

Draft Coastal Hazard Risk Management and Adaption Plan

Shire of Gingin

59917806



Prepared for
Shire of Gingin

31 January 2018

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Executive Summary

The Shire of Gingin is preparing for the threats of climate change and sea level rise to the coastal settlements of Guilderton, Seabird, Ledge Point and Lancelin. Historically, the coastal towns were established to service fishing industry, agricultural activities; primarily sheep grazing within the hinterland, 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 Seabird, Ledge Point and Lancelin and highlight possible strategies to adapt to the changing future oceanic and coastal conditions.

Development of the Gingin 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 three 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 (two at Seabird, four at Ledge Point and four at Lancelin) 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 within each township, 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 projections. 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.

The complex planning issues around setting the intent and establishing controls such Special Control Areas to either restrict development within currently developed areas and/or rezone currently undeveloped land to avoid future development are discussed for each of the management units within each township. A number of options was 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 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 table 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
Gingin LPS 9 Update and Endorsement by WAPC	17 Jan '20	30 Jun '20	\$40
Monitoring	1 May '18	14 May '29	\$410
Annual Beach Profile Surveys	4 May '18	14 May '29	\$300
Horizontal Shoreline Datum (Aerial Photo Analysis)	1 May '18	2 May '22	\$70
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	26 Feb '18	28 Jul '25	\$415
Comprehensive investigation of each community and visitors be undertaken to identify beneficiaries of proposed protection areas	26 Feb '18	30 Nov '18	\$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 '18	30 Jun '18	\$15
Assess Current and Future Sediment Budget in the Secondary Cell	1 Jul '18	30 Jun '21	\$80
Analysis of Flood, Storm Surge and Erosion event monitoring	14 May '20	5 Aug '20	\$40
Investigate Storm Surge and Coastal Processes Interactions to define triggers, set FFL, CHRMAP, Water Management Plans and Emergency Management Plan overlaps	25 Mar '25	28 Jul '25	\$50
Undertake economic analysis of options. Recommendations:	17 May '18	19 Sep '18	\$80
Operational	1 Feb '18	30 Nov '22	\$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 '18	26 Mar '19	\$20
Notifications - Potentially affected land owners by direct contact and property titles	1 Feb '18	30 Nov '22	\$10
CHRMAP Review and Update (2022)	1 Jan '19	30 Nov '22	\$210
Review Hazard line estimates (S1, S2, S3 and S4)	18 Feb '21	21 Apr '21	\$25
Review Risk Assessment and Future Pathway Options	29 Apr '21	30 Jun '21	\$40
Community and Stakeholder Consultation	1 May '21	31 Jan '22	\$50
Update CHRMAP	24 Jun '21	2 Mar '22	\$80
CHRMAP 2022 Endorsement by WAPC	7 Jul '22	30 Nov '22	\$15
CHRMAP Review and Update (2027)	8 Oct '26	8 Nov '28	\$210
Review Hazard line estimates (S1, S2, S3 and S4)	8 Oct '26	6 Jan '27	\$25
Review Risk Assessment and Future Pathway Options	1 Jun '27	2 Aug '27	\$40
Community and Stakeholder Consultation	1 Nov '26	31 Aug '27	\$50
Update CHRMAP	24 Jun '27	1 Mar '28	\$80
CHRMAP 2027 Endorsement by WAPC	6 Jul '28	8 Nov '28	\$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 (1997)
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)
TEC	Threatened Ecological Community
The Shire	Shire of Gingin
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 Coastal Planning Policy (SPP2.6) in 2013 to incorporate a projected SLR for WA of 0.9 m between 2010 and 2110 (**Figure 1-1**).

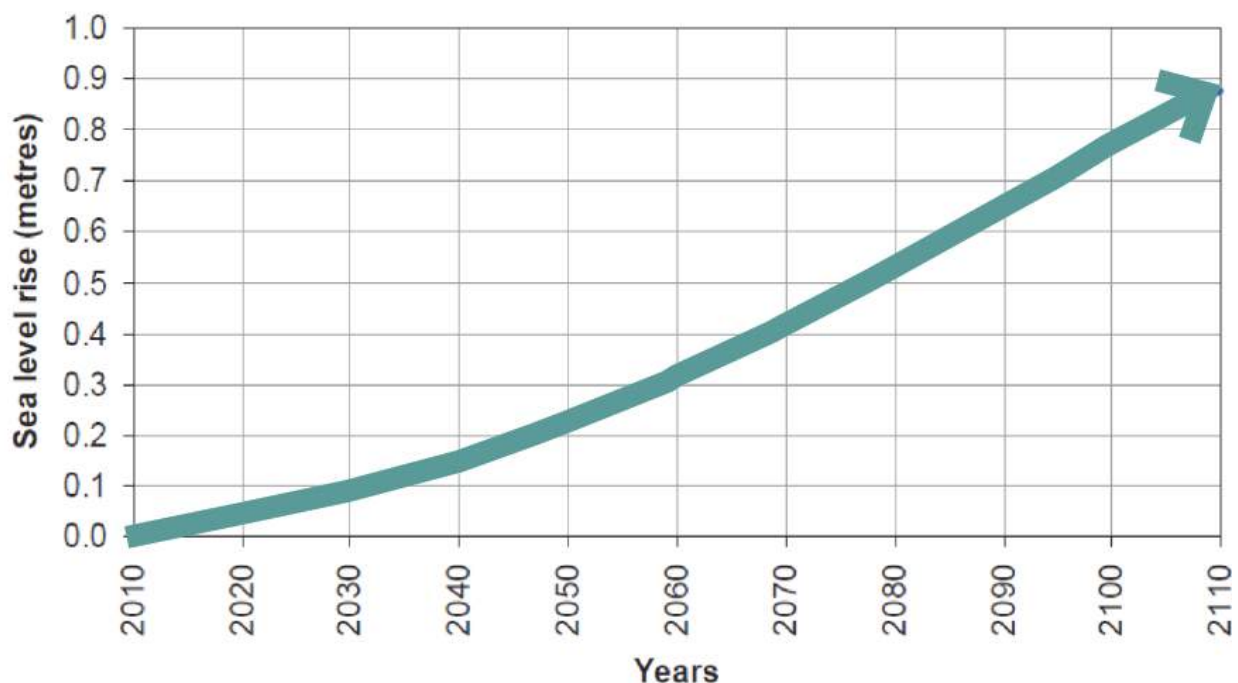


Figure 1-1 Recommended allowance for SLR in coastal planning for WA (source: DoT, 2010)

Gingin'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) describes the coastline of the Hill Primary Coastal Compartment (Guilderton to Jurien Bay) as low lying sandy coastal landforms, identified as being at risk to the impacts of coastal processes 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).

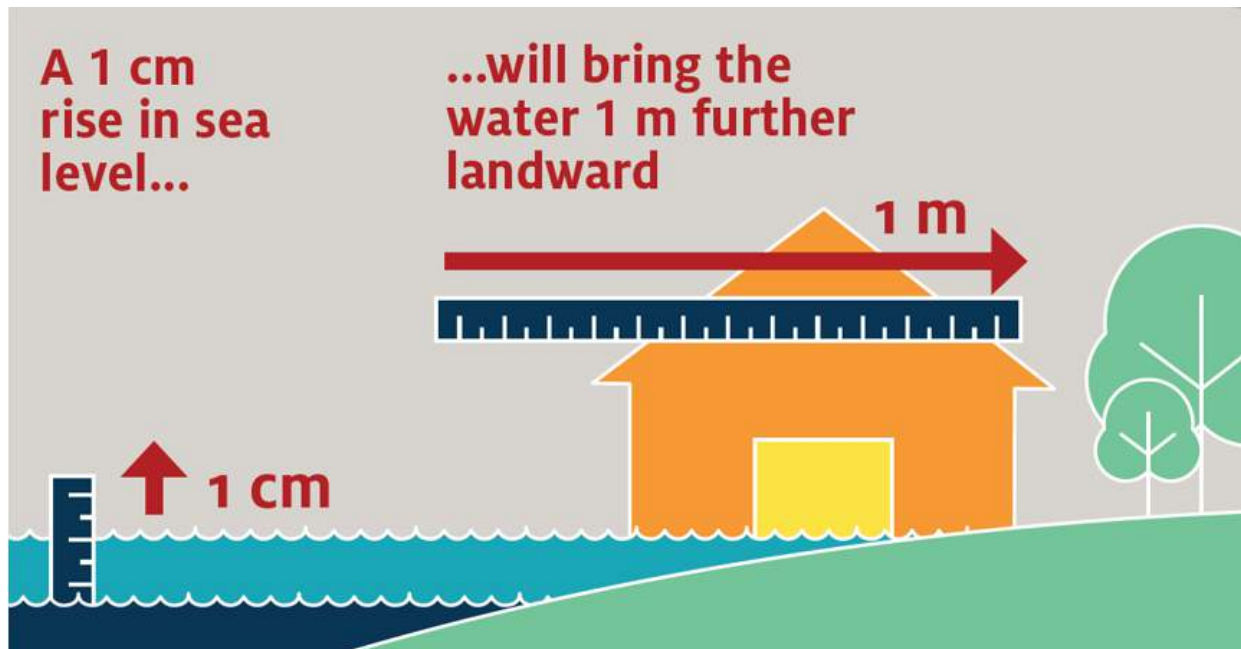


Figure 1-2 Influence of sea level rise on coastal erosion (source: CoastAdapt, 2017)

Development of this Coastal Hazard Risk Management and Adaption Plan (CHRMAP) is being undertaken by Cardno on behalf of the Shire of Gingin (hereafter called 'the Shire') to identify risks and plan adaptation responses to natural variability in coastal erosion 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 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' or 'State Coastal Planning Policy'). 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).

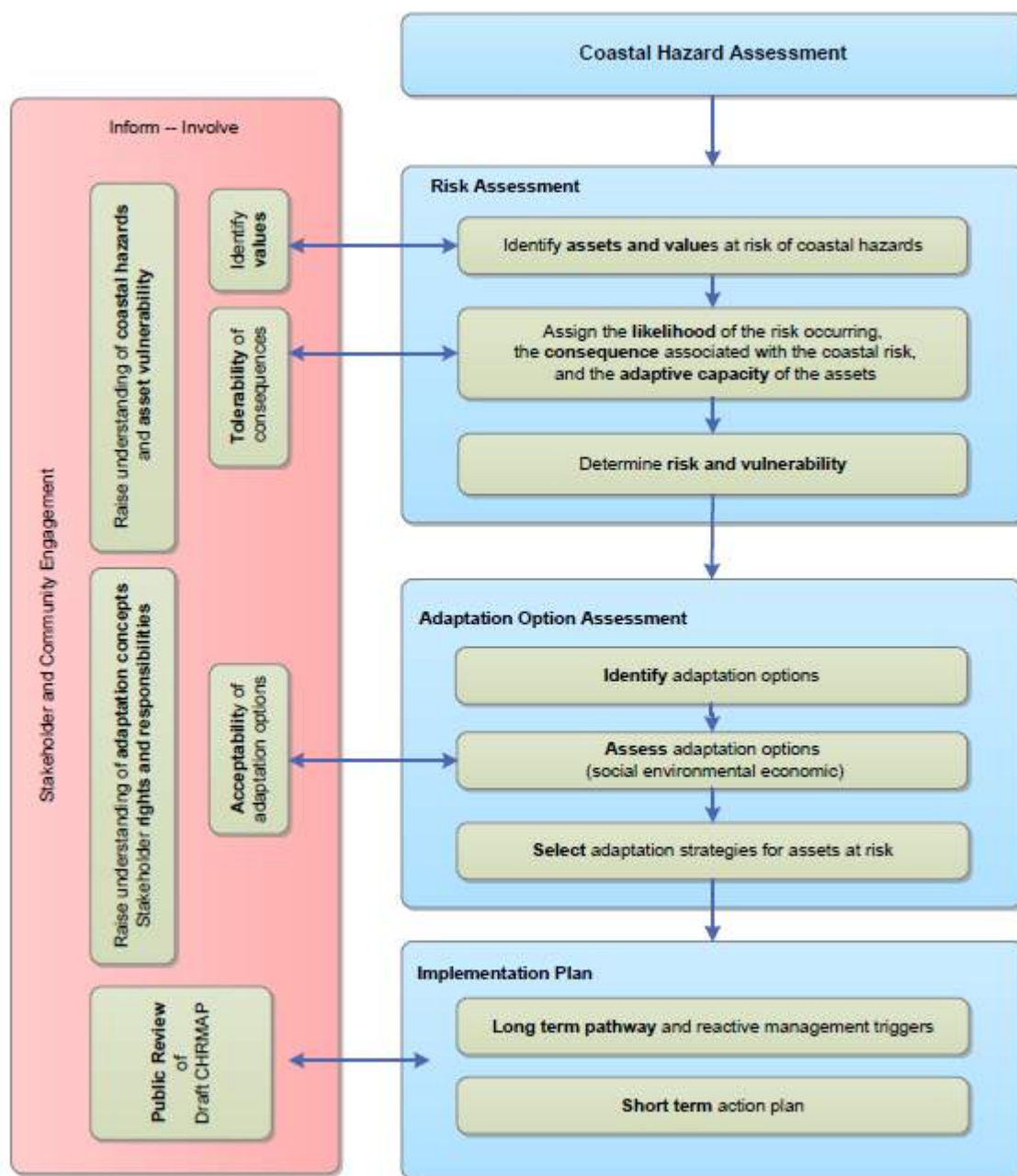


Figure 1-3 CHRMAP methodology flow chart (adapted from the WAPC, 2014a, CHRMAP Guidelines)

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 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 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 may create beneficiaries (those who are protected from hazards) and potentially disadvantage 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.

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 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.

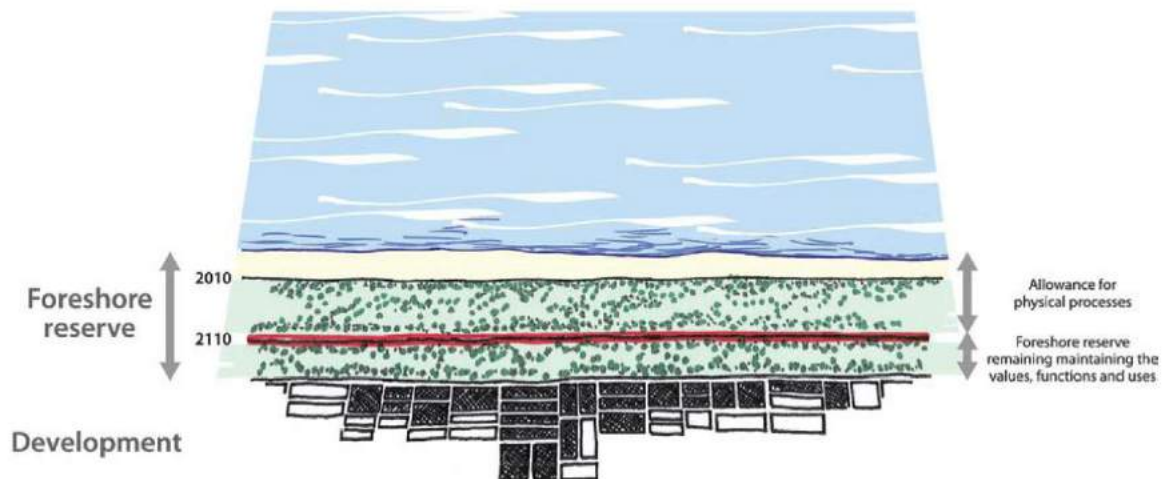


Figure 1-4 Coastal foreshore reserve – sandy coast example (source: WAPC 2013b)

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 Gingin 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], 2016a and b). 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 2.9.1**).

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 '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 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.

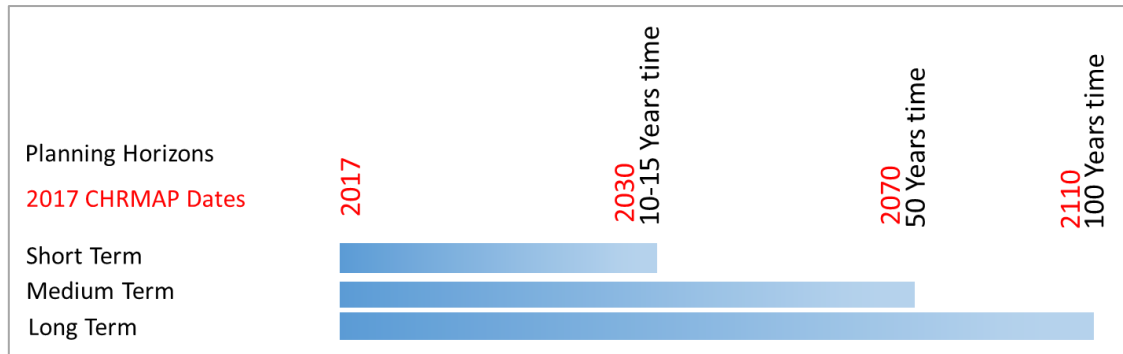


Figure 1-5 Coastal planning timeframes used in this report

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, 2016a and b). 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-drift 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 hazard 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 future (for example, if shoreline recession is occurring faster than predicted, the management action to retreat may be implemented earlier than 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.

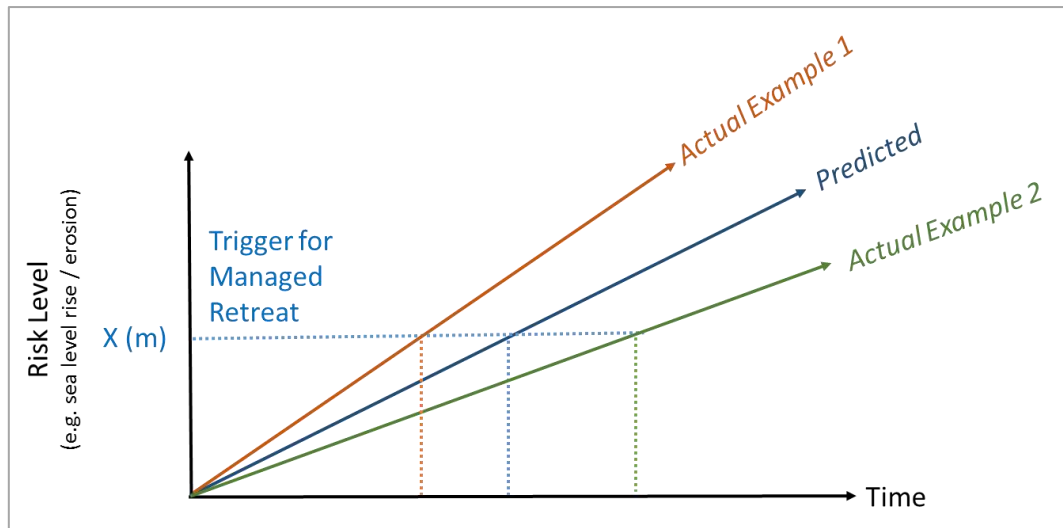


Figure 1-6 Conceptual timing for managed retreat in relation to predicted coastal hazards

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, 2016a and b 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.

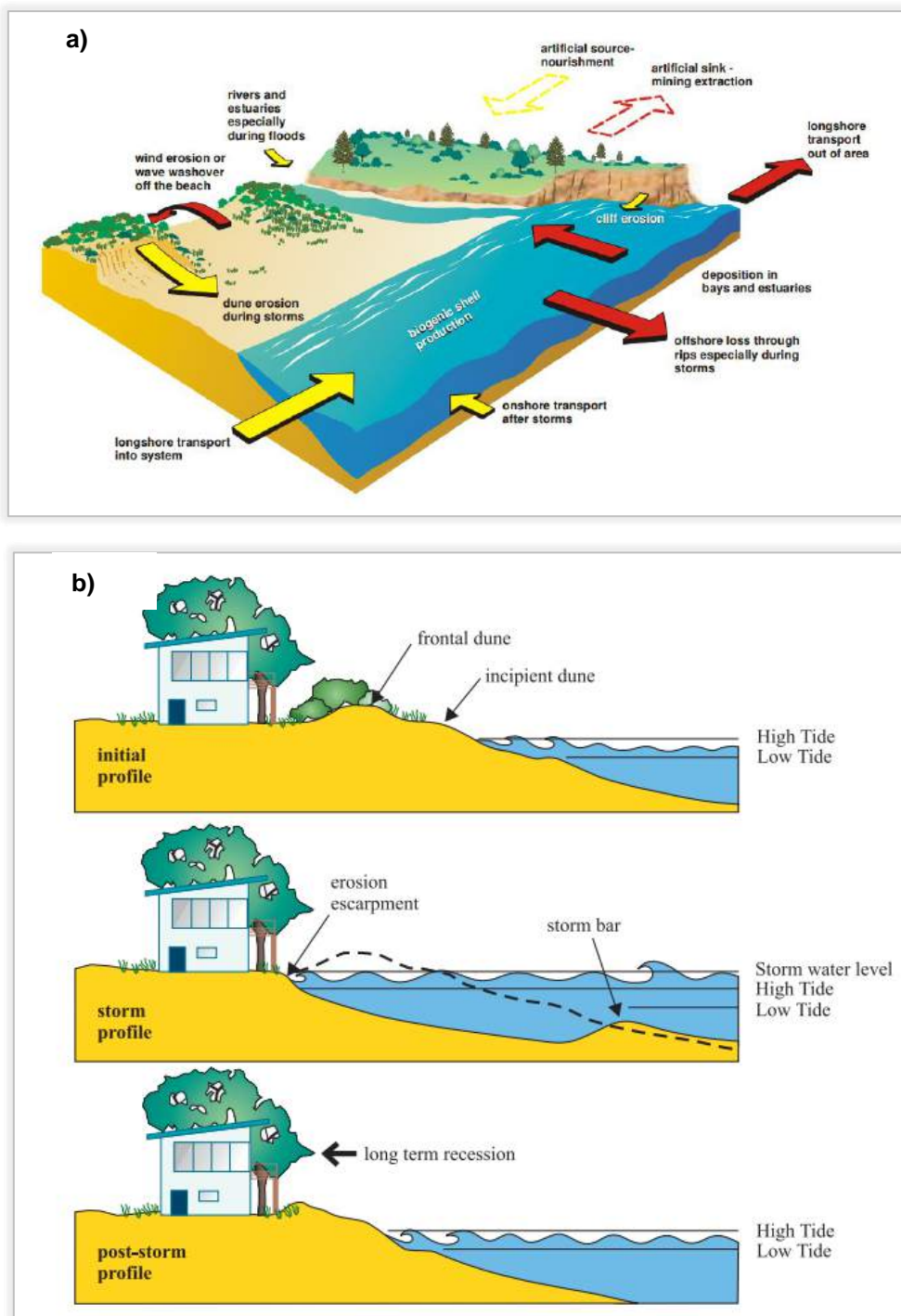


Figure 1-7 Conceptual representation of key coastal erosion concepts; a) sediment transport processes and b) long term beach recession due to permanent sand loss (source: NSW Department of Land and Water Conservation, 2001)

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 Dandaragan 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 Dandaragan, 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 2017 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 Gingin 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

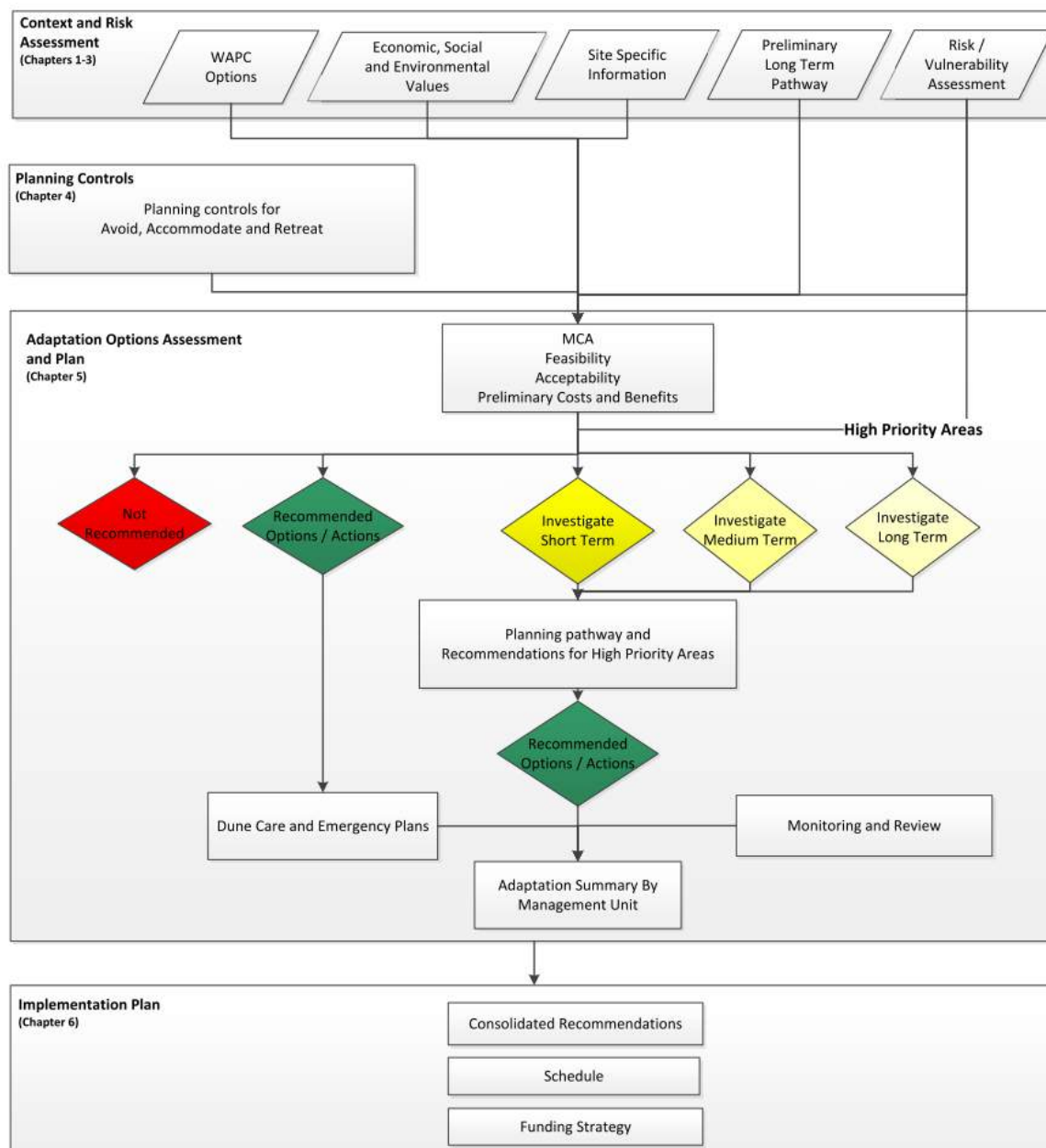


Figure 1-8 Overview of the CHRMAP process and its relationship to the chapters in this document.

