landowner to signify agreement with the notification being lodged. A condition could be placed upon a development approval, if appropriate, to require such a notification to be placed on the Title. Development would then not be able to proceed unless the notification was placed by the landowner/developer.

When there is no application for subdivision or development that could trigger a condition requiring a notification on the Title, it would be necessary to negotiate with landowners to achieve a notification under the Transfer of Land Act. A fee would be payable for each instance, unless a waiver of the fee could somehow be achieved.

Time Limited Approvals

A time limit can be applied to a development approval. For example, if a development is proposed on land that is forecast to be affected by coastal processes in say 30 years, an approval might be limited to within that timeframe. An application for a new approval could be sought at the end of that period and it would be assessed based on the information on risk available at that time. The condition may also identify an 'event trigger' to further limit an approval in case the hazard occurs sooner than predicted.

It is more acceptable to apply a time limit to a development approval where the scheme provides for the possibility, such as would be the case for an SCA for planned retreat.

Time limits on subdivision of land are not possible, as once new Titles are created they can't be extinguished without a lengthy and expensive process of resumption (or 'taking' as it is also known). Hence it is recommended that further subdivision of vulnerable land not be permitted.

H3 Management Responses and Planning Controls

Possible types of planning control relevant to these management responses are described in the following paragraphs.

H3.1 Avoid

Avoiding development means prohibiting development from taking place in locations identified as being at potential risk from coastal hazards.

This can be achieved by zoning or reserving the land to preclude development. If the appropriate zone does not already apply to the land, a scheme amendment would be required to change the designation of the land and introduce any necessary provisions.

H3.2 Accommodate

Accommodation options recognise that there is a hazard, but do not prohibit development. Instead, depending on the nature of the hazard and the timeframe within which it is expected to occur, development may be permitted within defined parameters.

For example, if inundation of land is anticipated it may be acceptable to have development that can accommodate occasional inundation by having a finished floor level that keeps habitable parts of buildings above the expected high-water level. How this elevated floor level is achieved will depend on the particular characteristics of the location but may involve buildings being raised on 'stilts' that allow flood waters to flow underneath with relative ease, or by raising the ground level with suitable fill and protection so that floor levels remain above predicted flood levels.

The local planning scheme will need to identify where these controls would apply, and a local planning policy could outline the types of building that the Shire would be prepared to consider to achieve its objectives. In framing local planning controls, care should be taken not to inadvertently exclude innovative alternative solutions that can be shown to be effective.

An alternative scenario could be to acknowledge that the land might be subject to erosion in the future, but that the planning horizon is sufficiently far off that temporary development could be acceptable until such time as the threat of erosion becomes imminent. In such a situation certain types of construction might be acceptable (e.g.: transportable or easily dismountable), and/or certain types of development only might be permitted (e.g.: short term accommodation and tourism activities).

Again, the planning scheme will have to identify these areas and the types of development that will be permitted. A supporting local planning policy could detail the Shire's expectations for the design and/or management of temporary development.

A scheme amendment would be required to introduce any necessary provisions and if necessary to rezone or change the designation of the land. Types of scheme amendments to achieve this outcome are discussed further in **H4**.

Additionally, notification on the Title of affected land would be advisable so that the owner and/or future owners are aware of the requirements. This was discussed in **H2.4**.

H3.3 Managed Retreat

Existing development would be permitted to remain for as long as it remains unaffected by coastal hazards, but new development or expansion of existing development would not be permitted as intensification of development would mean more assets at risk. Approval of any development would be time limited, based on the forecast hazard timeframe.

H4 LPS 7 Recommendations

The following sections provide recommendations for incorporation into LPS 7 or any new planning scheme.

H4.1 Amend LPS 7 to Include State Coastal Planning Policy

Schedule 1 of the *Regulations* includes model provisions for local planning schemes. Part 4, clause 29 of the model provisions provides for State planning policies identified in this clause to be read as part of the scheme.

It is recommended that the Shire amend LPS 7 to introduce a clause based on this clause of the model provisions and include *SPP 2.6 State Coastal Policy* in the table included in that clause. In this way, the provisions of the *State Coastal Policy* will have statutory effect to any development on the coast, anywhere in the Shire.

H4.2 Introduce a Special Control Area

LPS 7 should be immediately amended to include zoned land seaward of the forecast 2110 hazard line within a Special Control Area (SCA). Where the hazard line cuts across a lot less than one hectare in area, the whole of the cadastral boundary of that lot should be included in the SCA.

Within the SCA development approval would be required for any new development including single houses, outbuildings, fences, retaining walls, and additions or extensions or other structural modifications to existing buildings.

Any new development approved should have a time limit placed upon it, after which time the development should be removed by the landowner unless a subsequent new approval is applied for and granted for a further period. The length of the approval should be related to the forecast hazard lines

Serious consideration should be given to not permitting (avoiding) any new development at all forward of the 2020 hazard line (where this is defined) or the 2030 hazard line (where no 2020 line is defined).

If development is contemplated in such areas then it would be preferable not to permit permanent accommodation due to the relatively short timeframe within which serious impacts can be expected.

No development should be permitted on any vacant land between the 2030 and 2110 hazard lines that is not:

- (a) capable of accommodating short term inundation that may result from storm surges; and
- (b) capable of being relocated if necessary.

The former may involve elevated finished floor levels with 'stilt' construction that will allow water to flow under and around the structure with minimal disturbance. The latter may involve 'lightweight' construction that could be readily disassembled and relocated if necessary.

The Shire may also require a local development plan (LDP) on specific areas of undeveloped land within the SCA to provide detailed guidance for the location and/or construction of any development that may be contemplated. An LDP is a plan that sets out specific and detailed guidance for a future development including one or more of the following —

- (a) site and development standards that are to apply to the development;
- (b) specifying exemptions from the requirement to obtain development approval for development in the area to which the plan relates.

Recommended wording for an SCA for Coastal Processes is provided by the WAPC within the draft *Planned and Managed Retreat Guidelines* (2017).

H4.3 Local Planning Policy for Coastal Development

A Local Planning Policy (LPP) should be developed and adopted using the procedures of Division 2 of the deemed provisions of LPS 7. Such a policy would cover matters such as the acceptable forms of 'temporary' construction within land forecast to be impacted by coastal processes.

A separate corporate policy for temporary development on coastal foreshore reserves might be appropriate to guide the Shire's own operations (eg: provision of beach shelters and other public amenities).

To provide guidance for future planning by the Shire and private landowners it is recommended that the Shire identify a default minimum distance required to accommodate public amenity within any foreshore reserve, for inclusion in the LPP. Depending on the location and purpose of the foreshore reserve public amenities may include beach access, car parking, picnic/barbeque facilities, public toilets, beach kiosks, etc, and the minimum distance required to fit them in will vary accordingly. This allowance for public amenity should be added to the 2110 hazard line to delineate an indicative minimum distance from the coast for the landward boundary of future planning scheme coastal reserves.

H4.4 Subdivision

Undeveloped parcels of zoned or reserved land lying seaward of the 2110 hazard line should not be permitted to be further subdivided. Subdivision includes strata titling. Time limited leasehold might be acceptable in situations where an appropriate temporary development necessitates a smaller parcel of land for management purposes, however this should be carefully considered and only contemplated where there are demonstrable benefits of the proposed development for the community. A lease has a defined expiry date and does not result in permanent fragmentation of the landholding.

Where a structure plan is prepared, coastal foreshore reserve boundaries should be determined in accordance with Section 5.9 of the State Coastal Planning Policy, and include an allowance for coastal processes as well as future public amenity at the end of the planning timeframe (2110). This recommendation is also consistent with Section 5.2(i) of the State Coastal Planning Policy, which encourages urban development around existing settlements and discourages continuous linear urban development along the coast.

H4.5 Reserved Land

Where Crown Land (including reserves as defined under the Land Administration Act 1997) is forecast to be impacted by coastal hazards, the foreshore Parks and Recreation reserve in LPS 7 should be extended as described above. Publicly owned freehold land that is not developed should similarly be included in the foreshore reserve, if possible. In either case this would be subject to negotiation with the public agency that has the management order (in the case of Crown Land) or that owns it (in the case of freehold land) and the Lands section of the Department of Planning, Lands and Heritage.