2 ESTABLISHING THE CONTEXT

2.1 Shire of Gingin

The Shire of Gingin is located 84 kilometres north of Perth. There are five townships within the Shire: the inland town of Gingin, and the coastal towns of Guilderton, Lancelin, Ledge Point and Seabird, of which only the latter three are considered in this CHRMAP (**Figure 2-1**).

Gingin is one of the fastest growing rural areas in Western Australia and it is anticipated that the Shire's population will grow from 5,000 to approximately 6,600 by 2023, increasing to 7,900 by 2031 (Shire of Gingin, 2017). Agriculture (more recently including horticulture) is the Shire's primary economic contributor. In addition to rural industries the Shire's economy is also based around tourism, with coastal areas in particular experiencing a large influx of people during the summer holiday season. Annual Shire rate revenues are in the order of \$7M.

The Shire of Gingin (2016a) Strategic Community Plan (2015-2025) lists the dominant demographic in the Shires coastal towns are "empty nesters" aged 60 – 69 (around 20% of the population), with around 40% of households having no children. This is in contrast to rural areas which are dominated by parents and home builders (24%) aged between 35 and 40.

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 three 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	Estimated Number of Residents [#]	Approximate coastline length assessed (km)	Number of Management Units
Seabird	140	80	1.7	2
Ledge Point	379	200	3.1	4
Lancelin	754	600	5.1	4

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

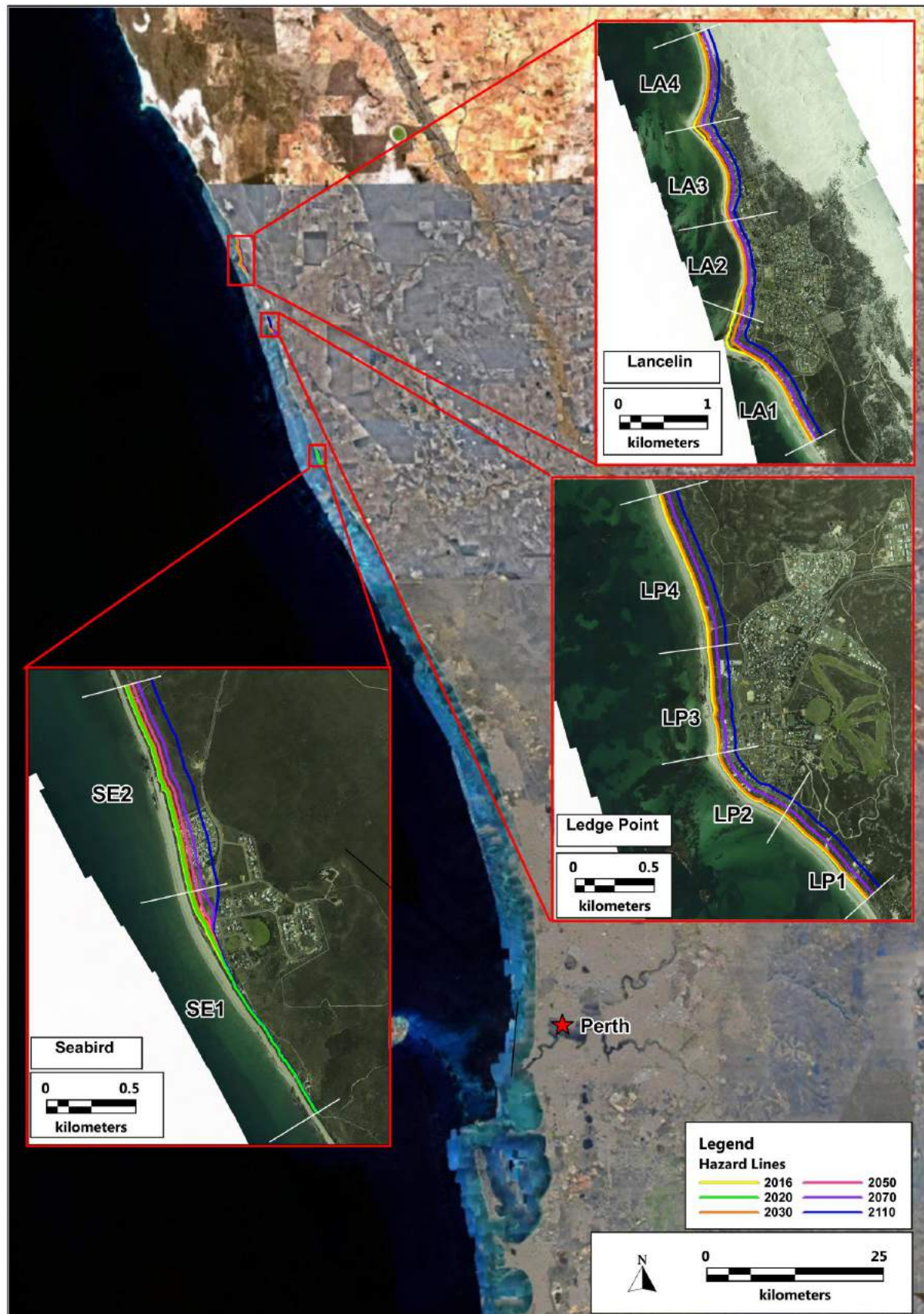


Figure 2-1 CHRMAP location map, townships and management unit boundaries

2.2 Seabird

Seabird is located approximately 40 km north of the Perth Metropolitan area (**Figure 2-1**). The townsite was gazetted in 1968 and currently has an estimated population of around 80 (**Table 2-1**).

The township has been subject to ongoing coastal erosion, which has caused the loss of a substantial portion of the township's primary coastal dunes and a coastal road (Turner Street). Historically, management of erosion has included beach nourishment and temporary protection works (MRA, 2016a), before a seawall was constructed in 2015 (and extended in 2016) to protect residential properties. Funding for the seawall was provided by the State Government and ongoing responsibility for maintenance and management of the structure will be one of the considerations of this CHRMAP. The seawall is currently being managed by the Shire of Gingin under a license issued under section 91 of the Western Australian *Land Administration Act (1997)* (LAA) by the Department of Lands.

The townsite is on a broad salient (coastal point) in a localised area of greater vulnerability relative to the general coastline within its coastal cell, which is considered to have a moderate vulnerability (Eliot et al, 2012). There is some beach rock (Tamala Limestone) visible along the coast in front of the township and scattered offshore reefs which provide some protection from incoming wave energy. This site lacks, however, the significant reefs or offshore islands which are present off some townships further to the north. MPR (2016a) collated geophysical data collected by Gordon Geological Consultants and the DoT in 2002 to confirm the presence of a limestone cliff, of low to medium strength, under the dunes to the south of the Coastal Point. It was estimated that this cliff deviates away from the coast in line with the northern end of Turner St and extends to the junction of McCormick and Edwards Streets. This geological feature has been taken into consideration in the risk assessment process (see **Section 3.2.1**).

During a site visit in early 2017, the presence of the seawall was noted to have limited the beach extent in front of the town to the north of the seawall. As the seawall was designed as an interim measure public access to the beach from the top of the seawall has not been allowed for and public open space along the foreshore within the town is subsequently very limited. The coastal values for Seabird are presented in **Appendix B** and the map shows public beach access to the north and south of the seawall.

The hazard assessment extended for 2.6 km along the coast (MRA, 2016a), and for risk assessment and adaptation planning purposes, this CHRMAP has divided the Seabird coastal area into two management units (**Figure 2-1**). Development potential beyond the existing township has not been identified in the Shire's Local Planning Scheme (Shire of Gingin, 2012a) (see maps in **Appendix B**).



Figure 2-2 Photograph of seabird in 2016 following construction of the seawall (source: DoT)

2.3 Ledge Point

The township of Ledge Point is located approximately 70 km north of the Perth Metropolitan area (**Figure 2-1**) and has an estimated population of around 200 (Table 2-1). The townsite was gazetted in 1955, intended for retirees and holiday housing and to service the local fishing and crayfishing industries (Landgate, 2017). It is understood that many of the properties in the town are holiday houses, owned by farmers from inland parts of the Shire. The township has a general store, cafe/fish and chip shop and a country club which has a restaurant, bar, golf course, tennis courts and lawn bowls. Ledge Point is well known as a windsurfing venue, hosting the Ledge Point to Lancelin Windsurfing Classic in January each year. The beach and nearshore waters are used for launching and mooring of boats.

Ledge Point lies at the boundary of two coastal cells; Cell 11 (Green Reef to Ledge Point) and Cell 12 (Ledge Point to South Pacific Reef) and the coastline in both these cells was assessed as having moderate vulnerability (Eliot et al, 2012). Broad scale geological mapping covering the Ledge Point 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 in December 2015 (MRA, 2016b).

The Ledge Point townsite is located on a sandy foreland formed in the lee of a shore-parallel reef (Short, 2006). There are no islands offshore, however, both offshore and nearshore reefs protect the Ledge Point beach from wave energy (MRA, 2016b).

The hazard assessment extended approximately 3 km along the coast (MRA, 2016b), and for risk assessment and adaptation planning purposes, the CHRMAP has divided this area into four management units (**Figure 2-1**). There are two groynes, the smaller 'southern groyne' (constructed in 1975 at the boundary between management units LP2 and LP3) and the larger 'northern groyne' (constructed in 1985 slightly to the south of the centre of management unit LP3). The southern-most, LP1, and northern-most, LP4, management units are predominantly undeveloped at present, but the potential for development of these areas has been identified in the Shire's Local Planning Scheme (Shire of Gingin, 2012a). A map depicting the coastal values for Ledge Point is presented in **Appendix B**.

The main coastal node for public recreation and tourism is focused around Key Biscayne Park, to the north of the northern groyne. The park comprises a large grassed park area that has had extensive coast care attention, including dune rehabilitation. The beach area between the two groynes is the main swimming area, with the beach to the south of the southern groyne being used for boat launching, with four wheel drives and tractors traversing and parking on the beach. A new boat-launching facility/marina has been proposed for a location to the south of the study area.

The main coastal erosion risk area is in management unit LP3, where a number of private residences along DeBurgh Street overlook the beach to the south of the southern groyne.



Figure 2-3 Aerial view of Ledge Point in 2016 (source: DoT)

2.4 Lancelin

The township of Lancelin is located approximately 100 km north of the Perth Metropolitan area (**Figure 2-1**) and has an estimated residential population of around 600 (**Table 2-1**). The townsite was used in the late 1940s for camping and as a port for the lobster fishery. The townsite was declared in 1950 and gazetted in 1953 (Landgate, 2017). The township is the regional centre for the Upper Coastal area of the Shire (Shire of Gingin 2016b). Lancelin is well known as a windsurfing venue, hosting the Ledge Point to Lancelin Windsurfing Classic in January each year. Crayfishing is a significant local industry, as well as seasonal tourism. The town has a jetty managed by the DoT.

Lancelin townsite occupies three sandy forelands formed in the lee of Edwards Reef to the south and Lancelin Island to the north (Short, 2006). There are two islands close to the shore, the smaller, rocky Edward Island and the larger, vegetated Lancelin Island to the north (**Figure 2-4**). Edward Island is connected to an approximately 850 m long shallow nearshore reef which provides good protection from wave energy to the adjacent shoreline (MRA, 2016b). There is also a shallow nearshore reef that is approximately 450 m long, located in between the two islands and extending between approximately 500 m and one km offshore. Deeper passages exist between the shallow reefs and islands, which allow boat access to Lancelin and also permit wave energy to reach the shoreline (MRA, 2016b).

The Lancelin area lies within three sediment cells (13-15, Eliot et al, 2012), which were assessed as having moderate (cells 13-14) or moderate-high (cell 15) vulnerability. Broad scale geological mapping covering the Lancelin 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, 2016b). In the absence of detailed geotechnical information, the Lancelin area was classified as a sandy coast for the purpose of coastal hazard assessment (MRA, 2016b).

The hazard assessment (MRA, 2016b) extended approximately five km along the coast, and for risk assessment and adaptation planning purposes, the CHRMAP has divided this area into four

management units (**Figure 2-1**). The southern-most management unit is largely undeveloped, with the intention to use the area primarily for sporting and recreation purposes. The area has also been identified for linking the town to future urban development at Lancelin South (Shire of Gingin, 2012a). A map depicting the coastal values for Lancelin is presented in **Appendix B**.



Figure 2-4 Aerial view of Lancelin in 2009 (source: Birdseye View Photography, <http://www.birdseyeviewphotography.com.au/lancelin.shtml>)

The Shire's local planning strategy identifies three coastal nodes for public recreation at Lancelin. The first is at Edward Island Point and includes Grace Darling Park. The second is in the coastal foreshore park in the town centre and the third is at Lancelin Point. Grace Darling Park, in management unit LA2, has been affected by erosion over recent years, causing public concern and highlighting coastal erosion issues.

2.5 Stakeholder and Community Engagement

2.5.1 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.

2.5.2 **Methods**

Since 2012, the Shire has worked closely with the Shire of Dandaragan, 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. Key stakeholders identified and engaged throughout the engagement process in listed in **Appendix B**.

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 (**Figure 2-5**). A community engagement session was facilitated by the Shire in Lancelin on the 28th of May 2017. This was followed by an online survey that was conducted in June 2017.

2.6 **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 2.7 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

2.7 Survey Results

2.7.1 Context

Contextual information from the online survey is 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 the “Lancelin main beach”. Indicative beach usage by management unit based on the survey results is provided in **Table 2-2**.

While most respondents believed they have some idea of the causes of coastal erosion, only around 10% considered themselves to be very well informed. Slightly more than half had viewed the hazard maps, but there was a high level of concern (45% very concerned and 35% somewhat concerned) about coastal erosion.

Most respondents were between 60 – 75 years of age and were landowners in the shire, but a majority did not live in areas identified as being vulnerable to coastal erosion. As introduced in **Section 2.1**, “empty nesters” aged 60 to 69 are the dominant demographic in the coastal towns of the Shire, and it is a positive result that the survey reflects this.

Of the 80 respondents who provided their postcode, the majority (73%) were from either Lancelin, Guilderton or Gingin and the remaining 17% of respondents were from outside the Gingin LGA.

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

Seabird (SE)		Ledge Point (LP)		Lancelin (LA)	
Management Unit	Number	Management Unit	Number	Management Unit	Number
SE1	13	LP1	0	LA1	40
SE2	11	LP2	8	LA2	54
		LP3	6	LA3	32
		LP4	2	LA4	12

2.7.2 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 2-6**). Opportunities for commercial enterprises and active recreations (i.e. boat ramps and jetties) received the least support.

2.7.3 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. The responses to these questions have been taken into consideration in formulating the adaptation plans discussed in **Section 4**.

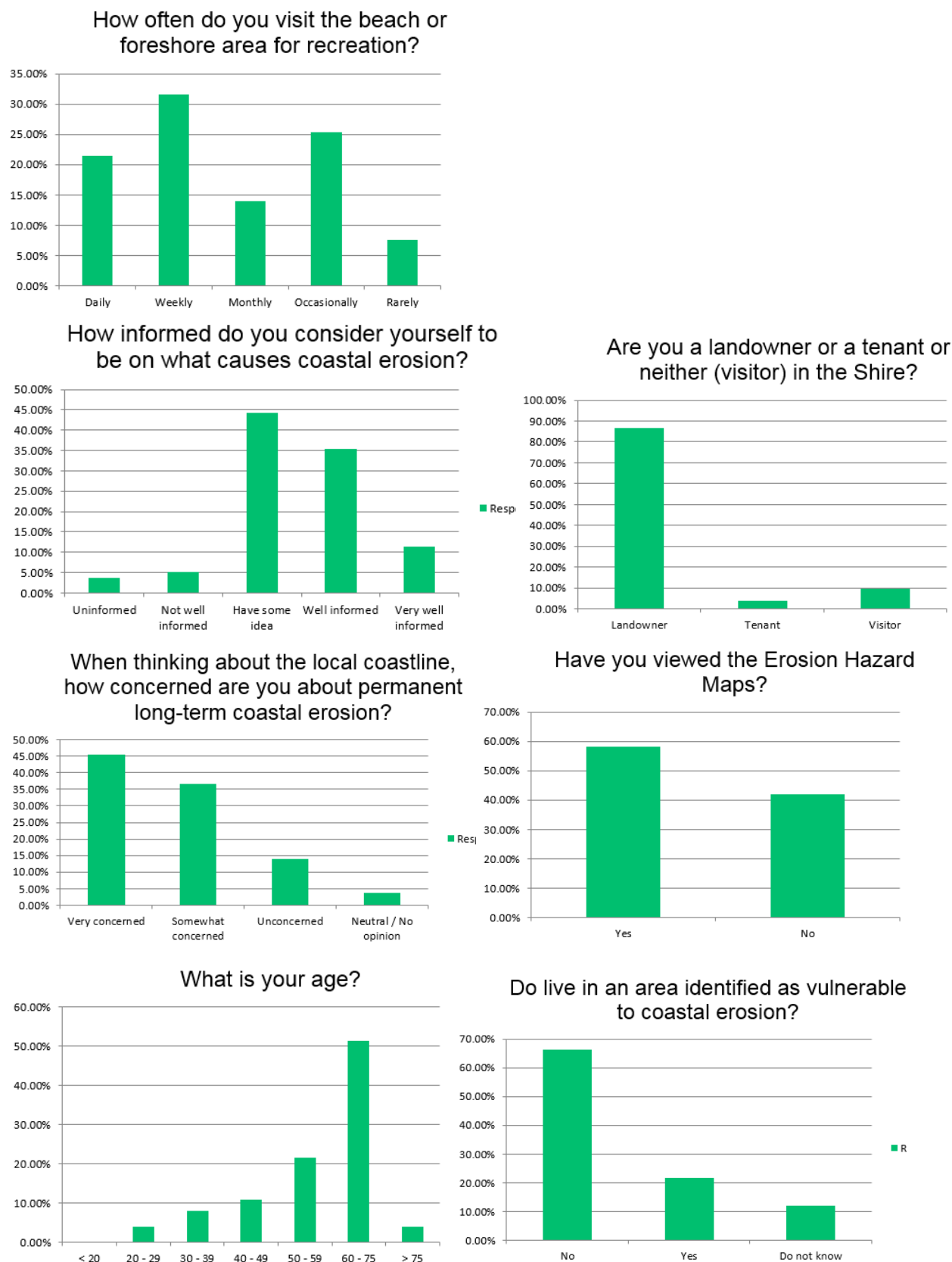
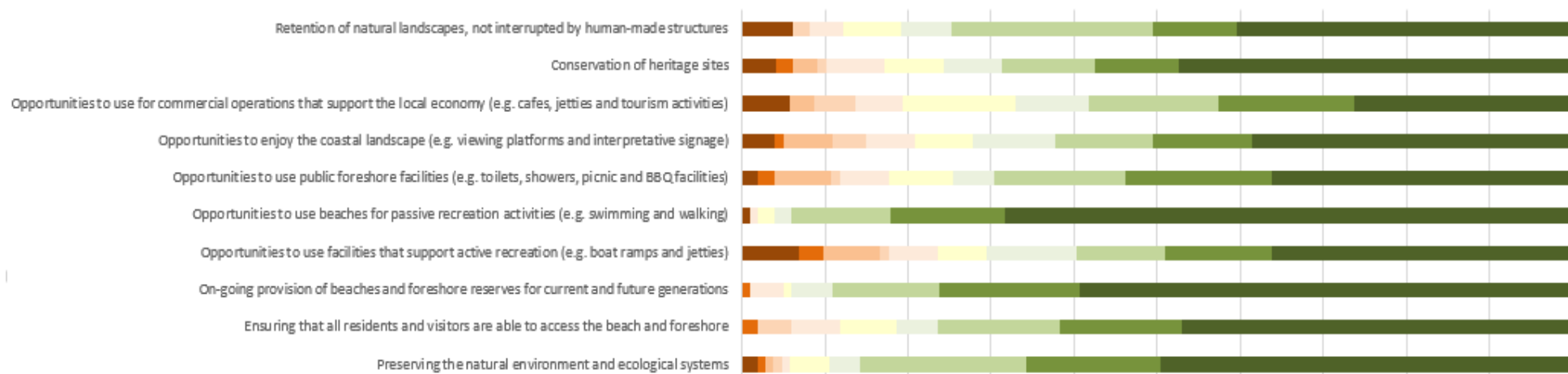


Figure 2-6 Summary charts of online survey questionnaire responses

Coastal Values



Adaptation Options

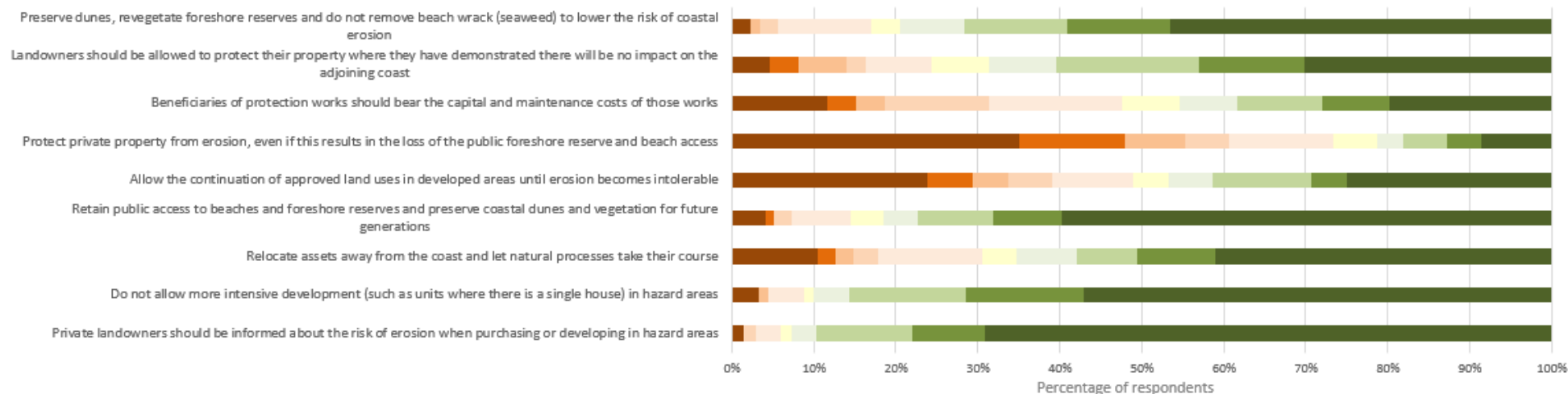


Figure 2-7 Responses to questions “what do you value about the coast” and “how strongly do you support the following erosion management approaches”. Generally, more green indicates more agreement and more red indicates more disagreement.