Shire of Dandaragan
Coastal Hazard Risk Management
and Adaptation Plan

APPENDIX

I


LONG TERM PATHWAYS

CE1: South of Thirsty Point

Predicted Pathway	2016	2030	2070	2110
				
Vulnerability Rating				
Beach	Low	Low	Low	Low
Coastal/dune vegetation	Low	Low	Medium	Medium
Cervantes Lodge	Low	Low	Low	High
Carpark (Thirsty Point)	Low	Low	Medium	Medium
Thirsty Point Walk Trail	Low	Low	Medium	Medium
Asset lifecycle				
Pathways				
Undeveloped Areas	Avoid			
Developed Areas	Accommodate			
Minor Infrastructure	Managed Retreat			
Actions				
Undeveloped Areas	AV, MR3 - Implement planning controls to prevent new development and intensification of development in the Coastal foreshore reserve. PR1 - Dune care and sand management			
Developed Areas	AC1, MR3 - Implement planning controls and emergency plans to accommodate coastal risk			
Minor Infrastructure	MR1, MR2 - Remove minor infrastructure as it becomes damaged, irreparable and/or unsafe			

Management Pathway Triggers	Trigger 1	Trigger 2	Trigger 3	Trigger 4
Trigger	CHRMAP recommendation	HSD plus S1 reaches 2030 vulnerability line	HSD plus S1 reaches 2070 vulnerability line	Minor infrastructure becomes damaged or unsafe
Action	Implement planning controls to avoid development in undeveloped areas	Commence dune program and sand management	Commence dune program and sand management	Remove assets
Responsibility	Shire of Dandaragan and State Government	Shire of Dandaragan	Shire of Dandaragan	Shire of Dandaragan


CE2: Cervantes Township South



Predicted Pathway	2016	2030	2070	2110
Vulnerability Rating				
Beach	Low	Low	Medium	Very High
Coastal/dune vegetation	Low	Low	Medium	Very High
Road (Seville St)	Low	Low	Medium	High
Residential	Low	Low	Low	High
Thirsty Point Carpark (sealed)	Low	Low	Medium	High
Ronsard Reserve	Low	Low	Low	Medium
Asset lifecycle				End of asset lifecycle
Pathways				
Undeveloped Areas	Avoid			
Developed Areas	Accommodate			
Minor Infrastructure	Managed Retreat			
Actions				
Undeveloped Areas	AV, MR3 - Implement planning controls to prevent new development and intensification of development in the Coastal foreshore reserve. PR1 - Dune care and sand management			
Developed Areas	AC1, MR3 - Implement planning controls and emergency plans to accommodate coastal risk			
Minor Infrastructure	MR1, MR2 - Remove minor infrastructure as it becomes damaged, irreparable and/or unsafe			

Management Pathway Triggers	Trigger 1	Trigger 2	Trigger 3	Trigger 4
Trigger	CHRMAP recommendation	HSD plus S1 reaches 2030 vulnerability line	HSD plus S1 reaches 2070 vulnerability line	Minor infrastructure becomes damaged or unsafe
Action	Implement planning controls and emergency plans, apply notification on title, Investigate interim protection measures	Commence dune program and sand management	Commence dune program and sand management	Remove assets
Responsibility	Shire of Dandaragan and State Government	Shire of Dandaragan	Shire of Dandaragan	Shire of Dandaragan

CE3: Cervantes Township Central

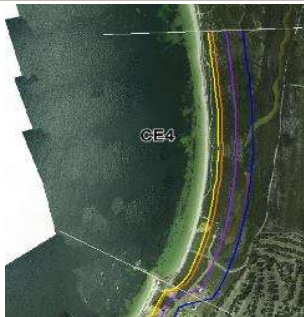


Predicted Pathway	2016	2030	2070	2110
Vulnerability Rating				
Beach	High	High	Very High	Very High
Coastal/dune vegetation	High	High	Very High	Very High
Jetty	Low	Medium	High	High
Road (Calatonia St)	Low	Low	High	High
Caravan Park (RAC Holiday Park)	Low	Low	High	High
Foreshore recreation	Low	High	Very High	Very High
Café (Seashells)	Low	Low	High	High
Light Industrial Area (Lobster Shack)	Very High	Very High	Very High	Very High
Residential	Low	High	Very High	Very High
Asset lifecycle		End of asset lifecycle		
Pathways				
Undeveloped Areas	Avoid			
Developed Areas	Accommodate		Managed Retreat	
Minor Infrastructure	Managed Retreat			
Actions				
Undeveloped Areas	AV, MR3 - Implement planning controls to prevent new development and intensification of development in the Coastal foreshore reserve			
Developed Areas	AC1, MR3 - Implement planning controls and emergency plans to accommodate coastal risk		MR2 - Remove assets as their risk becomes intolerable	
Minor Infrastructure	MR1, MR2 - Remove minor infrastructure as it becomes damaged, irreparable and/or unsafe			