2.8 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.

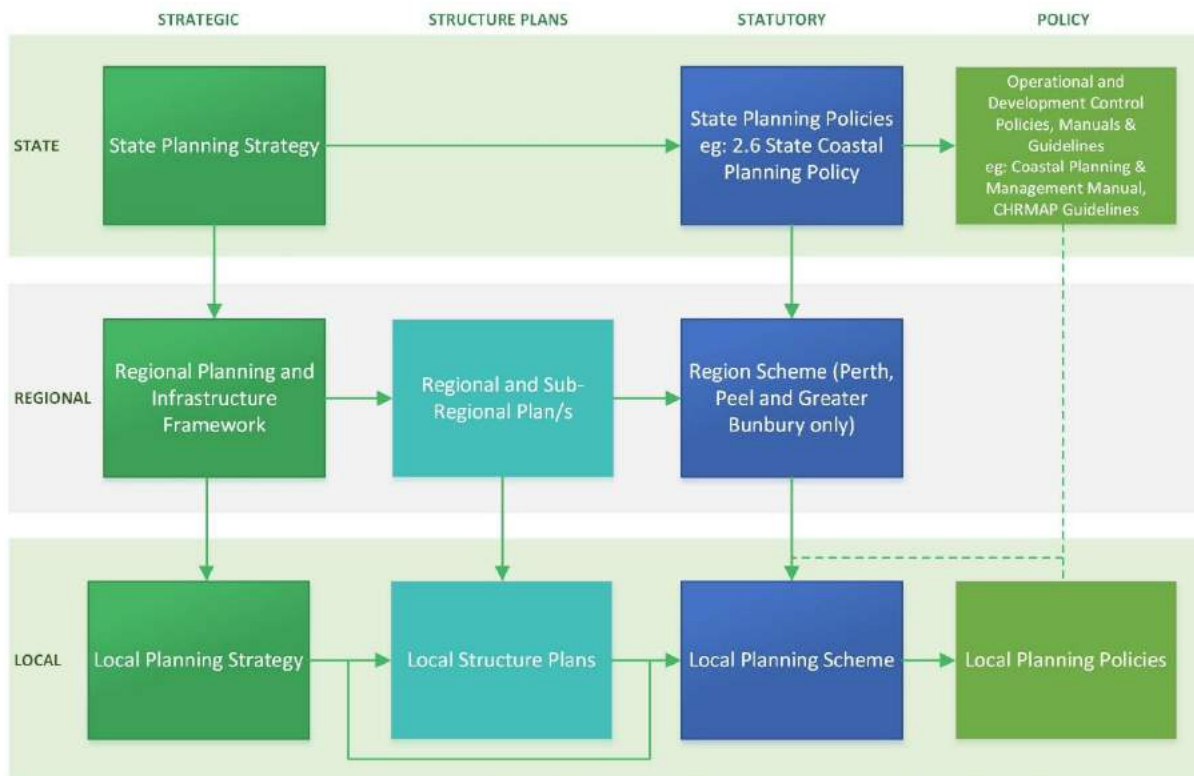


Figure 2-8 Planning context overview

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

- State Planning Strategy 2050 (State)
- Wheatbelt Planning and Infrastructure Framework 2015 – (Regional)
- Shire of Gingin Local Planning Strategy 2012 (Local)

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

- Local Planning Scheme No. 9 (LPS 9)
- State Planning Policy: Coastal Planning Policy (SPP 2.6)
- Local Planning Policy 1.2 Foreshore Protection Areas (LPP1.2)
- Local Planning Policy 1.4 Foreshore Reserves along Water Courses (LPP1.4)

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 Gingin, is outlined in the following sections.

2.8.1 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 Gingin 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 initiatives:

- > *Identification 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*
- > *Facilitation of long-term strategic planning for the lower Gingin – Indian Ocean Drive corridor, focussing on possible economic and employment opportunities, service provision and the preservation of environmental assets (the latter including coastal assets).*

The *Shire of Gingin Local Planning Strategy 2012*, generally aligns with the Wheatbelt PIF strategy direction, placing importance on both planning for long-term predicted shoreline movement and other impacts of climate variability, such as storm surge.

The *Local Planning Strategy* identifies coastal erosion and management of coastal dunes as key issues for the Shire, acknowledging that the vulnerability is predicted to worsen as sea level rises in response to climate change. It recognises that a strategic approach is needed in managing coastal land use, future development and the impacts of coastal processes, including dune movement, blow outs and erosion. This strategy also maps general areas identifying 'Coastal setbacks required in accordance with State Planning Policy'. These areas include the coast north of Lancelin, coast in the southern parts of Ledge Point, Guilderton north of the Moore River, and Seabird. Since the strategy's adoption in 2013, more detailed coastal studies (MRA, 2016a and 2016b, GHD, 2015) have provided improved definition of vulnerable areas.

Within the coastal areas designated at risk from sea level rise and coastal erosion at the 100 year planning horizon the preparation of this CHRMAP assumes the more recent strategies and adaption hierarchy outlined is SPP2.6 (2013) and the WAPC CHRMAP guidelines (2014a) will take precedence when considering the appropriate adaptation strategies for the Gingin Shire coastline.

2.8.2 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) (PDA). The State Coastal Policy (SPP 2.6) is an environmental sector policy consistent with the higher order SPP 2 Environmental and Natural Resources Policy.

The key statutory planning document for the Shire of Gingin is Local Planning Scheme No. 9 (LPS 9), gazetted on 27 September 2012 and amended several times since. LPS 9 applies zones and reserves to land within the Shire and outlines permissibility of land uses, requirements for development and processes for seeking proposed development approval.

Recent relevant amendments to LPS 9, regarding coastal development, planning and hazards, require compliance with the provisions of SPP 2.6, in accordance with the PDA. This amendment thereby effectively gives statutory effect to the SPP 2.6 under LPS 9.

2.8.3 Local Structure Plans

Local Structure Plans, also referred to as Outline Development Plans (ODPs) can be made under LPS 9 via the mechanisms provided in Part 4 of the Deemed Provisions set out in the Planning and Development (Local Planning Scheme) Regulations 2015 (the Regulations). In the context of planning control and guidance, an ODP is the same as a structure plan. A structure plan, while not a statutory document, provides guidance for the future subdivision and development of land.

The Shire has only one structure plan relating to coastal land, the ODP for Moore River South adopted following the completion of a Foreshore Management Plan in August 2014. This ODP considers the same

coastal hazard mapping used for this CHRMAP, and provides for coastal foreshore reserves and public open space. Moore River South is not an area addressed by this CHRMAP.

2.8.4 **Local Planning Policies**

Under the provisions of LPS 9 local planning policies can be developed to affect the type of developments permissible within the designated zones/reserves of LPS 9. These provisions are outlined in Division 2 of Part 2 of the Regulations. The Shire have several local planning policies relevant to development of coastal land, including two adopted on 15 January 2013:

- Local Planning Policy 1.2 Foreshore Protection Areas (LPP1.2), and
- Local Planning Policy 1.4 Foreshore Reserves along Water Courses (LPP1.4)

Additionally, while not addressing coastal development, Local Planning Policy 1.3 *Interim Position on Seabird Coastal Erosion*, is general policy regarding the management and monitoring of coastal erosion at Seabird.

2.8.5 **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 9) local government has a responsibility to the future community to direct new development away from high risk areas.

2.9 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.

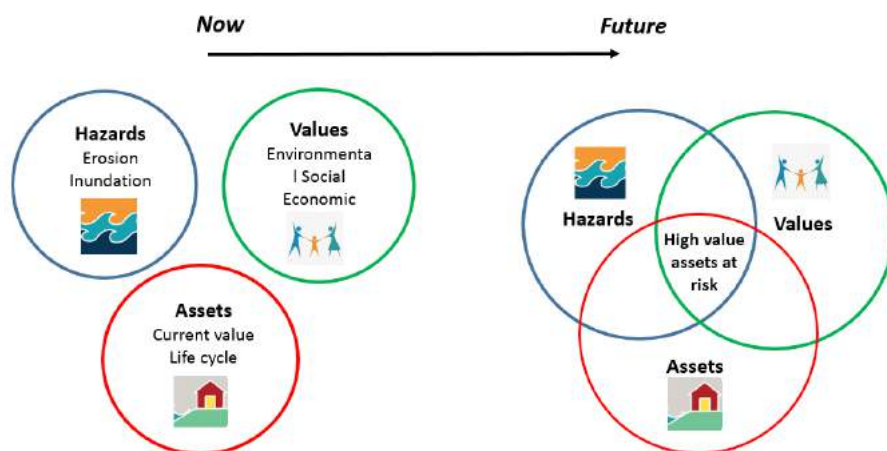


Figure 2-9 Conceptual relationship between key inputs to the coastal risk assessment process

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

2.9.1 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 Seabird (MRA, 2016a) and Ledge Point, Lancelin (and Cervantes) (MRA, 2016b). The assessments were reviewed and accepted for adaptation planning purposes by the WA Department of Transport and are available at the Shire's website. In accordance with SPP2.6, coastal erosion hazard lines have been collated for the present day (2016), 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, 2016a and 2016b).

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
Seabird*							
SE1	+2.0	15 - 21	0.4 – 1.2%	15 - 21	15 - 46	16 - 50	21 - 55
SE2	+1.8	33	0.35 – 0.5	33	49 - 52	105 - 114	181 - 196
Ledge Point#							
LP1	+1.6	19	0	19	29	69	128
LP2	+1.6	12 – 19	0	12 - 19	22 - 29	62 - 69	121 – 128
LP3	+1.6	12 – 24	0	12 - 24	22 - 34	62 - 74	121 – 133
LP4	+1.6	24	0	24	34	74	133
Lancelin#							
LA1	+1.4	14 – 22	0.3 – 3.3	14 - 22	37 - 82	89 - 134	160 – 205
LA2	+1.4	11 – 14	0 – 3.3^	11 - 14	18 - 74	50 - 126	101 – 197
LA3	+1.4	11 – 30	0 – 2.3	11 - 30	18 - 75	50 - 131	101 - 202
LA4	+1.4	30	0.2 – 2.3	30	43 - 75	93 - 131	161 - 202

* Values for Seabird are taken from MRA (2016a)

Values for Ledge Point and Lancelin are taken from MRA (2016b)

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

% The application of the S2 erosion allowance in this area is complicated by the presence of rock. Refer to MRA (2016a) for details.

2.9.2 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 Council'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**.

2.9.3 Values

The estimated value of assets has been derived, in the first instance, from their economic value or replacement cost. This economic value can be easily estimated for physical infrastructure and property, but not always for natural assets that provide a range of values and services. 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 assessments (MRA, 2016a and 2016b) 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 1.3.6**).

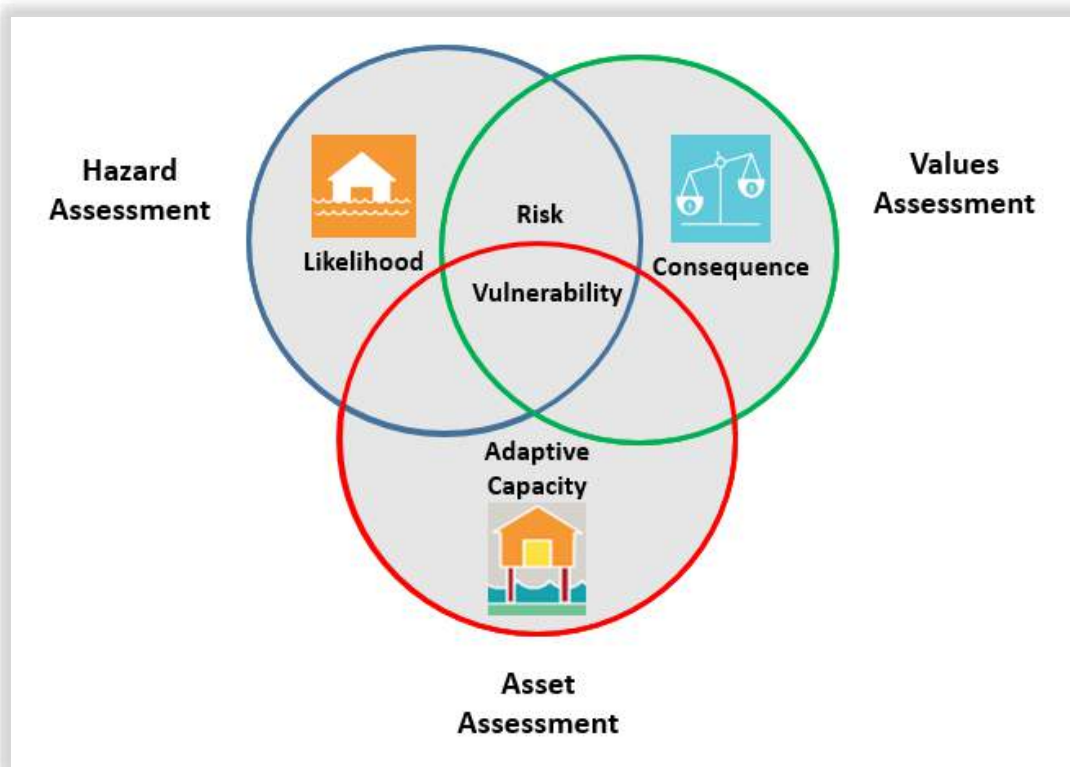


Figure 3-1 Conceptual relationship between risk assessment elements

Consequence and adaptive capacity criteria used in this assessment are presented in **Table 3-1**. A full description of the risk assessment process is provided in **Appendix D**. Summary tables 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 Risk 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 may improve current environmental and or social values.

3.2 Risk Assessment Outcomes

The outcomes of the risk assessment for each management unit are discussed 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 **SE1 - Seabird South**

The Seabird South management unit extends along 1400 m of coastline and the southern half fronts undeveloped land. The management unit contains 22 residential properties in the northern half that are fully or partly located seaward of the 2110 coastal hazard line, as well as a number of roads, carparks and public assets (**Figure 3-2**). There is a lack of foreshore reserve width to facilitate public amenity and beach access along the section of coast adjacent to the township. To the south of the township, natural assets comprising the beach and vegetated dunes are not bounded by development. **Appendix C** provides more information on the assets and their values in this management unit.



Figure 3-2 Photograph of the Seabird seawall during construction in the SE1 management unit (source, watoday.com.au)

A limestone ridge lying beneath the dunes and extending along the majority of this management unit forms a significant existing control on potential future erosion. This ridge has been considered in the coastal hazard assessment (MRA, 2016a) and this current risk assessment process. The seawall, constructed in 2016 (subsequent to the Coastal Hazard Assessment, MRA 2016a) and extending along the northern half of the management unit, forms another control on future erosion of the coast. Scattered offshore and nearshore reefs also influence current and future sediment transport and accretion/erosion of the coast within this management unit. The presence of the limestone ridge acts a barrier to erosion and limits the inland extent of the 2110 hazard line to less than 50 m width for the majority of the management unit. At the northern end the limestone ridge dips lower and the coastline has been classified as sandy for the purpose of coastal hazard assessment (MRA, 2016a). At the northern end the 2110 coastal hazard line extends to about 200m inland (see **Appendix A** and **Table 2-3**).

Residential properties in the northern portion of the management unit have been deemed very highly vulnerable at present, due to their value and proximity to potential coastal erosion hazards. It must be noted that a seawall is currently in place protecting these properties, which should prevent them from being impacted for the duration of its assessed 20-year design life. However, responsibility for maintaining the seawall is still uncertain, and the possibility of it being removed if responsibility cannot be allocated must be considered. Other built assets, such as carparks and roads, have a medium vulnerability at present increasing to high by 2030. Natural assets, such as the beach and coastal dunes/vegetation, have increasing vulnerability ratings across the planning timeframes, becoming very highly vulnerable by 2050. The adaptive capacity of these assets diminishes over time as they are restricted by existing development, particularly in the northern portion of the site (see **Appendix E**). The key outcomes of the risk assessment for management unit SE1 are:

- > Residential properties have a very high vulnerability rating at present;
- > Carparks and roads in the management unit have a medium vulnerability at present, increasing to a high vulnerability rating by 2030; and
- > The beach has a high vulnerability rating by 2030 and both the beach and coastal dunes/vegetation have very high vulnerability ratings by 2050.

3.2.2 **SE2 - Seabird North**

This Seabird North management unit contains the Seabird Tavern, a number of roads, carparks and public assets and the strata titled caravan park (**Figure 3-3**). The width of the 2110 coastal hazard line is typically 190 m for the 1200m of coastline the above assets are all partially or fully located seaward of the 2110 hazard line. As with SE1, there is a lack of foreshore dune width to facilitate public amenity and beach access along the, roughly 400m section of coast adjacent to the township. To the north of the township, the coast fronts natural assets comprising the beach and vegetated dunes and there is no development within the 2110 hazard line. See **Appendix C** for more information on assets and their values in this management unit.



Figure 3-3 Photograph of the northern section of the Seabird town site SE2 (source: DoT, 2016)

Scattered offshore and nearshore reefs, and visible beach rock along the shore form existing controls that might affect future erosion within this management unit and which have been considered in the risk assessment process. The coastal hazard assessment (MRA, 2016a) treated the coast as sandy and coastal hazard lines advance steadily landward over the planning timeframes (see **Appendix A** and **Table 2-3**).

The caravan park (Seabird Private) in the southern portion of the management unit has an increasing vulnerability over time, becoming high by 2050 and very high by 2070. Natural assets, such as the beach and coastal dunes/vegetation, have increasing vulnerability ratings across the planning timeframes, becoming highly vulnerable by 2050. The adaptive capacity of these assets in front of the town diminishes over time as they are restricted by existing development, particularly adjacent to the caravan park. The tavern has increasing vulnerability over time as the risk of erosion increases, becoming highly vulnerable by 2070 (see **Appendix E**). The key outcomes of the risk assessment for this management unit, SE2, are:

- > The caravan park has a high vulnerability rating by 2050 and a very high vulnerability rating by 2070;
- > The beach and coastal dunes/vegetation have medium vulnerability ratings by 2030 and high vulnerability ratings by 2050; and
- > The tavern has a high vulnerability rating by 2070.

3.2.3 **LP1 - Ledge Point South of Township**

The Ledge Point South of Township management unit contains predominantly natural assets such as the beach and vegetated dunes (**Figure 3-4**). There are unsealed roads and an unsealed coastal carpark lying seaward of the 2110 coastal hazard line and the values of these assets are described in **Appendix C**.

The coastal hazard assessment treated this coastline as sandy (MRA, 2016b) and the hazard lines advance steadily landward (see **Appendix A** and **Table 2-3**) to the 2110 width of approximately 130 m.



Figure 3-4 Photograph of the Ledge Point South of Township LP1 management unit (source: DoT, 2016)

Although the current beach and vegetated dune system is likely to be eroded over time, this dunal ecosystem extends over broad areas of the coast and hence the consequence of future erosion within this management unit 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 natural assets in this area are therefore low to medium across the planning timeframes. The medium to high rating for coastal dunes/vegetation towards the end of the century 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. The vulnerability of unsealed roads and carparks is generally low across the planning timeframes, due primarily to their low value (see **Appendix E**) and ability to be relocated. The key outcomes of the risk assessment for this management unit, LP1 are:

- > The beach has a low vulnerability rating across the planning timeframes and the coastal dunes/vegetation have a low vulnerability rating to 2030, medium vulnerability rating by 2070 and high vulnerability rating by 2110; and
- > The beach carpark and road have low vulnerability ratings up to 2070.

3.2.4 **LP2 - Ledge Point Township South**

The Ledge Point Township South management unit has about 600 m of ocean front and contains beach and foreshore reserve, 33 residential properties, roads and associated public infrastructure that are located either partially or fully within the 2110 coastal hazard line (**Figure 3-5**). The natural beach and vegetated foreshore reserve is bounded on the landward side by residential development. A small recreational area at the northern end of the management unit is located seaward of the 2070 hazard line. The values of these assets are described in **Appendix C**.



Figure 3-5 Ledge Point Township South LP2 management unit (source: DoT, 2016)

The groyne and headland feature at the northern boundary of the management unit and the scattered nearshore and offshore reefs structures form existing controls to sediment transport and erosion. The coastal hazard assessment treated this coastline as sandy (MRA 2016b) and the estimated hazard lines advance steadily landward (see **Appendix A** and **Table 2-3**) to the 2110 width of approximately 130 m.

Residential properties in the management unit are highly vulnerable at present and predicted to be very highly vulnerable by 2030, due to their value and proximity to potential coastal erosion hazards. Roads associated with these properties have high vulnerability by 2070. Natural assets, such as the beach and

foreshore recreation area, have increasing vulnerability ratings across the planning timeframes, becoming highly vulnerable by 2070. The adaptive capacity of these assets diminishes over time as their ability to adapt is restricted by existing development (see **Appendix E**). The key outcomes of the risk assessment for this management unit, LP2 are:

- > Residential properties have a high vulnerability rating at present and a very high vulnerability rating by 2030;
- > Roads have a high vulnerability rating by 2070; and
- > The beach and foreshore recreation area have medium vulnerability ratings by 2030 and high vulnerability ratings by 2070.

3.2.5 **LP3 - Ledge Point Township North**

The Ledge Point Township North management unit contains a mixture of residential and commercial properties (i.e. the Holiday Village), as well as roads and carparks, located either partially or fully seaward of the 2110 coastal hazard line (**Figure 3-6**). This foreshore area contains the town's main swimming and recreation beach. A large portion of coastal land is allocated for recreation use and tourism, including Key Biscayne Park, beach access paths and car parking at De Burgh Street. The values of these assets are highlighted in **Appendix C**.



Figure 3-6 Ledge Point Township North LP3 management unit (source: DoT, 2016)

Two groynes: one at the southern boundary and one located slightly south of the centre of the management unit shoreline form important controls for coastal erosion. The coastal hazard assessment treated this coastline as sandy (MRA 2016b) and the estimated hazard lines advance steadily landward (see **Appendix A** and **Table 2-3**) to the 2110 width of approximately 130 m.

Residential properties and the Holiday Village are predicted to be very highly vulnerable by 2070 as the risk of coastal erosion increases. All other built and natural assets are predicted to have medium vulnerability by 2070 and high or very high vulnerability by 2110 (see **Appendix E**). The key outcomes of the risk assessment for this management unit, LP3 are:

- > Residential properties have a very high vulnerability rating by 2070;
- > The Holiday Village has a high vulnerability rating by 2070 and very high vulnerability rating by 2110; and
- > All other assets have medium vulnerability ratings by 2070 and high or very high vulnerability ratings by 2110.

3.2.6 **LP4 - Ledge Point North of Township**

The Ledge Point North of Township management unit contains predominantly natural assets with the beach and vegetated dunes as well as unsealed tracks and a sailing club (reportedly at the end of its lifecycle) lying seaward of the 2110 coastal hazard line (**Figure 3-7**). The values ascribed to these assets are provided in **Appendix C**.



Figure 3-7 Ledge Point North of Township LP4 management unit (source: DoT, 2016)

There are some scattered nearshore and offshore reef structures but the coastal hazard assessment treated this coastline as sandy (MRA 2016b) and the estimated hazard lines advance steadily landward (see **Appendix A** and **Table 2-3**) to the 2110 width of approximately 130 m

Although the current beach and vegetated dune system is likely to be eroded over time, this dunal ecosystem extends over broad areas of the coast and hence the consequence of future erosion within this management unit 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 natural assets in this area are therefore low to medium across the planning timeframes. The medium to high rating for coastal dunes/vegetation towards the end of the century 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. The vulnerability of unsealed roads and carparks is generally low across the planning timeframes, due primarily to their low value (see **Appendix E**) and ability to be relocated. The key outcome of the risk assessment for this management unit, LP4 is:

- > All assets within the management unit have low vulnerability ratings across the planning timeframes.

3.2.7 **LA1 - Lancelin South of Township**

The Lancelin South of Township management unit contains predominantly natural assets such as the beach and vegetated dunes. The northern part of the management unit contains a caravan park and Grace Darling recreation that lie partially or wholly, respectively, seaward of the 2110 coastal hazard line (**Figure 3-8**). The values of assets are described in **Appendix C**.

Scattered nearshore reef, Edward Island and the Edward Island Point headland towards the northern end of the management unit form controls on the sediment transport and erosion processes considered in the risk assessment process. The coastal hazard assessment treated this coastline as sandy (MRA 2016b) and the estimated hazard lines advance steadily landward (see **Appendix A** and **Table 2-3**) to the 2110 width of varying from 160 to 200 m.



Figure 3-8 Lancelin South of Township LA1 management unit (source: DoT, 2016)

Grace Darling Park and the Sea Rescue building have been assessed as highly vulnerable at present, and very highly vulnerable by 2030 and 2070, respectively. This is due to the current and increasing risk of erosion impacts, because of their proximity to the coast. The caravan park is seen to have a medium vulnerability at present, becoming highly vulnerable by 2070. The beach and coastal dunes/vegetation have

been assessed as having low vulnerability across the planning timeframes, due to their ability to adapt to ongoing erosion impacts (see **Appendix E**). The key outcomes of the risk assessment for management unit LA1 are:

- > Grace Darling Park has a high vulnerability rating at present and a very high vulnerability rating by 2030;
- > The Sea Rescue building has a high vulnerability rating at present and a very high vulnerability rating by 2070; and
- > The beach, coastal dunes/vegetation and Back Beach Carpark have low vulnerability ratings across the planning timeframes.

3.2.8 **LA2 - Lancelin Township South**

The Lancelin Township South management unit contains roads, 53 residential properties and associated public infrastructure that are located either partially or fully within the 2110 coastal hazard line (**Figure 3-9**). The natural beach and foreshore reserve are bounded on the landward side by public infrastructure and residential development. Commercial assets include a Lobster receival depot and restaurant at the northern end. The values of these assets are highlighted in **Appendix C**.



Figure 3-9 Lancelin Township South LA2 management unit (source: DoT, 2016)

Extensive nearshore reefs form existing controls within this management unit and have been considered in the risk assessment process. The coastal hazard assessment treated this coastline as sandy (MRA 2016b) and the estimated hazard lines advance steadily landward (see **Appendix A** and **Table 2-3**) to the 2110 width of varying from 100 to 200 m.

Commercial assets in the light industrial area at the northern end are seen as having medium vulnerability at present and are predicted to be highly vulnerable by 2070, due to their value and proximity to coastal erosion hazards. Residential properties and the associated road are predicted to be highly vulnerable by 2070 and 2110, respectively. The beach and coastal dunes/vegetation are predicted to become highly vulnerable by 2070, as coastal erosion risk increases and their ability to adapt diminishes, due mainly to development restricting inland migration (see **Appendix E**). The key outcomes of the risk assessment for this management unit, LA2 are:

- > The light industrial area and Café have medium vulnerability ratings at present and have high vulnerability ratings by 2070;
- > The beach and coastal dunes/vegetation have low vulnerability ratings at present and high vulnerability ratings by 2070; and
- > Residential properties have high vulnerability ratings by 2070 and very high vulnerability ratings by 2110.

3.2.9 **LA3 - Lancelin Township North**

The Lancelin Township North management unit contains 41 residential properties, roads and associated public infrastructure located partially or fully within the 2110 coastal hazard line (**Figure 3-10**). The beach and coastal dunes/vegetation are bounded to various extents on the landward side by public infrastructure and residential development. Commercial assets include the Endeavour Tavern, the Lancelin Beach Hotel and a caravan park at the northern end. A foreshore recreation area and a small portion of the Primary School also lie seaward of the 2110 coastal hazard line. The values of assets are described in **Appendix C**.



Figure 3-10 Lancelin Township North LA3 management unit (source: DoT, 2016)

Extensive nearshore reefs, Lancelin Island offshore the northern boundary and the Lancelin Island Point headland at the northern boundary form existing controls to future erosion considered in the risk assessment process. The coastal hazard assessment treated this coastline as sandy (MRA 2016b) and the estimated hazard lines advance steadily landward (see **Appendix A** and **Table 2-3**) to the 2110 width of varying from 100 to 200 m.

Due to the value of residential properties in this management unit and the increasing risk of coastal erosion impacts, the assets are predicted to be highly vulnerable by 2030 and very highly vulnerable by 2070. The beach and coastal dunes/vegetation have increasing vulnerability across the planning timeframes as their ability to adapt is restricted by development on their landward side. These natural assets are predicted to be highly vulnerable by 2070. Other valuable assets, such as the Caravan Park, Lancelin Beach Hotel, park and Endeavour Tavern are predicted to be highly vulnerable by 2070, as the risk of coastal erosion impacting them becomes high (see **Appendix E**). The key outcomes of the risk assessment for this management unit LA3 are:

- > Residential properties have a high vulnerability rating by 2030 and very high vulnerability rating by 2070;
- > The beach and coastal dunes/vegetation have high vulnerability ratings by 2070 and very high vulnerability ratings by 2110; and
- > The Caravan Park, Lancelin Beach Hotel, park and Endeavour Tavern have high vulnerability ratings by 2070.

3.2.10 **LA4 - Lancelin North of Township**

The Lancelin North of Township management unit contains 40 residential properties that are located partially or fully within the 2110 coastal hazard line, as well as roads and associated public infrastructure (**Figure 3-11**). Natural assets include the beach and foreshore reserve, which are well used for recreation near Lancelin Island Point. The beach and dunes are bounded inland by development in the southern portion of the management unit, but unbounded to the north. See **Appendix C** for more information on assets and their values in this management unit.



Figure 3-11 Lancelin North of Township LA4 management unit (source: DoT, 2016)

Nearshore reefs, Lancelin Island offshore the southern boundary and the Lancelin Island Point headland at the southern boundary form existing controls considered in the risk assessment process. The coastal hazard assessment treated this coastline as sandy (MRA 2016b) and the estimated hazard lines advance steadily landward (see **Appendix A** and **Table 2-3**) to the 2110 width of varying from 160 to 200 m.

The beach and coastal vegetation/dunes are predicted to be increasingly vulnerable into the future, particularly in the south of the management unit where their ability to migrate inland is restricted by existing development. These natural assets are predicted to become very highly vulnerable by 2070. Residential properties at the south of the management unit are predicted to be highly vulnerable by 2030 and very highly vulnerable by 2070, as the risk of erosion increases across planning timeframes. Existing beach access is predicted to be highly vulnerable by 2070. The key outcomes of the risk assessment for this management unit, LA4 are:

- > Residential properties have a high vulnerability rating by 2030 and very high vulnerability rating by 2070;
- > The beach and coastal dunes/vegetation have very high vulnerability ratings by 2070; and
- > Beach access ways have a high vulnerability rating by 2070.

3.3 Management Units for Priority Consideration of future Options

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

Management units containing assets assessed as having 'High' or 'Very High' present day vulnerability and/or 'Very High' vulnerability by 2030 have been identified to take priority when developing adaptation options for the current CHRMAP process. The priority management units identified include:

- > SE1: Seabird Township South (Residential (houses and land));
- > LP2: Ledge Point Township South (Residential (houses and land)); and
- > LA1: Lancelin South of Township (Grace Darling Park and Sea Rescue building).

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 vulnerability 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 SLR and coastal erosion are threatening, currently fixed, coastal zone assets at an increasing rate into the future 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 SPP2.6 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 of SPP2.6 is to manage retreat from vulnerable areas before assets are threatened. 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 LAA. The LAA empowers the Minister for Lands to take interests in land on behalf of the State or any "acquiring authority". An "acquiring authority" may include a local government. 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 or Managed Retreat Guideline*?

It is recommended that a comprehensive investigation of each township community and visitors be undertaken to identify beneficiaries of the proposed protection areas. Further, an economic assessment of mechanisms for recouping costs from beneficiaries (e.g. parking fees, visitor entry fee, increased council rates or levy and other options) is required to inform the future review of the strategy 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 (SCA), 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 Schemes) Regulations 2015 (WA), 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 (SPP2.6).

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 (predominantly the LAA).

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.

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 plan for adaption 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**.

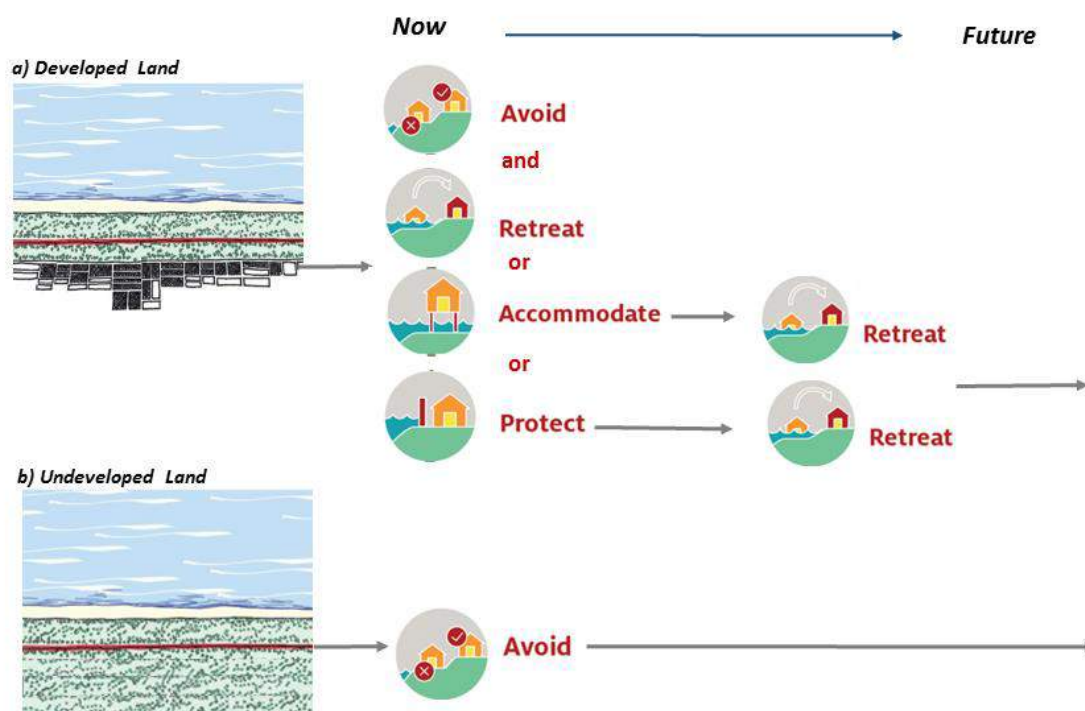


Figure 4-1 Long-term pathways for a) developed and b) undeveloped land

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 strategy but is generally only 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 long term strategy for areas of existing development at risk. This option aims to remove assets from the risk of coastal hazards and is economically responsible over the long term, although it may involve significant expenditure during implementation. The planning mechanisms around implementing 'avoid' and 'managed retreat options' have been discussed 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 rarely applicable to areas, at risk of coastal erosion but is suitable to some areas prone to coastal inundation, where assets can be elevated above flooding to maintain land use in a designated hazard 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 adjacent 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 only 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.”

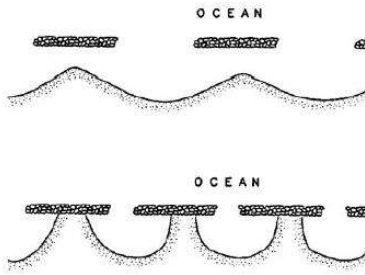



Table 5-1 Adaptation and Management Options (adapted from WAPC, 2014a)

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).
Do nothing	Do nothing	DN	Take no action. No limitations on development or implementation of adaptation planning. Accept risk.

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. 0 provides additional detail on protection options available.

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.
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.

d) Nearshore Reef / Breakwater		
		<p>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.</p>
e) Seawall		
		<p>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.</p>

5.2 Adaptation Options Assessment Process

Each of the adaptation options presented in **Table 5-1** has been considered for each of the three priority management units identified in the risk assessment for this study. As recommended in the State 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 in the assessment. Options have also been assessed in terms of their 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 considered 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 priority management units (as defined in **Section 3.3**) those options recommended for further investigation have been assessed in greater detail. This additional detail is discussed for each of priority management unit in **Sections 5.4** to **5.6**, respectively. 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 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 Seabird South (SE1 and SE2)

The outcomes of the multi-criteria analysis are consistent for the two management units within Seabird (SE1 and SE2).

The multi-criteria analysis recommended further investigation of the following options:

- MR2, the process of implementing managed retreat of assets;
- PR3, using groynes as a protection measure; and
- PR5, extending the recently constructed seawall and/or maintaining it beyond its 20-year design life to provide ongoing protection to assets.

The options recommended for implementation in the short term include:

- AV, avoiding further development in identified hazard areas;
- MR3, implementing planning controls to facilitate future managed retreat from these areas;
- AC1, planning controls to accommodate risk;
- AC2, the preparation of emergency plans and controls; and
- PR1, low cost protection options such as dune care and sand management.

An assessment of adaptation options recommended for further investigation is discussed in **Section 5.4** and the implementation plan presented in **Section 6**.

5.3.2 Ledge Point

LP1 and LP4

Ledge Point South of Township (LP1) and Ledge Point North of Township (LP4) management units are characterised by undeveloped natural assets and the outcomes of the multi-criteria analysis are consistent for both management units. It is recommended that substantial residential and commercial development is avoided (AV) in these 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.

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 are not recommended.

LP2 and LP3

The outcomes of the multi-criteria analysis are consistent for both this and the Township North management unit (LP3).

Options recommended for further investigation included:

- MR2, the process of implementing managed retreat of assets; and
- PR2, PR5, and PR3, protection options of beach nourishment, groyne(s) and a seawall require further investigation to assess their suitability for implementation.

The options recommended for implementation in the short term include:

- AV, avoiding further development in identified hazard areas;
- MR3, implementing planning controls to facilitate future managed retreat from these areas,

- AC1, planning controls to accommodate risk;
- AC2, the preparation of emergency plans and controls; and
- PR1, low cost protection options such as dune care and sand management.

An assessment of adaptation options recommended for further investigation is discussed in **Section 5.5** and the implementation plan presented in **Section 6**.

5.3.3 Lancelin

Identifying suitable adaptation options and determining an adaptation pathway for the priority management unit at Lancelin South of Township (LA1), is considered urgent. The outcomes of the multi-criteria analysis are consistent among all management units within Lancelin (LA1, LA2, LA3 and LA4).

The multi-criteria analysis recommended further investigation of the following options:

- MR2, the process of implementing managed retreat of assets;
- PR2, beach nourishment; and
- PR3 and PR5, groynes and a seawall, respectively, require further investigation to assess their suitability and cost (initial capital and ongoing maintenance costs).

The options recommended for implementation in the short term include:

- AV, avoiding further development in identified hazard areas;
- MR3, implementing planning controls to facilitate future managed retreat from these areas;
- AC1, planning controls to accommodate risk;
- AC2, the preparation of emergency plans and controls; and
- PR1, low cost protection options such as dune care and sand management.

An assessment of adaptation options recommended for further investigation is discussed in **Section 5.6**, for LA1 and the implementation plan presented in **Section 6**.

5.4 **Adaptation Options – Seabird Township South (SE1)**

The coastal hazard assessment (MRA, 2016a) was undertaken prior to construction of the recently constructed seawall. The present day and 2030 coastal hazard extents should be reassessed during the next round of review of the CHRMAP, particularly for the area adjacent to the seawall. This risk assessment and multi-criteria analysis processes, however, have considered the protective structure.

The current seawall was installed as a temporary protection device while the broad range of issues on the management of the coastal zone are considered and implemented at some point in future. The seawall was not designed as a permanent solution and it is likely that it will fail under extreme events at some point in the future. If this was to occur, the presence of the limestone ridge is likely to reduce the risk of erosion landward of McCormick Street as shown by the hazard map (**Appendix A**) but properties seaward of McCormick St would be affected.

The coastal hazard risk to built assets has been mitigated for the short term (up to ca. 2030) by the construction of the seawall. This seawall has, however, impacted (and is likely to continue to impact) the adjacent beach to the north of the seawall, the public amenity and associated coastal access. The long term tenure and management arrangements for the seawall are still undecided and continue to be the subject of discussions between the State and the Shire. Planning for management of this area should consider the following:

- > Tenure of land and management responsibility;
- > Design life of the current seawall (estimated to be 20 years);
- > Economic value of assets at risk from coastal processes / benefiting from the seawall;
- > Investigation of medium to long term adaptation options:
 - managed retreat (MR2);

- groyne(s) (PR3);
- seawall extension and/or maintenance (PR5); and

> Equity implications and sources of funding.

Government has no legal responsibility to protect this area but in the recent past the State provided funding for the seawall. Potential funding sources, including private property owners, the State or the Shire will need to be carefully considered during the investigation of solutions to this issue.

5.4.1 **Land Tenure and Seawall Management**

The Seabird seawall was constructed on Shire road reserve (the portion of Turner St that previously existed in front of some of the houses) and unvested (or unallocated) Crown land (UCL) on the seaward side of the road reserve. Management of the UCL is the responsibility of the Department of Planning, Lands and Heritage.

The seawall is currently being managed by the Shire of Gingin under a license issued under section 91 of the LAA by the Department of Lands. The license authorises temporary use to other parties. The Licence has been extended for 3 years to 2020; however, this arrangement is not considered to be a long term management solution. Tenure of the land, and therefore management responsibility for the seawall, should be transferred to the Shire for ongoing control, monitoring and maintenance of the structure until a long term solution is considered during the CHRMAP review process in 5 to 10 years.

5.4.2 **Value of Assets at Risk**

An estimate of the economic value (2015 \$) of built assets lying seaward of the 2030 coastal hazard line is presented in **Table 5-4** (draft CHRMAP, Shire of Gingin 2016b). The value of assets protected by the seawall at the 2030 planning timeframe is around \$8M. To provide context for subsequent discussion of the application of a beneficiary pays system to fund future coastal management the Shire's revenue base, in 2105 dollars, for the 15-year period (2015 to 2030) is also estimated in **Table 5-4**. The Shire's current revenue is allocated to a broad range of Council activities across the Shire. The current budget does not include provision for current or future allocation of funds to address coastal management issues nor respond to coastal erosion events.

Table 5-4 Summary of estimated value (2015 \$) of vulnerable built assets in the Seabird Township South management unit (from draft CHRMAP, Shire of Gingin, 2016b)

Asset type	2030			
	unit	Rate(\$)	#	value (\$)
Roads (main)	m	800	0	0
Roads (secondary)	m	500	174.7	\$ 87,350
Footpaths / Cycleways / Beach Access	m	350	123.5	\$ 43,225
Carpark	m ²	70	1150	\$ 80,500
Private properties: residential				
- land vacant	#	250,000	0	\$ 4,000,000
- houses and improvements	#	250,000	16	\$ 4,000,000
Private properties: commercial, holiday accommodation				
- land	m ²	150	0	0
- improvements (chalets)	#	180,000	0	0
Total				\$ 8,211,075
Rate Base Revenue over 15 years, 2015 to 2030 (in 2015 \$)				
Affected properties	#	\$997	16	\$239,280
Township	#	\$997	140	\$2,093,700
Shire	#	\$997	1273	\$19,037,715

* includes S2

The Shire is reliant upon the State for emergency response assistance and limited funding of ongoing coastal projects through the State's coastal program which is subject to competitive bidding process. Options for increasing equitable enjoyment of the ocean frontage aspect enjoyed by properties positioned above the seawall, for example rezoning of some areas to allow for commercial use may also be considered.

5.4.3 **Remove and Relocate (MR2)**

There are currently no specific mechanisms for implementing government funded managed retreat in the CHRMAP context. Further, government has no legal obligation to maintain property or access. Noting that the State funded the seawall construction its present maintenance arrangements (eg., to maintain its structural integrity as a protection for hinterland property against extreme erosion events) are subject to negotiation between the Shire and the State. Under the present arrangements the likely scenario is that as extreme events erode the shoreline and private assets, access to properties in SE1 would be prohibited as they become unsafe and/or illegal to occupy. The mechanism to implement a managed retreat policy including legal and financial/economic considerations as well as agreement on the future of the seawall, its costs (maintenance or removal) and its role in ongoing protection needs further investigation. For example, the development of a managed retreat policy that seeks to invoke the provisions of the LAA or the PDA, regarding voluntary or compulsory acquisition, will need to carefully consider the cost implications and apportionment of costs prior to adopting such an approach.

Triggers for retreat might include:

- > Distance of the asset from the HSD datum is less than S1 (noting that this has not been recalculated to include the presence of the seawall);
- > Loss of legal access to property; or
- > Loss of essential services

R_SE1.1: 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.

5.4.4 **Groynes (PR2)**

A groyne, or groynes, could be considered as part of a future protection strategy for assets at risk in this management unit. Given that an existing protection measure is already in place (seawall (PR5)) and expected to provide protection for at least the next 20 years, a detailed assessment of the suitability of a groyne(s) for this area is not required in the immediate term.