Management Pathway Triggers	Trigger 1	Trigger 2	Trigger 3	Trigger 4
Trigger	CHRMAP recommendation	HSD plus S1 reaches 2030 vulnerability line	HSD plus S1 reaches 2070 vulnerability line	Minor infrastructure becomes damaged or unsafe
Action	Implement planning controls to avoid development in undeveloped areas, investigate options to retreat public assets as they become affected	Retrofit seawall, commence dune care program	Remove damaged assets and relocate assets at risk	Remove assets
Responsibility	Shire of Dandaragan and State Government	Shire of Dandaragan	Shire of Dandaragan	Shire of Dandaragan

CE4: Cervantes Township North

CE4: Cervantes Township North

	Predicted Pathway	2016	2030	2070	2110
	Vulnerability Rating				
	Beach	Low	Low	Low	Low
	Coastal/dune vegetation	Low	Low	Medium	Medium
	Residential	Low	Low	Medium	Medium
	Sailing Club (currently inactive)	Low	Medium	Medium	Medium
	Asset lifecycle				
	Pathways				
	Undeveloped Areas	Avoid			
	Developed Areas	Accommodate			
	Minor Infrastructure	Managed Retreat			
Actions					
Undeveloped Areas	AV, MR3 - Implement planning controls to prevent new development and intensification of development in the Coastal foreshore reserve. PR1 - Dune care and sand management				
Developed Areas	AC1, MR3 - Implement planning controls and emergency plans to accommodate coastal risk				
Minor Infrastructure	MR1, MR2 - Remove minor infrastructure as it becomes damaged, irreparable and/or unsafe				


Management Pathway Triggers	Trigger 1	Trigger 2	Trigger 3	Trigger 4
Trigger	CHRMAP recommendation	HSD plus S1 reaches 2030 vulnerability line	HSD plus S1 reaches 2070 vulnerability line	Minor infrastructure becomes damaged or unsafe
Action	Implement planning controls to avoid development in undeveloped areas	Commence dune program and sand management	Commence dune program and sand management	Remove assets
Responsibility	Shire of Dandaragan and State Government	Shire of Dandaragan	Shire of Dandaragan	Shire of Dandaragan

JB1: South of Island Point

Predicted Pathway	2016	2030	2070	2110
Vulnerability Rating				
Beach	Low	Low	Low	Medium
Coastal/dune vegetation	Low	Low	Medium	Medium
Turquoise Way Trail	Low	Medium	High	High
Asset lifecycle				
Pathways				
Undeveloped Areas	Avoid			
Developed Areas	NA			
Minor Infrastructure	Managed Retreat			
Actions				
Undeveloped Areas	AV, MR3 - Implement planning controls to prevent new development and intensification of development in the Coastal foreshore reserve. PR1 - Dune care and sand management			
Developed Areas	AC1, MR3 - Implement planning controls and emergency plans to accommodate coastal risk			
Minor Infrastructure	MR1, MR2 - Remove minor infrastructure as it becomes damaged, irreparable and/or unsafe			

Management Pathway Triggers	Trigger 1	Trigger 2	Trigger 3	Trigger 4
Trigger	CHRMAP recommendation	HSD plus S1 reaches 2030 vulnerability line	HSD plus S1 reaches 2070 vulnerability line	Minor infrastructure becomes damaged or unsafe
Action	Implement planning controls to avoid development in undeveloped areas, investigate options to retreat public assets as they become affected	Commence dune program and sand management	Commence dune program and sand management	Remove assets
Responsibility	Shire of Dandaragan and State Government	Shire of Dandaragan	Shire of Dandaragan	Shire of Dandaragan

JB2: Jurien Bay Township South



Predicted Pathway	2016	2030	2070	2110
Vulnerability Rating				
Beach	Low	Low	Medium	Medium
Coastal/dune vegetation	Low	Low	Medium	High
Turquoise Way Trail	Low	Medium	Medium	Medium
Casuarina Park	Low	Low	Low	Medium
Carpark (unsealed)	Low	Low	Low	Low
Asset lifecycle				
Pathways				
Undeveloped Areas	Avoid			
Developed Areas	NA			
Minor Infrastructure	Managed Retreat			
Actions				
Undeveloped Areas	AV, MR3 - Implement planning controls to prevent new development and intensification of development in the Coastal foreshore reserve. PR1 - Dune care and sand management			
Developed Areas	AC1, MR3 - Implement planning controls and emergency plans to accommodate coastal risk			
Minor Infrastructure	MR1, MR2 - Remove minor infrastructure as it becomes damaged, irreparable and/or unsafe			