Groynes could be implemented as a protection measure after the seawall has reached the end of its lifecycle. Material from the seawall could potentially be used in the construction of the groynes, reducing supply and transport costs. Installing groynes in addition to the existing seawall, as some community members have suggested, would not be recommended at this time. The presence of the seawall would reduce the effectiveness of groynes in retaining sediment and stabilising the shoreline in the area.

It should be noted that the installation of groynes, beyond the lifecycle of the seawall, would not be expected to provide protection for all existing assets. A loss of functionality (or the removal) of the seawall would likely trigger a need for managed retreat of multiple residential properties, due to a high risk of impact from coastal hazards. Installing groynes could help restore the useable beach, which has been eroded in front of the seawall, and provide temporary protection for some built assets.

MRA (2015) undertook a preliminary assessment of the feasibility and cost implications for protecting vulnerable assets using groynes up to 2030, prior to the construction of the seawall. They estimated a total cost of approximately \$14 million, the majority of this being associated with initial and ongoing sand nourishment required in addition to the groynes. The cost of implementing this protection measure for a 15-year period (for example) beyond the lifecycle of the seawall is likely to have similar cost implications to this amount. The benefit of implementing this management strategy should be assessed in detail, alongside the expected benefit it will provide, prior to the end of the seawall's lifecycle. The equitable apportionment of costs among beneficiaries of such an option would also require a detailed assessment to justify its viability for the Shire.

R_SE1.2: It is recommended that the feasibility and suitability of groynes be assessed in detail, prior to the end of the seawall's lifecycle (presently estimated to be 2035). It is not recommended that groynes be considered for implementation as a management strategy in the immediate term.

5.4.5 **Seawall Maintenance (PR5)**

A "temporary" seawall has been implemented in this management unit, to provide protection to residential properties (particularly in the northern part of this unit) that would otherwise highly vulnerable to coastal erosion hazards. The design life of the structure is estimated to be 20 years, meaning the protection measure is expected to be in place until at least 2035. Land tenure and management responsibility associated with the seawall is discussed in **Section 5.4.2**. 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 acceptability of the seawall to the community should also be monitored over the lifecycle of the structure and results reported as part of future reviews (each 5-10 years) of the CHRMAP. Feedback from community engagement associated with this CHRMAP has indicated that some community members are concerned with the loss of beach amenity and its accessibility caused by the seawall. Observations during a site visit in February of this year showed the beach in front of the seawall had receded, giving it limited accessibility and useability. Should this current and potentially ongoing, loss of public amenity be deemed unacceptable to the overall community, with respect to the benefit provided by the seawall, removal of the seawall before the end of its lifecycle (also see **Section 5.4.4**) could be triggered.

R_SE1.3: It is recommended that the seawall is monitored and maintained for the duration of its (estimated) 20 year design life, provided the consequences of its presence are acceptable to the overall community throughout this period. An assessment should be made prior to (approximately) 2035 to decide how this area should be managed beyond this timeframe. Options may include:

- > Continue monitoring, maintaining and retrofit (if required) the seawall to extend its useful life;
- > Completely remove the seawall (and by implication either manage retreat or do nothing and allow eventual abandonment);
- > Remove the seawall and use material (if appropriate) to implement groynes as a protection measure (see **Section 5.4.4**); and
- > Leave the seawall in place, discontinue monitoring and maintenance and allow it to deteriorate in future (do nothing and allow future abandonment).

It must be noted that depending upon the policy position adopted by the Shire the last three options are likely to trigger either abandonment (Do Nothing), or managed retreat of some assets that are presently behind the seawall (see **Section 5.4.4**), or a Protection policy. The cost and viability implications of adopting either these policy positions requires detailed assessment to inform optimal decision. The associated costs of maintaining the wall and equitable apportionment of these costs to beneficiaries creates a difficult issue for the Shire and the community that also needs to be considered as part of an investigation.



Figure 5-1 Photographs of the Seabird seawall taken during a site visit in February 2017

5.5 Adaptation Options – Ledge Point Township South (LP2)

There are 33 residential properties lying seaward of the 2110 coastal hazard line in this management unit, with six properties intersected by the present day hazard line (**Appendix A**). The economic value associated with these properties has led to their high vulnerability rating at present, meaning immediate implementation of adaptation measures is required. Examination of Landgate cadastral information indicates that some property boundaries extend seaward of the current vegetation line. Public access along top of the dunes across private property is possible, due to a lack of property boundary fencing, but there is no allocated public foreshore reserve and direct public access to the beach is limited.

The beach in this management unit is well used, particularly with vehicles accessing the beach and launching vessels from the shore. The preservation of this public amenity should be considered when assessing the suitability of adaptation options.

As described in **Section 2.3**, there are two rock groynes, one at the northern boundary of the management unit and one approximately 250 metres north of this. Historical aerial imagery suggests that, since their construction in the 1970s groynes have been effective in retaining sediment in the area. Recent aerial imagery suggests the groynes have become saturated with beach sand. It is important to note that the groyne structures themselves do not provide a protective function. Generally, the additional sediment they trap provides a greater buffer against coastal erosion impacts. Note, however, that trapping sediment that is part of a longshore transport system exacerbates the beach erosion down-stream (to the north) of the groyne. **Figure 5-2**, below, illustrates how a sediment buffer can be eroded during storm activity.

Preliminary plans by the Department of Transport for a boat ramp/marina to the south of the Ledge Point township are currently being considered. Assessing the potential impacts of such a development is beyond the scope of this CHRMAP project.

R_LP2.1: It is recommended that the planning of the boat ramp/marina consider the short term implementation plan and long term management pathways for Ledge Point articulated in this CHRMAP. Similarly, the Shire should carefully review any plans for such a development with respect to the outcomes of this CHRMAP.



Figure 5-2 Photo monitoring images (NACC 2017) from LP2 showing erosion following storm events in September 2009 (left) and redevelopment and revegetation of dune slope by June 2016 (right).

5.5.1 Value of Assets at Risk

An estimate of the economic value (2015 \$) of built assets lying seaward of the 2030 coastal hazard line is presented in **Table 5-5** (draft CHRMAP, Shire of Gingin, 2016b). Note that this table only includes assets in LP2 impacted by 2030. The apportionment of costs on a beneficiary pays principle suggests that there needs to be significant assessment of the beneficiaries and the value each derives from retaining the beach.

5.5.2 **Remove and Relocate (MR2)**

Removal of properties at risk of erosion to the west of DeBurgh Street is an option in LP2.

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 of the LAA or the PDA (See **Section 4.1**).

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

- > distance of the asset from a datum such as the HSD is less than a yet to be determined set distance (for example 40 m);
- > distance of the asset from the HSD is less than S1 (i.e. 12 m for LP2);
- > Loss of legal access to property, or
- > Loss of essential services.

Since the distance of the assets from the HSD is around 20 m for most of the seafront properties in this area, the need for retreat in relation to S1 would not yet be triggered, however this could change in a single storm event.

In the event of voluntary or compulsory acquisition of the affected property, the total cost (assuming a future valuation of the property would be similar to its present estimated value) presented in **Table 5-5**, is estimated at about \$250,000.

Table 5-5 Summary of estimated value (2015 \$) of vulnerable built assets in Ledge Point (from draft CHRMAP, Shire of Gingin, 2016b)

Asset type	unit	Rate(\$)	2030*	
			#	value (\$)
Roads (main)	m	800	0	0
Roads (secondary)	m	500	0	\$0
Footpaths / Cycleways / Beach Access	m	350	66	\$23,100
Carpark	m ²	70	0	\$0
Private properties: residential				
- land vacant	#	250,000	0	\$0
- houses and improvements	#	250,000	1	\$250,000
Private properties: commercial				
- land	m ²	150	0	0
- improvements (chalets)	#	180,000	0	0
Total				\$523,100
Rate Base Revenue over 15 years, 2015 to 2030 (in 2015 \$)				
Affected properties	#	\$997	33	\$493,515
Township	#	\$997	379	\$5,667,945
Shire	#	\$997	1273	\$19,037,715

* all assets impacted by 2030 are located in LP2

5.5.3 **Beach Nourishment (PR2)**

Beach nourishment should aim to increase the profile of dunes at the back of a beach, providing additional buffer against storm-based erosion to protect assets inland. It is generally more effective when used amongst groynes, which help to retain the sediment in situ. Beach nourishment is a temporary protection measure that can provide additional buffer to areas inland for varying lengths of time, depending on the rate of ongoing nourishment and severity of storm event erosion. This variability makes it difficult to assess the predicted benefit of nourishment, with respect to the cost.

Sand nourishment could be used in front of vulnerable assets to provide additional protective buffer against coastal hazards and to help maintain the useable beach width and amenity in this area. The longevity of such nourishment would probably be assisted by the presence of an existing groyne at the north of the study area. Refurbishment and/or extension of this groyne (discussed below in **Section 5.5.5**) would also be likely to improve the effectiveness of any sand nourishment.

MRA (2015) suggested an initial nourishment volume of approximately 40,000 m³ for this area. The cost of such nourishment could range from approximately \$400,000 to \$2 million, depending primarily on the location of the sand source. A rough assumption would be that this nourishment provides additional protection to the area for a period of 18 months to 5 years, before the beach returns to its original state and additional nourishment is required to continue the protection technique. As nourishment sand is redistributed (offshore and alongshore) subsequent to its placement, the level of protection of areas behind the beach diminishes and progressively exposes these assets to severe storm events.

R_LP2.2: Beach nourishment would be recommended for this area if funding is available and can be allocated. Such funding could be sought from the 33 residential property owners who stand to benefit from beach nourishment. Should it wish to pursue this option, it is recommended that the Shire identify a suitable sediment source and refine a cost per cubic metre, to extract, transport and place material from this source. An affordable volume of nourishment can then be assessed and an appropriate beach profile can be designed to guide sand placement.

5.5.4 **Groynes (PR3)**

An existing groyne is in place at the northern boundary of this management unit. The installation of this groyne in the 70s was effective in reconfiguring and stabilising the shoreline to the south. The groyne now appears to be saturated and is unlikely to provide additional protection beyond this point in time. The effective use of groynes in the area previously suggests that this protection technique could continue to be used effectively into the future. A variety of groyne placements could be considered, including refurbishing existing groynes and installing up to two new groynes.



Figure 5-3 Existing rock groyne at northern boundary of the Ledge Point Township South management unit

In the immediate term, as a first stage, it is recommended that a detailed investigation of the sediment transport processes and sediment budget of the past 50 years be carried out to inform the selection of appropriate groyne/sand nourishment options. Pending the outcome of such an investigation, it may be recommended that the existing groyne at the northern boundary of the management unit be refurbished and extended seaward (see **Figure 5-3**). The cost of designing and constructing the extended groyne is likely to cost \$1-2 million. Monitoring and maintenance costs for the groyne are likely to be in the order of \$50,000 to \$150,000 per decade. A typical rock groyne structure would be expected to have a design life of 35 to 50 years.

Extending this groyne would help retain additional sediment (as additional protective buffer) on the beach in front of residential properties at the northern end of the management unit. The assets in this area have the highest vulnerability to coastal hazards at present. Extending the groyne would be more effective if associated with initial and ongoing beach nourishment, similar to that described in **Section 5.5.4** (also see **Figure 5-3**).

Partial or full funding for the protection works should be sought from the 33 residential property owners who stand to benefit from the management strategy.

It must be noted that the extension of this groyne is likely to exacerbate seasonal erosion to its north. The full extent of this erosion is difficult to predict. The additional management measures, and their costs, that may be required to the north of this management unit should be properly considered before this management technique is adopted.



Figure 5-4 Conceptual representation of existing groyne refurbishment and extension, with sand nourishment and potential locations for future groynes

Beyond this first stage, the installation of additional groynes could be considered to provide protection for assets further to the south of this management unit, as their vulnerability increases (**Figure 5-4**). MRA (2015) assessed an option to install two additional groynes in the management unit. They estimated the construction of groynes and associated beach nourishment, providing protection for 15 years, would cost approximately \$4 million. The suitability of installing additional groynes can be investigated at a later stage, and should be based on ongoing beach monitoring in the short term and also the performance on the first stage groyne extension, should that option be implemented.

5.5.5 Seawall (PR5)

A seawall could be considered as a protection measure in this area and has been investigated previously by MRA (2015) who estimated the cost to install a seawall at approximately \$1.2 million. The concept location is shown in **Figure 5-5**. They noted that the approach and costing was of a preliminary nature and that detailed design would need to be carried out based on site specific data and further, the potential impacts on the amenity of the beach and potential to increase erosion in adjoining areas would need to be investigated. Ongoing maintenance of the rock seawall would cost approximately \$130,000 per decade.

The above costings are also representative of “best practice” for a long term structure design and more cost effective options may be adequate for medium term protection of assets in LP2.



Figure 5-5 Conceptual representation of seawall

5.6 Adaptation Options - Lancelin South of Township (LA1)

The key asset at risk in management unit LA1 is Grace Darling Park (**Figure 5-6**). This is a grassed recreation area and is a very popular spot for both tourists and locals. It offers sheltered, shallow waters with some protection from southerly winds, and the grass is used as a rigging area for kite and windsurfers. Built infrastructure includes a Sea Rescue Building, an ablution block and picnic facilities. The erosion of the park has generated considerable concern in the community, and raised local awareness of coastal erosion threats to adjacent residential areas.

There is some conjecture that the grassed nature of the area has contributed to localised erosion, however this is unsubstantiated. It is more likely that the localised erosion is due to wave energy and currents formed due to the presence of Edward Island (see Section 5.6.3). The grassed area is slightly elevated in relation to the natural dunes to the north, which may be significant in relation to coastal inundation in later revisions of the CHRMAP.

Inland from Grace Darling Park is the Lancelin South Caravan Park (hereafter referred to as the caravan park) which is vested in the Shire. Hazard lines also intersect parts of the leased area, including some on-site infrastructure and semi-permanent structures. Lease arrangements for new management of the caravan park are currently close to finalisation. The new lessees are required to provide a plan demonstrating how coastal hazards will be managed and public foreshore reserve will be maintained over time.

In previous years, short-term management of erosion has been carried out through nourishment. The beach was renourished by placing sand in front of the erosion scarp in November 2014 and May 2015 (Seashore Engineering, 2015). It is understood sand was sourced locally from Aglime Australia's lime sand pit, with a bobcat used to distribute sand in front of the erosion scarp. A portion of this material was lost rapidly. It is also understood that some opportunistic renourishment has occurred in recent years when sand from dredging operations carried out by DoT at the town jetty became available.

The Lancelin coastal zone is predominantly low lying, and coastal inundation will be a major factor that needs to be carefully assessed during the next stage of adaptation planning.

R_{LA1.1}: It is therefore recommended that major investment decisions with regards to coastal infrastructure are reserved until after the coastal inundation impact assessment mitigation planning has been completed.



Figure 5-6 Grace Darling Park a) during a storm event (May 2015) and b) February 2017

5.6.1 Value of Assets at Risk

An estimate of the economic value (2015 \$) of built assets lying seaward of the coastal hazard lines for each planning timeframe is presented in **Table 5-4** (draft CHRMAP, Shire of Gingin, 2016b). Note that this table only includes assets in LA1 impacted by 2030. The apportionment of costs on a beneficiary pays principle suggests that there needs to be significant assessment of the beneficiaries and the value each derives from the retaining the beach and park. Note that this table encompasses all management units in Ledge Point, however for 2030 only assets in LA1 are impacted.

Table 5-6 Summary of estimated value (2015 \$) of vulnerable built assets in Lancelin (from draft CHRMAP, Shire of Gingin, 2016b)

Asset type	unit	Rate(\$)	2030*	
			#	value (\$)
Roads (main)	m	800	111	\$88,800
Roads (secondary)	m	500	150	\$75,000
Footpaths / Cycleways / Beach Access	m	350	755	\$26,4250
Carpark	m ²	70	3676	\$25,7320
Private properties: residential				
- land vacant	#	250,000	1	\$25,0000
- houses and improvements	#	250,000	0	0
Private properties: commercial				
- land	m ²	150	0	0
- improvements (chalets)	#	180,000	16	\$2,880,000
Total				\$3,815,370
Rate Base Revenue over 15 years, 2015 to 2030 (in 2015 \$)				
Affected properties	#	\$997	0	\$0
Township	#	\$997	754	\$11,276,070
Shire	#	\$997	1273	\$19,037,715

* all assets impacted by 2030 are located in LA1

It is important to note that the primary values of Grace Darling Park are of a social nature, and may not be captured by the above cost estimates. The current assessment has not placed an economic value on the natural assets of the beach and the social aspects of the grassed area, however for cost benefit analyses in relation to specific proposals, these factors would need to be included to produce a holistic assessment. In particular, the area has tourism benefits with flow on economic benefit to local businesses.

5.6.2 **Remove and Relocate (MR2)**

Removal of infrastructure and allowing natural erosion to occur is an option for management unit LA1. Grace Darling Park is vested in the Shire (foreshore Parks and Recreation Reserve – see **Appendix C**) and its long term plan is to remove and relocate the facilities following severe erosion. In the interim ongoing repairs for minor damage following storm events is likely to continue until repairs are no longer viable. For the caravan park, mechanisms for retreat will be provided upon assessment of a development application for the site.

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

- > distance of the asset from a datum such as the Horizontal Shoreline Datum (HSD) is less than a yet to be determined set distance (for example 40 m); or
- > distance of the asset from the HSD datum is less than S1 (i.e. 14 m for this part of LA1);
- > Damage repair following storm event exceeds maintenance budget allocation;
- > Loss of legal access to property; or
- > Loss of essential services.

The distance of built assets from the HSD is greater than 14 m for the built assets in the caravan park, but some of the infrastructure in Grace Darling Park (including the sea rescue building) is currently less than 14 m from the HSD. These structures could therefore be impacted by a single storm event.

R_LA1.2: It is recommended that the sea rescue building is removed, however the ablution block and shade structures should remain until unserviceable.

Ongoing provision of a grassed recreation area which has the same appeal as the existing grassed area (including sheltered shallow water and seafront position) is contingent upon land being available which is currently part of the caravan park lease area. The caravan park in turn is constrained from expanding due to the presence of a Threatened Ecological Community (TEC) to the south. Removal of dunes to create a grassed area to the north of the existing park is an option but is likely to be unacceptable due to damage this would cause to dunes that are currently protecting public and private assets. If the toilet facilities are removed from this location, then alternative facilities will need to be built in the vicinity to cater for visitors. These issues will need to be explored further to reach an optimal solution.

5.6.3 **Sand Nourishment**

A study of potential engineering options for the protection of Grace Darling Park was undertaken by Seashore Engineering in 2015. This report recommended:

“Following conventional coastal practice, and due to the relatively low costs of obtaining sand, the interim management option of sand renourishment appears to be appropriate, albeit likely needing higher volumes of material than has been placed recently. Some improved performance of the renourishment could be achieved by ensuring the use of sand which is as coarse as practically available. It is understood that the most recently used source (from Aglime) is slightly smaller sized than the in situ beach material, which may substantially reduce its retention.”

Seashore’s (2015) estimated requirement for annual renourishment was 3000 m³, which at \$16/m³ would cost \$48,000 per year.

It is important to note that localised sediment transport at Grace Darling Park may often be from north to south, due to circulation and wave diffraction patterns caused by Edward Island (**Figure 5-7**, from Sanderson and Eliot, 1999). Assuming this model is still largely correct, then an alternative source of sand for renourishment may be the Edward Island salient. Sourcing sand that has previously moved past the Grace Darling Park beach could be considered to be “back passing” – a technique where sediments are routinely moved upstream on the understanding that they will migrate back to the place of origin. This may be a cost effective approach and it is recommended that this be investigated further.

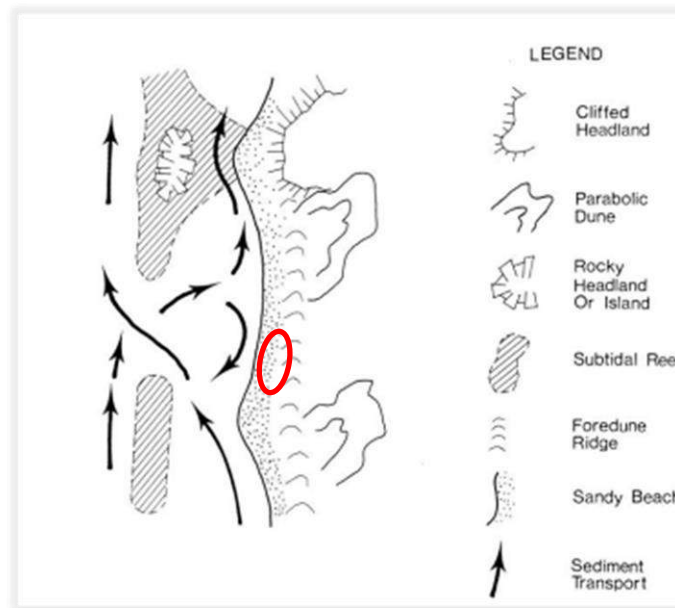


Figure 5-7 Circulation pattern in relation to salient formations from Sanderson and Eliot (1999) and the relative position of Grace Darling Park (red oval)

5.6.4 Accommodate (AC2)

Infrastructure in the caravan park is generally of a relocatable nature and it is therefore better able to accommodate the risk of erosion than other land uses. It is understood that the new managers will be required to prepare a plan for management of coastal hazards, which includes mechanisms for relocation in relation to erosion triggers, and ongoing provision of a public foreshore reserve.

5.6.5 Groynes (PR3)

A preliminary costing of structural protection options for Lancelin was undertaken by MRA in 2015. A best practice approach was adopted and recommended the following components for protection up to 2030:

- > 4 groynes;
- > Additional width of beach profile required: 20 m;
- > Total length of 280 m; and
- > Sand nourishment volume 168,000 m³.

The cost estimate for this option was estimated at \$12M. In addition to the capital cost, ongoing groynes maintenance costs were estimated to be around \$400,000 per decade.

Note this is a preliminary estimate based on concept designs and would require further detailed design and investigation of the impacts on adjoining areas prior to being adopted. The above costings are also representative of “best practice” for a long term design life and it is possible that more cost effective options may be adequate to protect assets in the short term.

It is assumed that the above option aims to protect the caravan park as well as Grace Darling Park. Smaller scale options in the vicinity of Grace Darling Park might cost considerably less than the above amount. Assessment of potential impacts from groynes would require careful investigation due to a range of uncertainties associated with the nature of cusped headlands.

5.6.6 Seawall (PR5)

Preliminary costings, based on concept designs, for construction of a 700 m long rock seawall at Lancelin (**Figure 5-8**) were estimated at \$2.7M and ongoing maintenance estimated at \$300,000 per decade (MRA, 2015). This preliminary estimate was based on concept designs and would require further detailed design and investigation of the impacts on adjoining areas prior to being adopted.

The above costings are also representative of “best practice” for a long-term design life and more cost effective options may be adequate to protect assets in the short term.

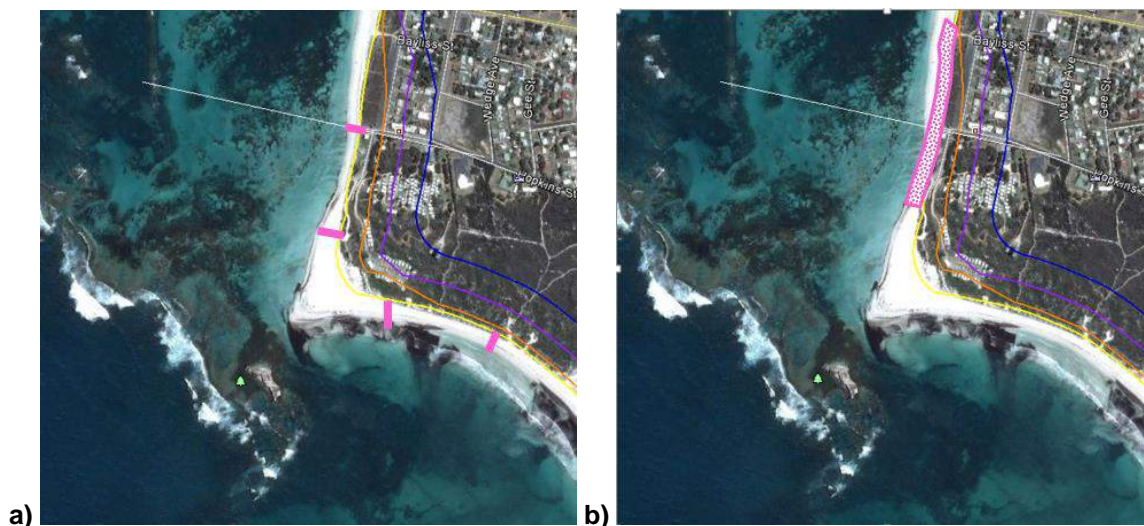


Figure 5-8 Indicative positions of a) new groynes and b) seawall options costed for LA1

Seashore Engineering (2015) carried out an assessment of three additional seawall options for the Grace Darling Park foreshore. These focused on the use of Geotextile Sand Container (GSC) revetments (**Figure 5-9**). Three options were examined which ranged in price from \$710,000 to \$920,000.

A GSC revetment is thought to provide advantages over a rock seawall (for example as constructed at Seabird) due to their lesser visual impact and greater retention of beach amenity however they are less durable and generally have a shorter design life. Seashore Engineering (2015) note that the nature of the GSC revetment is to provide a 'back stop' to acute erosion events, providing protection to existing infrastructure. However, performance of a revetment is likely to be compromised if the rate of progressive erosion observed since 2011 continues.



Figure 5-9 GSC revetment example and conceptual layout from Seashore Engineering (2015)

Regardless of the type, seawalls have the potential to result in negative impacts to surrounding areas, including scour in front of and increased erosion to either side of the structure. In addition, it may hinder beach access and diminish the current amenity of the area.

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. 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 of the likely adjustments over the next century, to 2110.

The CHRMAP process recognises the difficult decisions that will need to be made in the near future and the CHRMAP document is intended to be updated each 5 to 10 years or as new information becomes available that may significantly affect the extent of hazards, such as new state sea level rise benchmarks.

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 Seabird SE1

As introduced in **Section 2.2**, the presence of the limestone ridge should protect the majority of the township (excluding the Holiday Park) from coastal erosion for some decades. Along the southern beach the seawall was constructed as an interim measure in 2015/16 to protect the 16 houses deemed under immediate threat of coastal erosion during storm events. As a consequence, the original beach is no longer accessible during high water levels and moderate wave conditions and access to this area has effectively been restricted by the seawall. The beach to the north and south of the seawall remain accessible to the community, albeit with some added inconvenience. The key beneficiaries of the seawall are therefore the 16 property owners immediately behind the seawall. The present values of these ocean front properties (while remaining viable) are likely to be worth significantly more than Seabird properties with limited or no ocean views.

The cost of maintaining the seawall was estimated at \$24,000 p/a (**Section 5.4.5**). Applying the beneficiaries pay principle suggests an annual contribution from the 16 beneficiaries of around \$1,500 each may be sufficient to cover the cost of maintenance. This could be charged in the form of a specified area rate or levy.

The lifecycle of this temporary seawall is assumed to be around 20 years and the cost of building a new seawall is estimated to be around \$2.4 M (2015 \$). This equates to a capital expense of around \$150,000 per property owner when it falls due in about 2035. The State and Shire may consider contributing to this seawall beyond the recent capital outlay but this will need to be explored further. For the longer term, and given current day knowledge of coastal processes and protection measures, the implementation plan aims to exercise either the retreat or avoid option, pending the outcomes of an investigation into the implications of adopting the approach outlined in the draft Guidelines for Planned or Managed Retreat (DoPLH, 2017c).

The likely increase in erosion along SE2 should be monitored into the future and options considered now. While residents behind the seawall are beneficiaries of the structure, owners of property in the Holiday Park may be disadvantaged. An equitable mechanism for determining apportionment of costs to the beneficiaries of the seawall needs to be investigated should the managed retreat option be adopted. Landowners must note, however, that there is no obligation on government to compensate losses associated with shoreline erosion and if adopted, an Avoid or Do Nothing policy position would ultimately lead to abandonment of property.

6.1.2 Ledge Point

In contrast to Seabird, there is no known underlying rock present in the hazard zone at Ledge Point, and the hazard lines reflect the likely future erosion of the sandy coast. Two rows of housing and De Burgh St fall within the 2110 hazard line in LP2 and the southern section of LP3. Should a protect strategy be adopted then the capital cost of around \$2M for the seawall or groynes options 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 or do nothing strategy at the end of the design life of the seawall/groynes around 2070, by which point the removal/relocation of De Burgh St and utilities infrastructure would need to be considered.

The complex coastal processes around Ledge Point and its offshore reefs and the general south to north movement of sand between the sediment cells around Ledge Point will need to be monitored to inform the need for sand nourishment in future, within both LP2 and LP3. 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.

6.1.3 Lancelin

In the case of Grace Darling Park, the beneficiaries of any protection actions would primarily be the broader community. The protection measures may also have benefits for Cunliffe Street residents, however there may also be negative impacts if the presence of a seawall increases erosion. Ongoing provision of a grassed recreation area which has the same appeal as the existing grassed area (including sheltered shallow water and seafront position) is contingent upon land being available which is currently part of the caravan park lease area. The caravan park in turn is constrained from expanding due to the presence of a Threatened Ecological Community (TEC) to the south. Removal of dunes to create a grassed area to the north of the existing park is an option but is likely to be unacceptable due to damage this would cause to dunes that are currently protecting public and private assets. If the toilet facilities are removed from this location, then alternative facilities will need to be built in the vicinity to cater for visitors. These issues will need to be explored further to reach an optimal solution.

Maintaining the current features of the shoreline will require some form of coastal protection and renourishment in the short to medium term. Alternatively, retreating or relocating the assets to accommodate the rising sea level and ongoing erosion may better be implemented sooner, pending an acceptable outcome of investigations into the cost implications of the managed retreat strategy. The estimated costs for protecting the Park, maintaining beach amenity by constructing groynes and the initial sand nourishment is around \$12M, with ongoing costs of around \$50,000 per annum. This infrastructure would likely last for around 50 years before the retreat option would need to be implemented and decommissioning costs would need to be considered.

It would thus appear reasonable to apportion the costs for maintaining the Park across the local community and visitors to the Park, both of whom benefit, the latter group particularly during summer holidays and at wind and kite surfing events. Funding for such works may be sought from the State Government, or via a levy on the local rate payers and/or fees for non-local visitors to the park. As an example, if the 754 local ratepayers (**Table 5-6**) were to completely fund the capital cost (\$12M) over a 10 year period then a levy of approximately \$1,600 per annum per rate payer would be required.

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 of coastal hazards in the immediate to short term, 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 actions 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 or do nothing 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 close to the coast are now at risk. Asset owners need to appreciate past government decisions on property boundaries do not imply an obligation to maintain these areas and that ultimate abandonment of property and assets without any form of compensation is a strategy option that may be considered.

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 council rates or levies, etc.) to inform the future review of 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 SE1, SE2, LP2, LP3, LA2 and LA4 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

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 Seabird

6.4.1 Long Term Pathway

The long term pathway for the Seabird 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 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 Seabird (SE1 and SE2) 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**. There is currently an interim protection mechanism (seawall) in place for a large portion of Seabird's coastline. The transition from this protection approach to one of managed retreat or do nothing will need to be carefully considered in line with the draft Guidelines for Planned or Managed Retreat (DoPHL, 2017c) and guided by appropriate triggers for the transition.

6.4.2 Short Term Implementation – Seabird Township South (SE1)

The following adaptation pathway is proposed:

Short to Medium term: Protect for life cycle of the current seawall; investigate the land tenure and future management arrangements for the seawall; investigate the mechanism for planned retreat of the affected properties; and Implement Planning changes to avoid future development in currently undeveloped areas.

Recommendations arising from the above assessment for SE1 are provided in **Table 6-1**.

Table 6-1 Recommendations and adaptation planning recommendations for SE1

ID	Recommendation
R_SE1.1	The Shire and State to undertake comprehensive study, including detailed economic analysis and proposed costs apportionment to identified beneficiaries, to guide eventual retreat from or abandonment of assets in hazardous areas. This needs to assess managed retreat versus a do nothing and ultimate abandonment strategy.
R_SE1.2	The feasibility and suitability of groynes be assessed in detail, prior to the end of the seawall's lifecycle (presently estimated to be 2035). It is not recommended that groynes be considered for implementation as a management strategy in the immediate term.
R_SE1.3	<p>The seawall be monitored and maintained for the duration of its (estimated) 20 year design life, provided the consequences of its presence are acceptable to the overall community throughout this period. An assessment should be made prior to (approximately) 2035 to decide how this area should be managed beyond this timeframe. Options may include:</p> <ul style="list-style-type: none"> > Continue monitoring, maintaining and retrofit (if required) the seawall to extend its useful life; > Completely remove the seawall; > Remove the seawall and use material (if appropriate) to implement groynes as a protection measure; and > Leave the seawall in place but discontinue monitoring and maintenance. <p>It must be noted that the last three options are may to trigger managed retreat of some assets that are presently behind the seawall. The implications of triggering managed retreat should be assessed in detail to understand the implications of selecting one of these management options. The associated costs of maintaining the wall and equitable apportionment of these costs to the beneficiaries creates a difficult issue for the Shire and the community that also requires further investigation.</p>

R_SE1.4	Long term tenure arrangements and management responsibility for the seawall should be established through negotiated agreement between the State and the Shire.
R_SE1.5	Options for increasing equitable enjoyment of the ocean frontage aspect enjoyed by properties positioned above the seawall, for example rezoning of some areas to allow for commercial use, should be investigated.
R_SE1.6	Undertake annual beach surveys to monitor the change in beach profile
R_SE1.7	Investigate current and future sediment budget in the Secondary Cells to inform likely future nourishment and protection options assessment

6.5 Ledge Point

6.5.1 Long Term Pathway

The long term pathway for the Ledge Point Township should aim for the eventual 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 property, 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. The long term pathway for undeveloped areas, particularly LP1 and LP4, should focus on rezoning land to avoid inappropriate development to limit potential future liability for the Shire.

Proposed long term pathways for the individual Management Units within Ledge Point (LP1, LP2, LP3 and LP4) 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 criteria to determine their suitability for implementation. Note the implementation of retreat through a managed retreat process or the do nothing and eventual abandonment needs to be carefully considered and implications for the Shire and private property owners addressed.

6.5.2 Short Term Implementation – Ledge Point Township South (LP2)

The following adaptation pathway is proposed:

Short to Medium term: Protect within budget constraints, but with erosion triggers for retreat in place

Recommendations arising from the above assessment are provided in **Table 6-2**.

Table 6-2 Recommendations and adaptation planning recommendations for LP2

ID	Recommendation
R_LP2.1	Planning for the proposed boat ramp/marina needs to consider the short term implementation plan and long term management pathways for Ledge Point articulated in this CHRMAP. Similarly, the Shire should carefully review any plans for such a development to ensure the proposal's long term impacts on adjacent coastline are adequately assessed and are consistent with the CHRMAP pathways.
R_LP2.2	Should the Shire wish to pursue the beach nourishment option, it is recommended that a suitable sediment source be identified and nourishment costs to extract, transport and place material from this source be refined. An affordable volume of nourishment can then be assessed and an appropriate beach profile designed to guide sand placement.
R_LP2.3	Investigate potential efficacy and cost of extending the existing southern groyne to increase salient stability and promote accretion to the south.
R_LP2.4	Commission a high level investigation of cost of an offshore breakwater based on existing natural reef offshore from southern groyne.

R_LP2.5	Evaluate aeolian transport rates and consider use of wind fences and limiting vehicle access at the base of the scarp to promote dune growth followed by dune stabilisation and planting.
R_LP2.6	Manage vehicle use to ensure that vehicles do not exacerbate erosion of existing beach and dune
R_LP2.7	Consider geotechnical investigations to identify if any subsurface rock exists within the 100-year hazard zone. This would increase the accuracy of the hazard assessment, and better inform the broader CHRMAP process.

6.6 Lancelin

6.6.1 Long Term Pathway

The long term pathway for the Lancelin 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 commercial and residential property, managed retreat should occur when it is no longer viable to repair damaged property, such as Grace Darling Park, and risk to infrastructure becomes intolerable. For undeveloped areas, the long term pathway should focus on rezoning to avoid inappropriate development in future.

Proposed long term pathways for the individual Management Units within Lancelin (LA1, LA2, LA3 and LA4) are provided in **Appendix I**. The key tools underpinning the achievement of long term pathways are planning controls, which were discussed in **Section 4**. Prior to the adoption of any of the protection options it is recommended that these be investigated in detail and guided by appropriate trigger projections to determine their suitability for implementation.

6.6.2 Short Term Implementation – Lancelin South of Township (LA1)

Short to Medium term: Protect in a manner that maintains existing social values within budgetary constraints until such time as triggers for retreat are exceeded. Develop the planned retreat strategy to be implemented during the next stage of the CHRMAP (5 to 10 years).

Recommendations arising from the above assessment are provided in **Table 6-3**.

Table 6-3 Recommendations and adaptation planning recommendations for LA1

ID	Recommendation
R_LA1.1	Major investment decisions with regards to coastal infrastructure are reserved until after the coastal inundation impact assessment has been completed.
R_LA1.2	Sea rescue building be removed, however the ablution block and shade structures should remain until unserviceable.
R_LA1.3	Investigate renourishment using sand sourced from the salient.
R_LA1.4	Manage vehicle use in the area to ensure that vehicles do not exacerbate erosion.
R_LA1.5	Continue to involve Caravan Park lessors and local community in decisions regarding coastal management in this area to preserve coastal values and uses.

6.7 Shire of Gingin 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. Assessment and interpretation of monitoring observations will also inform future revisions of hazard lines and the CHRMAP reviews. The *Seabrid, Ledge Point, Lancelin – Coastal Monitoring Action Plan* (Seashore Engineering, 2017) provides a high level of detail on coastal monitoring for the townsites. Consistent with their recommendations the general monitoring, data collation and analysis is to include:

- > Annual Beach Profile Surveys;
- > Horizontal Shoreline Datum determination from aerial photos;
- > Post wave erosion event (>2 yr ARI wave) beach profile surveys;
- > Cyclone storm surge post-flood event inundation level surveys; and
- > Seawall, groyne and shoreline protection infrastructure condition monitoring after significant events.

The Shire will also require data from updates to the State and Federal programs providing offshore wave data, winds and rainfall, ecological community information, threatened species registers, aerial image updates general statistics on population census, social and financial conditions provided through Australian Bureau of statistics and local land price trends available from Real Estate websites. This information needs to be collated and assessed to inform updates to hazard line projections and revise CHRMAP adaptation strategies as required during the CHRMAP review each 5 to 10 years.

6.8 Shire of Gingin 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 6-4**. Implementation of the plan is obviously subject to budget considerations and available funding.

Table 6-4 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
Gingin LPS 9 Update and Endorsement by WAPC	17 Jan '20	30 Jun '20	\$40
Monitoring	1 May '18	14 May '29	\$410
Annual Beach Profile Surveys	4 May '18	14 May '29	\$300
Horizontal Shoreline Datum (Aerial Photo Analysis)	1 May '18	2 May '22	\$70
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	26 Feb '18	28 Jul '25	\$415
Comprehensive investigation of each community and visitors be undertaken to identify beneficiaries of proposed protection areas	26 Feb '18	30 Nov '18	\$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 '18	30 Jun '18	\$15
Assess Current and Future Sediment Budget in the Secondary Cell	1 Jul '18	30 Jun '21	\$80
Analysis of Flood, Storm Surge and Erosion event monitoring	14 May '20	5 Aug '20	\$40
Investigate Storm Surge and Coastal Processes Interactions to define triggers, set FFL, CHRMAP, Water Management Plans and Emergency Management Plan overlaps	25 Mar '25	28 Jul '25	\$50
Undertake economic analysis of options. Recommendations:	17 May '18	19 Sep '18	\$80
Operational	1 Feb '18	30 Nov '22	\$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 '18	26 Mar '19	\$20

Notifications - Potentially affected land owners by direct contact and property titles	1 Feb '18	30 Nov '22	\$10
CHRMAP Review and Update (2022)	1 Jan '19	30 Nov '22	\$210
Review Hazard line estimates (S1, S2, S3 and S4)	18 Feb '21	21 Apr '21	\$25
Review Risk Assessment and Future Pathway Options	29 Apr '21	30 Jun '21	\$40
Community and Stakeholder Consultation	1 May '21	31 Jan '22	\$50
Update CHRMAP	24 Jun '21	2 Mar '22	\$80
CHRMAP 2022 Endorsement by WAPC	7 Jul '22	30 Nov '22	\$15
CHRMAP Review and Update (2027)	8 Oct '26	8 Nov '28	\$210
Review Hazard line estimates (S1, S2, S3 and S4)	8 Oct '26	6 Jan '27	\$25
Review Risk Assessment and Future Pathway Options	1 Jun '27	2 Aug '27	\$40
Community and Stakeholder Consultation	1 Nov '26	31 Aug '27	\$50
Update CHRMAP	24 Jun '27	1 Mar '28	\$80
CHRMAP 2027 Endorsement by WAPC	6 Jul '28	8 Nov '28	\$15

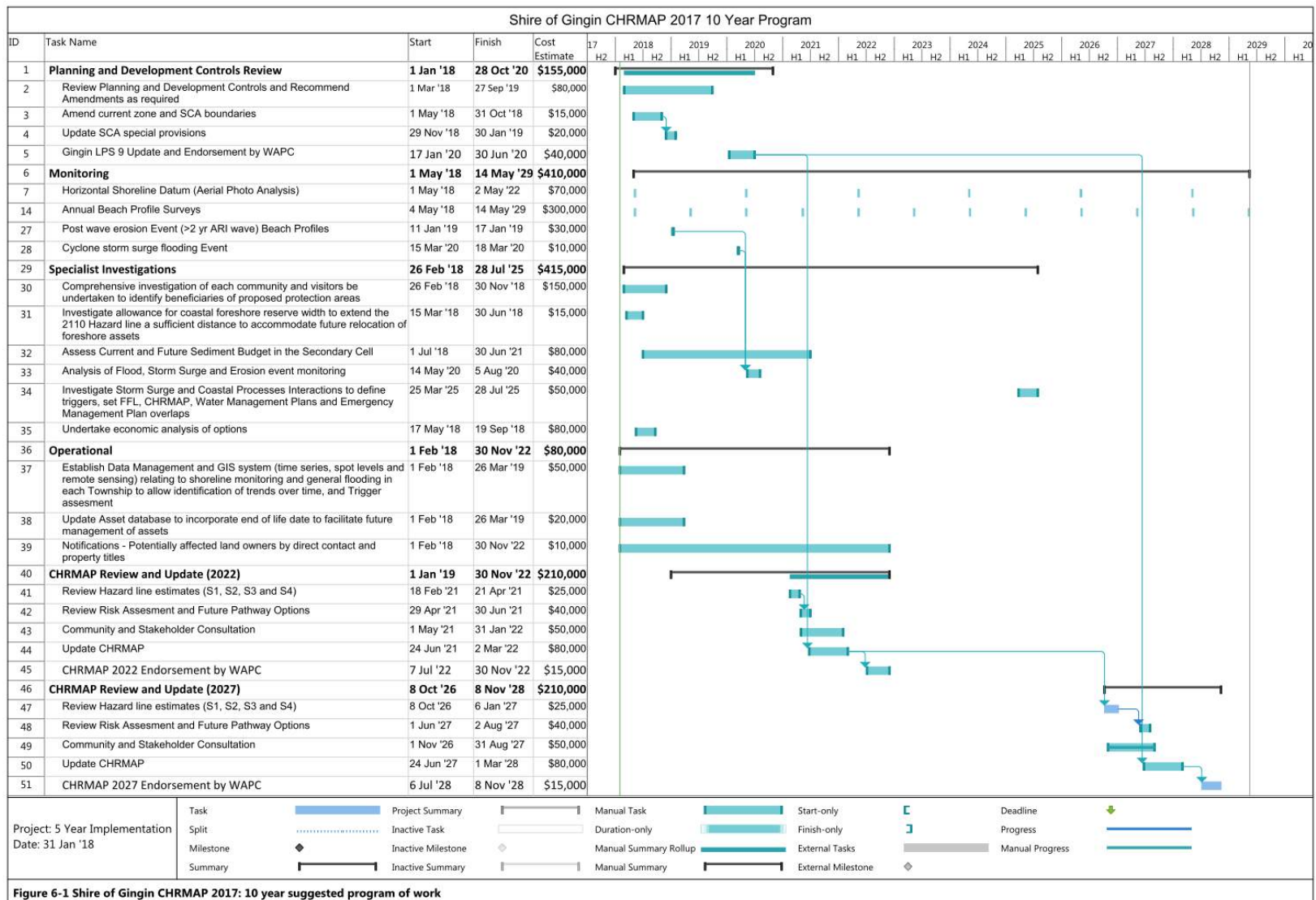


Figure 6-1 Shire of Gingin CHRMAP 2017: 10 year suggested program of work

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Shire of Gingin
Coastal Hazard Risk Management
and Adaptation Plan