Management Pathway Triggers	Trigger 1	Trigger 2	Trigger 3	Trigger 4
Trigger	CHRMAP recommendation	HSD plus S1 reaches 2030 vulnerability line	HSD plus S1 reaches 2070 vulnerability line	Minor infrastructure becomes damaged or unsafe
Action	Implement planning controls to avoid development in undeveloped areas, investigate options to retreat public assets as they become affected	Commence dune program and sand management	Commence dune program and sand management	Remove assets
Responsibility	Shire of Dandaragan and State Government	Shire of Dandaragan	Shire of Dandaragan	Shire of Dandaragan

JB3: Jurien Bay Township Central

Predicted Pathway		2016	2030	2070	2110
	Vulnerability Rating				
	Beach	Low	Medium	Very High	Very High
	Snorkel and Dive Trail	Low	Medium	High	High
	Jetty	Low	Medium	High	High
	Roads	Low	Medium	Medium	Medium
	Caravan Park (Jurien Bay Tourist Park)	Low	Low	Medium	Medium
	Residential	Low	Low	Very High	Very High
	Café (Jurien Jetty)	Low	Low	Medium	Medium
	Dobbyn Park	Medium	Medium	High	Very High
	Turquoise Way Trail	Low	Medium	Medium	Medium
	Foreshore Recreation	Low	Low	Very High	Very High
	Asset lifecycle			End of asset lifecycle	
Pathways					
Undeveloped Areas	Avoid				
Developed Areas	Accommodate			Managed Retreat	
Minor Infrastructure	Managed Retreat				
Actions					
Undeveloped Areas	AV, MR3 - Implement planning controls to prevent new development and intensification of development in the Coastal foreshore reserve				
Developed Areas	AC1, MR3 - Implement planning controls and emergency plans to accommodate coastal risk			MR2 - Remove assets as their risk becomes intolerable	
Minor Infrastructure	MR1, MR2 - Remove minor infrastructure as it becomes damaged, irreparable and/or unsafe				

Management Pathway Triggers	Trigger 1	Trigger 2	Trigger 3	Trigger 4
Trigger	CHRMAP recommendation	HSD plus S1 reaches 2030 vulnerability line	HSD plus S1 reaches 2070 vulnerability line	Minor infrastructure becomes damaged or unsafe
Action	Implement planning controls and emergency plans, apply notification on title	Commence dune program and sand management	Remove damaged assets and relocate assets at risk	Remove assets
Responsibility	Shire of Dandaragan and State Government	Shire of Dandaragan	Shire of Dandaragan	Shire of Dandaragan

JB4: Jurien Bay Township North



Predicted Pathway	2016	2030	2070	2110
Vulnerability Rating				
Beach	Low	Medium	High	Very High
Coastal/dune vegetation	Low	Medium	Very High	Very High
Turquoise Way Trail	Low	Medium	High	High
Federation Memorial Park	Low	Low	High	High
Residential	Low	High	Very High	Very High
Asset life cycle				End of asset lifecycle
Pathways				
Undeveloped Areas	Avoid			
Developed Areas	Accommodate		Managed Retreat	
Minor Infrastructure	Managed Retreat			
Actions				
Undeveloped Areas	AV, MR3 - Implement planning controls to prevent new development and intensification of development in the Coastal foreshore reserve			
Developed Areas	AC1, MR3 - Implement planning controls and emergency plans to accommodate coastal risk		MR2 - Remove assets as their risk becomes intolerable	
Minor Infrastructure	MR1, MR2 - Remove minor infrastructure as it becomes damaged, irreparable and/or unsafe			

Management Pathway Triggers	Trigger 1	Trigger 2	Trigger 3	Trigger 4
Trigger	CHRMAP recommendation	HSD plus S1 reaches 2030 vulnerability line	HSD plus S1 reaches 2070 vulnerability line	Minor infrastructure becomes damaged or unsafe
Action	Implement planning controls and emergency plans, apply notification on title	Commence dune program and sand management	Remove damaged assets and relocate assets at risk	Remove assets
Responsibility	Shire of Dandaragan and State Government	Shire of Dandaragan	Shire of Dandaragan	Shire of Dandaragan