APPENDIX

A

HAZARD MAPS BY
MANAGEMENT UNITS



SE1

Legend

Hazard Lines

- 2016
- 2020
- 2030
- 2050
- 2070
- 2110

Public Infrastructure

- Private Properties
- Commercial



SE2

Legend

Hazard Lines

- 2016
- 2020
- 2030
- 2050
- 2070
- 2110

Public Infrastructure

- Private Properties
- Commercial



0 0.1
kilometers

LP1

Legend

Hazard Lines

- 2016
- 2030
- 2070
- 2110

Public Infrastructure

- Private Properties
- Commercial



LP2

Legend

Hazard Lines

- 2016
- 2030
- 2070
- 2110

Public Infrastructure

- Private Properties
- Commercial



0 0.1
kilometers

LP3

Legend

Hazard Lines

- 2016
- 2030
- 2070
- 2110

Public Infrastructure

- Private Properties
- Commercial



0 0.1
kilometers

LP4

Legend

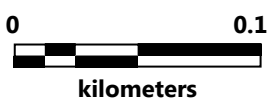
Hazard Lines

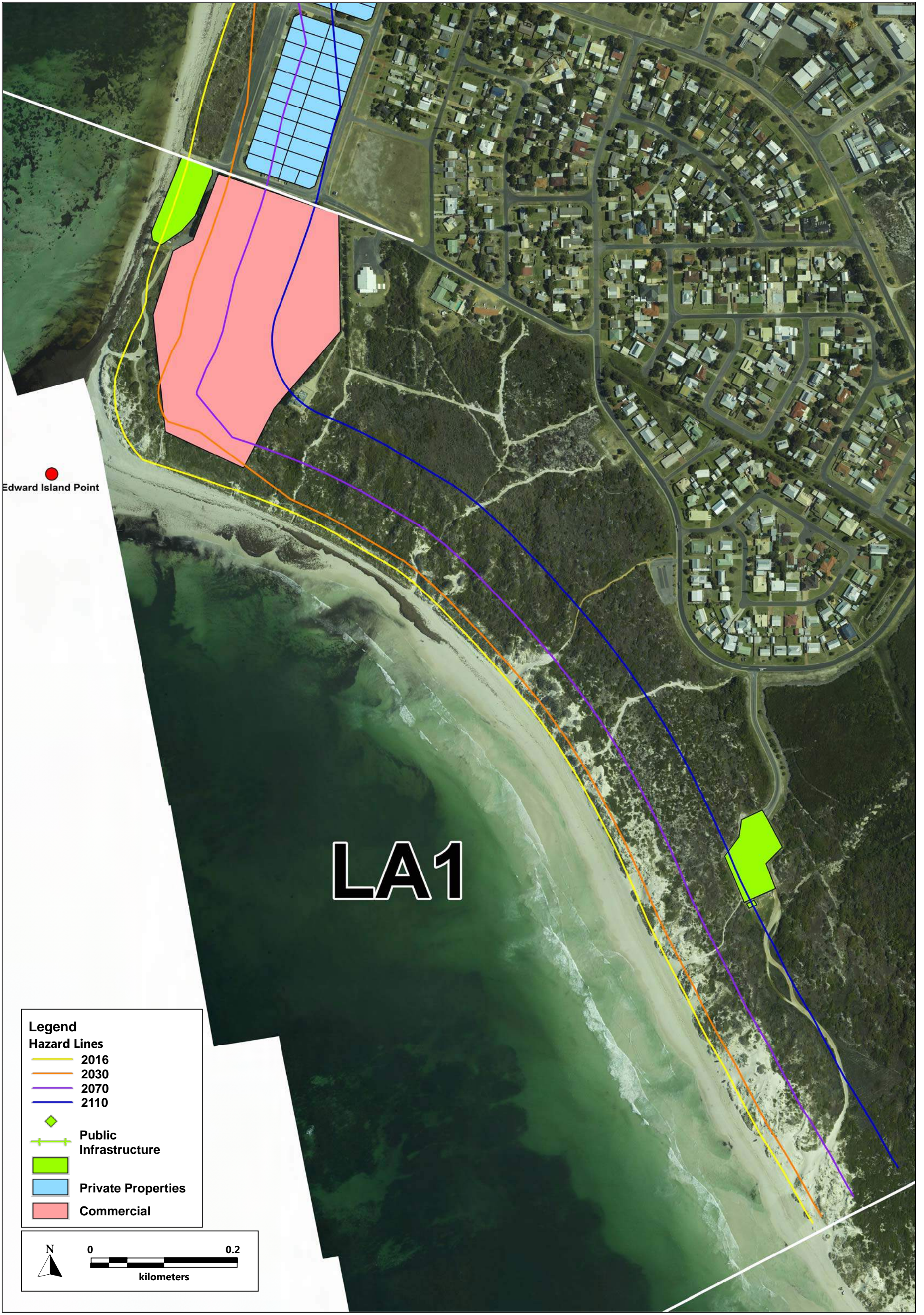
- 2016
- 2030
- 2070
- 2110

Public Infrastructure

Private Properties

Commercial





Edward Island Point

LA1

- Legend**
- Hazard Lines**
- 2016
 - 2030
 - 2070
 - 2110
- Public Infrastructure**
- Private Properties**
- Commercial**



0 0.2
kilometers

LA2

Legend

Hazard Lines

- 2016
- 2030
- 2070
- 2110

Public Infrastructure

- Private Properties
- Commercial



0 0.2
kilometers

ancelin Island Point

LA3

Legend

Hazard Lines

- 2016
- 2030
- 2070
- 2110

Public Infrastructure

Private Properties

Commercial

N

0 0.2

kilometers

LA4

Lancelin Island Point

Legend

Hazard Lines

- 2016
- 2030
- 2070
- 2110

Public Infrastructure

- Private Properties
- Commercial



0 0.2
kilometers

Shire of Gingin
Coastal Hazard Risk Management
and Adaptation Plan

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?

Legend

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

- Threatened Flora, Fauna;
Ecological Communities

Our Coastal Values

Cervantes





11 Harvest Terrace, West Perth,
WA, 6005, Australia
Phone: +61 8 9273 3888 Web: www.cardno.com

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 Jurien Bay 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

Jurien Bay



DATE
25/05/17

DRAWING NO
LA-002

ISSUE
DRAFT

SHIRE OF DANDARAGAN



Legend

- Recreational
- Enviromental
- Commercial

- Infrastructure
- Civic
- Heritage

- Threatened Flora, Fauna;
Ecological Communities





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

Ledge Point

11 Harvest Terrace, West Perth,
WA, 6005, Australia
Phone: +61 8 9273 3888 Web: www.cardno.com

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



DATE
25/05/17

DRAWING NO
LA-004

ISSUE
DRAFT

SHIRE OF GINGIN



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WA, 6005, Australia
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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 Seabird accessed on 8 May 2017. Prepared by the Species and Communities Branch for Cardno for the
Shire of Gingin CHRMAPS.

Legend

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

- Threatened Flora, Fauna;
Ecological Communities

Our Coastal Values

Seabird



DATE
25/05/17

DRAWING NO
LA-005

ISSUE
DRAFT

SHIRE OF GINGIN

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: ▪ Seabird Progress Association ▪ Ledge Point Community Association ▪ Ledge Point Coastcare Group ▪ Friends of Lancelin Coast ▪ Lancelin Ratepayers Association ▪ Kwelena Mambakort Aboriginal Corporation (Yued) ▪ 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

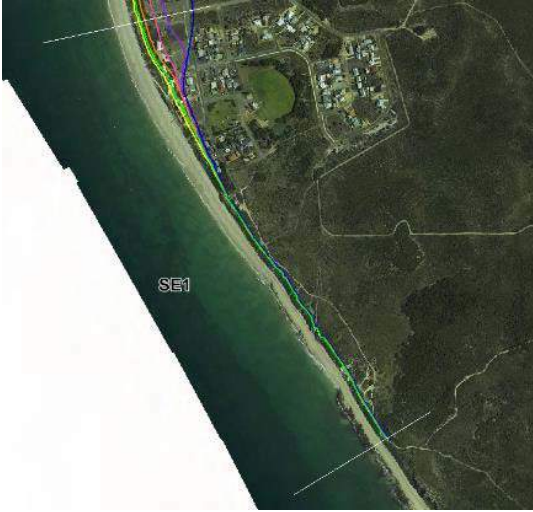






Shire of Gingin
Coastal Hazard Risk Management
and Adaptation Plan

APPENDIX





C

ASSET INFORMATION FOR EACH OF
THE MANAGEMENT UNITS

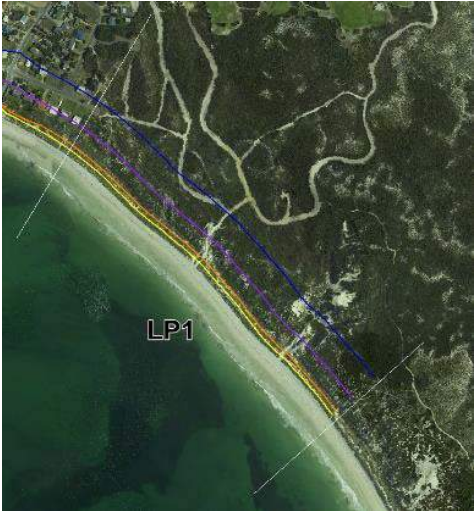



SE1: Seabird Township South

		Values	Assets at Risk
 	 	Environmental Beach Coastal/dune vegetation	Assets at Risk Beach Coastal/dune vegetation
		Social Beach access Carpark Lookout, toilets and picnic area	Beach access Carpark Lookout, toilets and picnic area
		Economic - Private Residential - 22 properties	Residential - 22 properties
		Economic - Public Beach Carpark (Edward St) Stairs (decommissioned) Roads Services in road reserve	Beach Carpark (Edward St) Stairs (decommissioned) Roads Services in road reserve
		Existing Coastal Controls	
		Small offshore reefs Seawall - sitting on rock platform, with matting placed over the top. Beach along seawall has eroded completely since Dec. 2016.	
		Existing Planning Controls	
		Local Planning Scheme No.9 (LPS9) Reserves and Zoning Parks and Recreation Reserve Some low-density residential Unallocated crown land Seabird Township Strategic Map	



SE2: Seabird Township North

		Values	Assets at Risk
   		Environmental	Beach Foreshore Reserve
		Social	Beach Caravan Park (Seabird Private) Tavern
		Economic - Private	Caravan Park - strata title lots Seabird Tavern
		Economic - Public	Beach
		Existing Coastal Controls	
		<p>Small offshore reefs</p> <p>Seawall - sitting on rock platform, with matting placed over the top. Beach along seawall has eroded completely since Dec. 2016.</p>	
		Existing Planning Controls	
		<p>Local Planning Scheme No.9 (LPS9)</p> <p>Reserves and Zoning</p> <ul style="list-style-type: none"> Parks and Recreation Reserve Some low-density residential Tourism zone <p>Seabird Township Strategic Map</p>	






LP1: Ledge Point South of Township

		Values	Assets at Risk
 		Environmental	Beach Coastal/dune vegetation
		Social	Beach Beach carpark (unsealed) Road (Unsealed)
		Economic - Private	
		Economic - Public	Beach
		Existing Coastal Controls	
		Offshore reefs to north	
		Existing Planning Controls	
		Local Planning Scheme No.9 (LPS9) Reserves and Zoning Parks and Recreation Reserve Ledge Point Township Strategic Map Proposed future urban development	



LP2: Ledge Point Township South

		Values	Assets at Risk
		Environmental	Beach
		Social	Beach - popular boat launching and offshore mooring spot Beach access (Jones St)
		Economic - Private	Residential - 39 properties
		Economic - Public	Beach Roads (De Burgh St, Jones St, Roe St) Services in road reserve
		Existing Coastal Controls	
		Offshore reefs to north	
		Existing Planning Controls	
		Local Planning Scheme No.9 (LPS9) Reserves and Zoning Parks and Recreation Reserve Ledge Point Township Strategic Map Proposed future urban development	







LP3: Ledge Point Township North

		Values	Assets at Risk
    		Environmental	Beach Coastal/dune vegetation
		Social	Beach - Lancelin Ocean Classic starting point Main swimming beach Beach access (Jones St) Coastal/dune vegetation Road (De Burgh St) Key Biscoyne Park
		Economic - Private	Caravan Park (Holiday Village) - old caravan park, now town houses Residential -13 properties
		Economic - Public	Beach Carparks (De Burgh St) BBQ and shelters Road (De Burgh St) Key Biscoyne Park Playground toilets and BBQs
		Existing Coastal Controls	
		Offshore reefs 2 Groynes	
		Existing Planning Controls	
		Local Planning Scheme No.9 (LPS9) Reserves and Zoning Parks and Recreation Reserve Low-density residential Road reserve Tourism zone Ledge Point Township Strategic Map	






LP4: Ledge Point North of Township

	<u>Values</u>	<u>Assets at Risk</u>
 	Environmental	Beach Coastal/dune vegetation
	Social	Beach Beach carpark (unsealed) Road (Unsealed)
	Economic - Private	
	Economic - Public	Beach
<u>Existing Coastal Controls</u>		
Offshore reefs		
<u>Existing Planning Controls</u>		
Local Planning Scheme No.9 (LPS9) Reserves and Zoning Parks and Recreation Reserve General rural zone (?) Ledge Point Township Strategic Map Proposed future urban development		







LA1: Lancelin South of Township

		Values	Assets at Risk
      		Environmental	Beach Coastal/dune vegetation
		Social	Beach Carpark (Back Beach) Grace Darling Park
		Economic - Private	Sea Rescue Building
		Economic - Public	Beach Carpark (Back Beach) Caravan Park (Lancelin South End) Grace Darling Park Cap park Toilet block
		Existing Coastal Controls	
		Edward Island and surrounding reefs Opportunistic beach renourishment during dredging	
		Existing Planning Controls	
		Local Planning Scheme No.9 (LPS9) Reserves and Zoning Parks and Recreation Reserve Low-density residential Tourism Lancelin Township Strategic Map Possible tourist zone expansion Linkage area to Lancelin South Development Identified as "sporting and recreation"	






LA2: Lancelin Township South of Jetty

		Values	Assets at Risk
 	  	Environmental	Beach
		Social	Beach Jetty Café (Kerfuffle By The Jetty)
		Economic - Private	Residential - 66 properties Light Industrial Area Café (Kerfuffle By The Jetty)
		Economic - Public	Beach Road (Cuncliffe St) Jetty
Existing Coastal Controls			
Edward Island and surrounding reefs to the south Lancelin Island to the north Offshore reef			
Existing Planning Controls			
Local Planning Scheme No.9 (LPS9) Reserves and Zoning Parks and Recreation Reserve Low-density residential Tourism zone Lancelin Township Strategic Map			

LA3: Lancelin Township Jetty to Lancelin Point

		<u>Values</u>	<u>Assets at Risk</u>
 	   	Environmental Beach Coastal/dune vegetation Beach Lookout	Assets at Risk Beach Coastal/dune vegetation Beach Lookout
		Social	Beach Park (Gingin Road) Primary School Tavern (Endeavour)
		Economic - Private	Beach Hotel & Dune Restaurant Tavern (Endeavour) Residential - 45 properties
		Economic - Public	Beach Fuel storage (DoT?) Road (Gingin Rd) Caravan Park (Lancelin North End) Park (Gingin Road) Primary School Beach Lookout
		<u>Existing Coastal Controls</u>	
		Lancelin Island and surrounding reefs	
		<u>Existing Planning Controls</u>	
		Local Planning Scheme No.9 (LPS9) Reserves and Zoning Parks and Recreation Reserve Low-density residential Tourism zone Lancelin Township Strategic Map	

LA4: Lancelin Township North of Lancelin Point

		Values	Assets at Risk	
 	  	Environmental	Beach Coastal/dune vegetation	
		Social	Beach Beach carpark Beach Access (Lancelin Island Point)	
		Economic - Private	Residential - 41 properties	
		Economic - Public	Beach	
		Existing Coastal Controls		
		Lancelin Island and surrounding reefs		
		Existing Planning Controls		
		Local Planning Scheme No.9 (LPS9) Reserves and Zoning Parks and Recreation Reserve Road reserve Low density residential Tourism zone Lancelin Township Strategic Map Development to the north not possible due to sand blowout States: " Coastal setbacks required in accordance with State Planning Policy"		

Shire of Gingin
Coastal Hazard Risk Management
and Adaptation Plan

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.

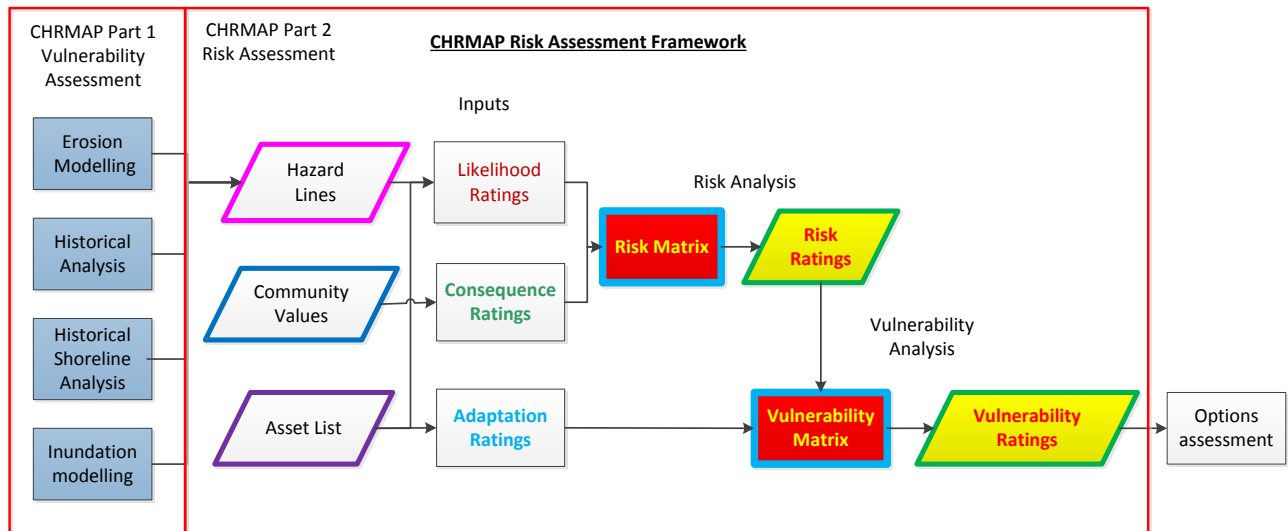


Figure 1-1 Schematic representation of the risk assessment process

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.

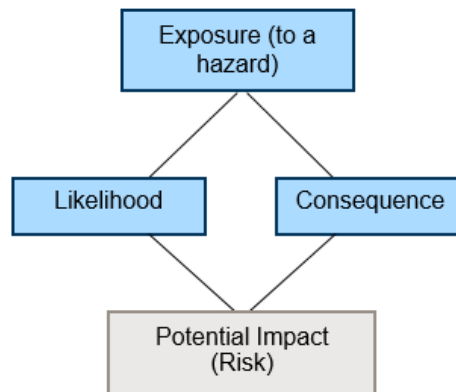


Figure 1-2 Risk analysis structure

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.

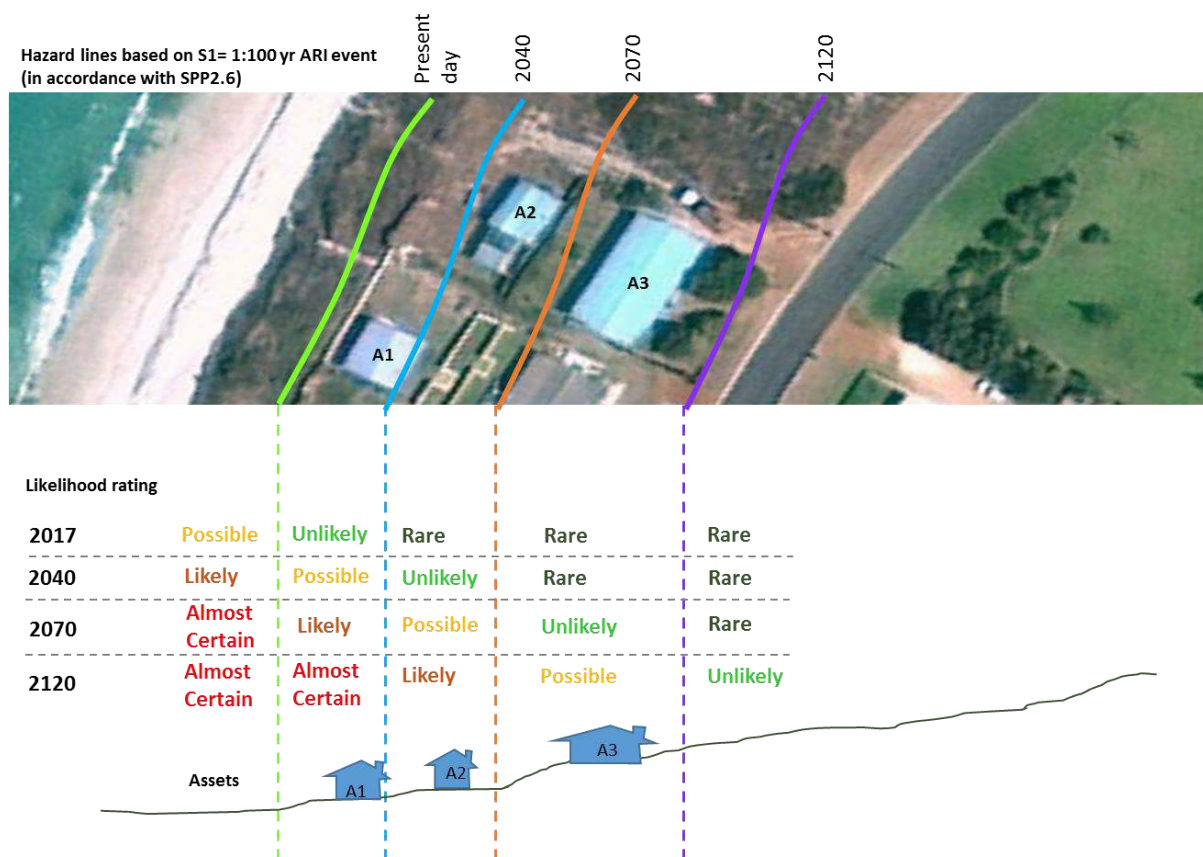


Figure 1-3 Representation of method used to assign likelihood ratings to individual assets for each planning timeframe

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

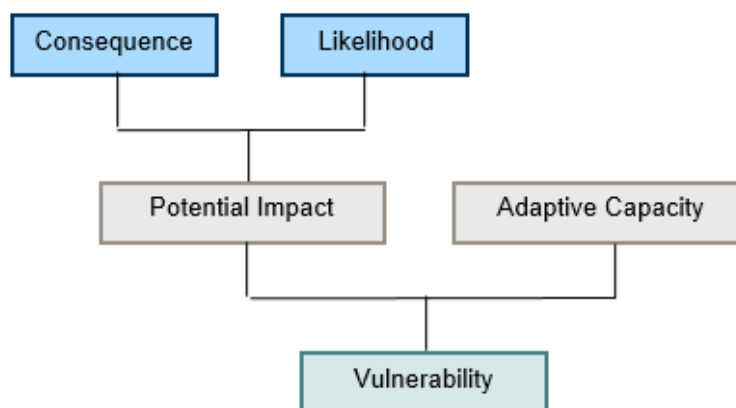


Figure 1-4 Vulnerability assessment structure

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

Shire of Gingin
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APPENDIX

E

RISK ASSESSMENT RATINGS
AND RESULTS

SE1: Seabird Township South

	Assessment Inputs					
	2016	2020	2030	2050	2070	2110
<u>Asset</u>	<u>Likelihood</u>					
Beach	Possible	Likely	Almost Certain	Almost Certain	Almost Certain	Almost Certain
Coastal/dune vegetation	Possible	Likely	Almost Certain	Almost Certain	Almost Certain	Almost Certain
Residential (houses and land)	Possible	Likely	Almost Certain	Almost Certain	Almost Certain	Almost Certain
Carparks and roads	Possible	Likely	Almost Certain	Almost Certain	Almost Certain	Almost Certain

<u>Asset</u>	<u>Consequence of Erosion</u>					
Impact on beach amenity	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Impact on ecological buffer	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Impact on residential lots	Major	Major	Major	Major	Catastrophic	Catastrophic
Impact on beach carpark and roads	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

<u>Asset</u>	<u>Adaptive capacity</u>					
Beach	High	Moderate	Moderate	Low	Low	Low
Coastal/dune vegetation	Moderate	Moderate	Moderate	Low	Low	Low
Residential (houses and land)	Low	Low	Low	Low	Low	Low
Carparks and roads	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

	Risk Assessment					
	2016	2020	2030	2050	2070	2110
	<u>Risk</u>					
Beach	Medium	Medium	High	High	High	High
Coastal/dune vegetation	Medium	Medium	High	High	High	High
Residential (houses and land)	High	High	Extreme	Extreme	Extreme	Extreme
Carparks and roads	Medium	Medium	High	High	High	High

	<u>Vulnerability</u>					
Beach	Medium	Medium	High	Very High	Very High	Very High
Coastal/dune vegetation	Medium	Medium	High	Very High	Very High	Very High
Residential (houses and land)	Very High	Very High	Very High	Very High	Very High	Very High
Carparks and roads	Medium	Medium	High	High	High	High

SE2: Seabird Township North

	Assessment Inputs					
	2016	2020	2030	2050	2070	2110
<u>Asset</u>	<u>Likelihood</u>					
Beach	Possible	Likely	Almost Certain	Almost Certain	Almost Certain	Almost Certain
Coastal/dune vegetation	Possible	Likely	Almost Certain	Almost Certain	Almost Certain	Almost Certain
Caravan Park (Seabird Private)	Rare	Unlikely	Possible	Likely	Almost Certain	Almost Certain
Tavern	Rare	Rare	Unlikely	Possible	Likely	Almost Certain

<u>Asset</u>	<u>Consequence of Erosion</u>					
Impact on beach amenity	Minor	Minor	Moderate	Moderate	Moderate	Moderate
Impact on ecological buffer	Minor	Minor	Minor	Moderate	Moderate	Moderate
Impact on Caravan Park (Seabird Private)	Minor	Minor	Moderate	Major	Major	Major
Impact on Tavern	Minor	Minor	Moderate	Moderate	Moderate	Moderate

<u>Asset</u>	<u>Adaptive capacity</u>					
Beach	Very High	Very High	High	Moderate	Moderate	Moderate
Coastal/dune vegetation	High	High	Moderate	Moderate	Moderate	Low
Caravan Park (Seabird Private)	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Tavern	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

	Risk Assessment					
	2016	2020	2030	2050	2070	2110
	<u>Risk</u>					
Beach	Low	Medium	High	High	High	High
Coastal/dune vegetation	Low	Medium	Medium	High	High	High
Caravan Park (Seabird Private)	Low	Low	Medium	High	Extreme	Extreme
Tavern	Low	Low	Medium	Medium	Medium	High

	<u>Vulnerability</u>					
Beach	Low	Medium	High	High	High	High
Coastal/dune vegetation	Low	Medium	Medium	High	High	Very High
Caravan Park (Seabird Private)	Low	Low	Medium	High	Very High	Very High
Tavern	Low	Low	Medium	Medium	Medium	High

LP1: Ledge Point South of Township

	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
Beach Carpark (unsealed)	rare	Unlikely	Possible	Likely
Road (unsealed)	Rare	Rare	Unlikely	Possible

<u>Asset</u>	<u>Consequence of Erosion</u>			
Impact on beach amenity	Insignificant	Insignificant	Insignificant	Insignificant
Impact on ecological buffer	Minor	Minor	Minor	Moderate
Impact on carpark	Minor	Minor	Minor	Minor
Impact on 4WD track	Insignificant	Insignificant	Insignificant	Insignificant

<u>Asset</u>	<u>Adaptive capacity</u>			
Beach	Very High	Very High	Very High	Very High
Coastal/dune vegetation	High	High	Moderate	Moderate
Beach Carpark (unsealed)	High	High	High	High
Road (unsealed)	High	High	High	High

	Risk Assessment			
	2016	2030	2070	2110
	<u>Risk</u>			
Beach	Low	Low	Low	Low
Coastal/dune vegetation	Low	Medium	Medium	High
Beach Carpark (unsealed)	Low	Low	Low	Medium
Road (unsealed)	Low	Low	Low	Low

	<u>Vulnerability</u>			
Beach	Low	Low	Low	Low
Coastal/dune vegetation	Low	Medium	Medium	High
Beach Carpark (unsealed)	Low	Low	Low	Medium
Road (unsealed)	Low	Low	Low	Low

LP2: Ledge Point Township South

Assessment Inputs				
	2016	2030	2070	2110
<u>Asset</u>	<u>Likelihood</u>			
Beach	Possible	Likely	Almost Certain	Almost Certain
Foreshore recreation area	rare	unlikely	Possible	likely
Residential	Possible	Likely	Almost Certain	Almost Certain
Roads	Unlikely	Possible	Almost Certain	Almost Certain

<u>Asset</u>	<u>Consequence of Erosion</u>			
Impact on beach amenity	Moderate	Moderate	Moderate	Moderate
Impact on recreation area	Minor	Minor	Moderate	Major
Impact on residential lots	Moderate	Major	Major	Catastrophic
Impact on roads	Minor	Minor	Moderate	Major

<u>Asset</u>	<u>Adaptive capacity</u>			
Beach	Very High	Very High	High	Moderate
Foreshore recreation area	High	High	Moderate	Moderate
Residential	Low	Low	Low	Low
Roads	Moderate	Moderate	Moderate	Moderate

Risk Assessment				
	2015	2030	2070	2110
	<u>Risk</u>			
Beach	Medium	Medium	High	High
Foreshore recreation area	Low	Low	Medium	High
Residential	Medium	High	Extreme	Extreme
Roads	Low	Low	High	Extreme

	<u>Vulnerability</u>			
Beach	Medium	Medium	High	High
Foreshore recreation area	Low	Low	Medium	High
Residential	High	Very High	Very High	Very High
Roads	Low	Low	High	Very High

LP3: Ledge Point Township North

Assessment Inputs				
	2016	2030	2070	2110
Asset	Likelihood			
Beach	Possible	Likely	Almost Certain	Almost Certain
Coastal/dune vegetation	Possible	Likely	Almost Certain	Almost Certain
Carpark (De Burgh St)	Unlikely	Unlikely	Possible	Almost Certain
Road (De Burgh St)	Unlikely	Unlikely	Possible	Almost Certain
Holiday Village	Rare	Rare	Unlikely	Possible
Residential	Possible	Likely	Almost Certain	Almost Certain
Key Biscoyne Park	Unlikely	Possible	Likely	Almost Certain

Asset	Consequence of Erosion			
Impact on beach amenity	Insignificant	Insignificant	Minor	Moderate
Impact on ecological buffer	Minor	Minor	Minor	Major
Impact on carpark a	Insignificant	Minor	Moderate	Moderate
Impact on De Burg St	Insignificant	Minor	Moderate	Moderate
Impact on Holiday Village	Insignificant	Insignificant	Moderate	Catastrophic
Impact on residential lots	Insignificant	Insignificant	Moderate	Major
Impact on Key Biscoyne Park	Minor	Minor	Moderate	Major

Asset	Adaptive capacity			
Beach	Very High	High	High	Moderate
Coastal/dune vegetation	High	High	Moderate	Low
Carpark (De Burgh St)	Moderate	Moderate	Moderate	Moderate
Road (De Burgh St)	Moderate	Moderate	Moderate	Moderate
Holiday Village	Low	Low	Low	Low
Residential	Low	Low	Low	Low
Key Biscoyne Park	High	High	Moderate	Moderate

Risk Assessment				
	2016	2030	2070	2110
	Risk			
Beach	Low	Low	Medium	High
Coastal/dune vegetation	Low	Medium	Medium	Extreme
Carpark (De Burgh St)	Low	Low	Medium	High
Road (De Burgh St)	Low	Low	Medium	High
Holiday Village	Low	Low	Medium	Extreme
Residential	Low	Low	High	Extreme
Key Biscoyne Park	Low	Low	Medium	Extreme

	Vulnerability			
Beach	Low	Low	Medium	High
Coastal/dune vegetation	Low	Medium	Medium	Very High
Carpark (De Burgh St)	Low	Low	Medium	High
Road (De Burgh St)	Low	Low	Medium	High
Holiday Village	Low	Low	High	Very High
Residential	Low	Low	Very High	Very High
Key Biscoyne Park	Low	Low	Medium	Very High

LP4: Ledge Point North of Township

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
Carpark (unsealed)	Rare	Rare	Possible	Almost Certain
Road (unsealed)	Rare	Rare	Unlikely	Possible

<u>Asset</u>	<u>Consequence of Erosion</u>			
Impact on beach amenity	Insignificant	Insignificant	Insignificant	Insignificant
Impact on ecological buffer	Insignificant	minor	minor	minor
Impact on carpark	Insignificant	Insignificant	Insignificant	Insignificant
Impact on 4WD track	Insignificant	Insignificant	Insignificant	Insignificant

<u>Asset</u>	<u>Adaptive capacity</u>			
Beach	Very High	Very High	Very High	Very High
Coastal/dune vegetation	High	High	High	High
Carpark (unsealed)	Very High	Very High	Very High	Very High
Road (unsealed)	Very High	Very High	Very High	Very High

Risk Assessment				
	2016	2030	2070	2110
	<u>Risk</u>			
Beach	Low	Low	Low	Low
Coastal/dune vegetation	Low	Medium	Medium	Medium
Carpark (unsealed)	Low	Low	Low	Low
Road (unsealed)	Low	Low	Low	Low

	<u>Vulnerability</u>			
Beach	Low	Low	Low	Low
Coastal/dune vegetation	Low	Medium	Medium	Medium
Carpark (unsealed)	Low	Low	Low	Low
Road (unsealed)	Low	Low	Low	Low

LA1: Lancelin South of Township

Assessment Inputs				
	2016	2030	2070	2110
Asset	Likelihood			
Beach	Possible	Likely	Almost Certain	Almost Certain
Coastal/dune vegetation	Possible	Likely	Almost Certain	Almost Certain
Carpark (Back Beach)	Rare	Rare	Unlikely	Possible
Caravan Park (Lancelin South End)	Unlikely	Possible	Likely	Almost Certain
Sea Rescue	Possible	Likely	Almost Certain	Almost Certain
Grace Darling Park	Possible	Likely	Almost Certain	Almost Certain

Asset	Consequence of Erosion			
Impact on beach amenity	Insignificant	Insignificant	Insignificant	Insignificant
Impact on ecological buffer	Insignificant	Insignificant	Minor	Minor
Impact on Back Beach carpark	Minor	Minor	Minor	Minor
Impact on Caravan park	Moderate	Moderate	Major	Major
Impact on Sea Rescue offices	Moderate	Moderate	Moderate	Moderate
Impact on Grace Darling Park	Major	Major	Major	Major

Asset	Adaptive capacity			
Beach	Very High	Very High	Very High	Very High
Coastal/dune vegetation	High	High	High	High
Carpark (Back Beach)	High	High	High	High
Caravan Park (Lancelin South End)	Moderate	Moderate	Moderate	Moderate
Sea Rescue	Low	Low	Low	Low
Grace Darling Park	Moderate	Moderate	Moderate	Moderate

Risk Assessment				
	2016	2030	2070	2110
	Risk			
Beach	Low	Low	Low	Low
Coastal/dune vegetation	Low	Low	Medium	Medium
Carpark (Back Beach)	Low	Low	Low	Low
Caravan Park (Lancelin South End)	Medium	Medium	High	Extreme
Sea Rescue	Medium	Medium	High	High
Grace Darling Park	High	High	Extreme	Extreme

	Vulnerability			
Beach	Low	Low	Low	Low
Coastal/dune vegetation	Low	Low	Medium	Medium
Carpark (Back Beach)	Low	Low	Low	Low
Caravan Park (Lancelin South End)	Medium	Medium	High	Very High
Sea Rescue	High	High	Very High	Very High
Grace Darling Park	High	High	Very High	Very High

LA2: Lancelin Township South of Jetty

Assessment Inputs				
	2016	2030	2070	2110
Asset	Likelihood			
Beach	Possible	Likely	Likely	Almost Certain
Coastal/dune vegetation	Possible	Likely	Likely	Almost Certain
Residential	Rare	Unlikely	Possible	Likely
Road (Cunliffe St)	Unlikely	Possible	Likely	Almost Certain
Jetty	Possible	Likely	Almost Certain	Almost Certain
Light Industrial	Rare	Rare	Unlikely	possible
Café	Rare	Rare	Unlikely	possible

Asset	Consequence of Erosion			
Impact on beach amenity	Insignificant	Minor	Moderate	Major
Impact on ecological buffer	Insignificant	Minor	Moderate	Major
Impact on residential lots	Insignificant	Minor	Moderate	Major
Impact on Cunliffe St	Insignificant	Minor	Moderate	Moderate
Impact on jetty	Minor	Minor	Moderate	Moderate
Impact on light industrial area	Moderate	Moderate	Major	Major
Impact on café	Moderate	Moderate	Major	Major

Asset	Adaptive capacity			
Beach	High	Moderate	Low	Low
Coastal/dune vegetation	High	Moderate	Low	Low
Residential	Low	Low	Low	Low
Road (Cunliffe St)	Moderate	Moderate	Moderate	Moderate
Jetty	Moderate	Moderate	Moderate	Moderate
Light Industrial	Moderate	Moderate	Moderate	Moderate
Café	Moderate	Moderate	Moderate	Moderate

Risk Assessment				
	2016	2030	2070	2110
	Risk			
Beach	Low	Medium	Medium	Extreme
Coastal/dune vegetation	Low	Medium	Medium	Extreme
Residential	Low	Low	Medium	High
Road (Cunliffe St)	Low	Low	Medium	High
Jetty	Low	Medium	High	High
Light Industrial	Low	Low	Medium	High
Café	Low	Low	Medium	High

	Vulnerability			
Beach	Low	Medium	High	Very High
Coastal/dune vegetation	Low	Medium	High	Very High
Residential	Low	Low	High	Very High
Road (Cunliffe St)	Low	Low	Medium	High
Jetty	Low	Medium	High	High
Light Industrial	Low	Low	Medium	High
Café	Low	Low	Medium	High

LA3: Lancelin Township Jetty to Lancelin 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
Road (Gingin Rd)	Rare	Unlikely	Possible	Likely
Caravan Park (Lancelin North End)	Rare	Unlikely	Possible	Likely
Hotel & Restaurant	Rare	Unlikely	Possible	Likely
Park (Gingin Rd)	Rare	Unlikely	Possible	Likely
Primary School	Rare	Rare	Unlikely	Possible
Tavern (Endeavour)	Rare	Unlikely	Possible	Likely
Residential	Rare	Unlikely	Possible	Likely

<u>Asset</u>	<u>Consequence of Erosion</u>			
Impact on beach amenity	Minor	Moderate	Moderate	Major
Impact on ecological buffer	Minor	Moderate	Moderate	Major
Impact on Gingin Rd	Minor	Moderate	Moderate	Moderate
Impact on caravan park	Moderate	Moderate	Major	Major
Impact on Beach Hotel & Dunes Restaurant	Minor	Moderate	Major	Major
Impact on park on Gingin Rd	Minor	Moderate	Major	Major
Primary School becomes impacted	Moderate	Moderate	Moderate	Moderate
Impact on tavern	Moderate	Moderate	Major	Major
Impact on residential lots	Minor	Major	Major	Catastrophic

<u>Asset</u>	<u>Adaptive capacity</u>			
Beach	High	Moderate	Moderate	Low
Coastal/dune vegetation	High	Moderate	Moderate	Low
Road (Gingin Rd)	Moderate	Moderate	Moderate	Moderate
Caravan Park (Lancelin North End)	Moderate	Moderate	Moderate	Moderate
Hotel & Restaurant	Moderate	Moderate	Moderate	Moderate
Park (Gingin Rd)	High	High	High	High
Primary School	Moderate	Moderate	Moderate	Moderate
Tavern (Endeavour)	Moderate	Moderate	Moderate	Moderate
Residential	Low	Low	Low	Low

Risk Assessment				
	2016	2030	2070	2110
	<u>Risk</u>			
Beach	Low	Medium	High	Extreme
Coastal/dune vegetation	Low	Medium	High	Extreme
Road (Gingin Rd)	Low	Medium	Medium	Medium
Caravan Park (Lancelin North End)	Low	Medium	High	High
Hotel & Restaurant	Low	Medium	High	High
Park (Gingin Rd)	Low	Medium	High	High
Primary School	Low	Low	Medium	Medium
Tavern (Endeavour)	Low	Medium	High	High
Residential	Low	Medium	High	Extreme

	<u>Vulnerability</u>			
Beach	Low	Medium	High	Very High
Coastal/dune vegetation	Low	Medium	High	Very High
Road (Gingin Rd)	Low	Medium	Medium	Medium
Caravan Park (Lancelin North End)	Low	Medium	High	High
Hotel & Restaurant	Low	Medium	High	High
Park (Gingin Rd)	Low	Medium	High	High
Primary School	Low	Low	Medium	Medium
Tavern (Endeavour)	Low	Medium	High	High
Residential	Low	High	Very High	Very High

LA4: Lancelin Township North of Lancelin 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
Residential	Rare	Unlikely	Possible	Likely
Beach Carpark (unsealed)	Rare	Unlikely	Possible	Likely
Beach Access (Lancelin Island Point)	Rare	Unlikely	Possible	Likely

<u>Asset</u>	<u>Consequence of Erosion</u>			
Impact on beach amenity	Minor	Moderate	Major	Major
Impact on ecological buffer	Minor	Moderate	Major	Major
Impact on residential lots	Minor	Moderate	Major	Major
Impact on beach carpark	Minor	Minor	Minor	Minor
Impact on beach access	Minor	Moderate	Moderate	Moderate

<u>Asset</u>	<u>Adaptive capacity</u>			
Beach	High	Moderate	Low	Low
Coastal/dune vegetation	High	Moderate	Low	Low
Residential	Low	Low	Low	Low
Beach Carpark (unsealed)	High	High	High	High
Beach Access (Lancelin Island Point)	High	High	High	High

Risk Assessment				
	2016	2030	2070	2110
	<u>Risk</u>			
Beach	Low	Medium	Extreme	Extreme
Coastal/dune vegetation	Low	Medium	Extreme	Extreme
Residential	Low	Medium	High	High
Beach Carpark (unsealed)	Low	Low	Low	Medium
Beach Access (Lancelin Island Point)	Low	Medium	Medium	Medium

	<u>Vulnerability</u>			
Beach	Low	Medium	Very High	Very High
Coastal/dune vegetation	Low	Medium	Very High	Very High
Residential	Low	High	Very High	Very High
Beach Carpark (unsealed)	Low	Low	Low	Medium
Beach Access (Lancelin Island Point)	Low	Medium	Medium	Medium

Shire of Gingin
Coastal Hazard Risk Management
and Adaptation Plan

APPENDIX

F

MULTI-CRITERIA ANALYSIS RESULTS

SE1: Seabird Township South



Asset types

Environmental, Social, Economic
Managed Retreat OR Protect

Preliminary long term pathway

Vulnerability ranking and timeframe

	2016	2030	2070	2110
	Vulnerability			
Beach	Medium	High	Very High	Very High
Coastal/dune vegetation	Medium	High	Very High	Very High
Residential (houses and land)	Very High	Very High	Very High	Very High
Carparks and roads	Medium	High	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									Not recommended
	MR2	Remove / relocate									Investigate
	MR3	Planning controls for retreat									Recommended
	AC1	Planning controls to accommodate risk									Recommended
Accommodate	AC2	Emergency plans and controls									Recommended
	AC3	Re-design to withstand impact	N/A								
	PR1	Dune care / sand management									Recommended
Protect	PR2	Beach nourishment									Not recommended
	PR3	Groyne									Investigate
	PR4	Nearshore reef / breakwater									Not recommended
	PR5	Maintain / extend seawall									Investigate
	DN	Do Nothing									Not recommended

SB2: Seabird Township North



Asset types

Environmental, Social, Economic
Managed Retreat OR Protect

Preliminary long term pathway

Vulnerability ranking and timeframe

	2016	2030	2070	2110
	Vulnerability			
Beach	Low	High	High	High
Coastal/dune vegetation	Low	Medium	High	Very High
Caravan Park (Seabird Private)	Low	Medium	Very High	Very High
Tavern	Low	Medium	Medium	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
	AC1	Planning controls to accommodate risk									Recommended
Accommodate	AC2	Emergency plans and controls									Recommended
	AC3	Re-design to withstand impact	N/A								
	PR1	Dune care / sand management									Recommended
Protect	PR2	Beach nourishment									Not recommended
	PR3	Groyne									Investigate
	PR4	Nearshore reef / breakwater									Not recommended
	PR5	Seawall									Investigate
	DN	Do nothing									Not recommended

LP1: Ledge Point South of Township



Asset types Environmental, social
Preliminary long term pathway Avoid / Accommodate
Vulnerability ranking and timeframe

	2016	2030	2070	2110
Vulnerability				
Beach	Low	Low	Low	Low
Coastal/dune vegetation	Low	Medium	Medium	High
Beach Carpark (unsealed)	Low	Low	Low	Medium
Road (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	N/A								
	MR3	Planning controls for retreat									Recommended
Accommodate	AC1	Planning controls to accommodate risk									Recommended
	AC2	Emergency plans and controls									Recommended
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

LP2: Ledge Point Township South



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

	2016	2030	2070	2110
Vulnerability				
Beach	Medium	Medium	High	High
Foreshore recreation area	Low	Low	Medium	High
Residential	High	Very High	Very High	Very High
Roads	Low	Low	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
Protect	PR1	Dune care / sand management									Recommended
	PR2	Beach nourishment									Investigate
	PR3	Groyne									Investigate
	PR4	Nearshore reef / breakwater									Not recommended
	PR5	Seawall									Investigate
Do Nothing	DN	Do nothing									Not recommended

LP3: Ledge Point Township North



Asset types

Social, Economic, Environmental

Preliminary long term pathway

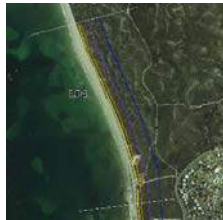
Avoid and Accommodate then Managed Retreat OR Protect

Vulnerability ranking and timeframe

	2016	2030	2070	2110
Vulnerability				
Beach	Low	Low	Medium	High
Coastal/dune vegetation	Low	Medium	Medium	Very High
Carpark (De Burgh St)	Low	Low	Medium	High
Road (De Burgh St)	Low	Low	Medium	High
Holiday Village	Low	Low	High	Very High
Residential	Low	Low	Very High	Very High
Key Biscoyne Park	Low	Low	Medium	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
Protect	PR1	Dune care / sand management									Recommended
	PR2	Beach nourishment									Investigate
	PR3	Groyne									Investigate
	PR4	Nearshore reef / breakwater									Not recommended
	PR5	Seawall									Investigate
Do Nothing	DN	Do nothing									Not recommended

LP4: Ledge Point North of Township



Asset types

Environmental, Social

Preliminary long term pathway

Avoid / Accommodate

Vulnerability ranking and timeframe

	2016	2030	2070	2110
Vulnerability				
Beach	Low	Low	Low	Low
Coastal/dune vegetation	Low	Medium	Medium	Medium
Carpark (unsealed)	Low	Low	Low	Low
Road (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	N/A								
	MR3	Planning controls for retreat									Recommended
Accommodate	AC1	Planning controls to accommodate risk									Recommended
	AC2	Emergency plans and controls									Recommended
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

LA1: Lancelin South of Township



Asset types Social, Environmental, Economic
Preliminary long term pathway 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
Carpark (Back Beach)	Low	Low	Low	Low
Caravan Park (Lancelin South End)	Medium	Medium	High	Very High
Sea Rescue	High	High	Very High	Very High
Grace Darling Park	High	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
Protect	PR1	Dune care / sand management									Recommended
	PR2	Beach nourishment									Investigate
	PR3	Groyne									Investigate
	PR4	Nearshore reef / breakwater									Not recommended
	PR5	Seawall									Investigate
Do Nothing	DN	Do nothing									Not recommended

LA2: Lancelin Township South of Jetty



Asset types 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	High	Very High
Residential	Low	Low	High	Very High
Road (Cunliffe St)	Low	Low	Medium	High
Jetty	Low	Medium	High	High
Light Industrial	Low	Low	Medium	High
Café	Low	Low	Medium	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
Protect	PR1	Dune care / sand management									Recommended
	PR2	Beach nourishment									Investigate
	PR3	Groyne									Investigate
	PR4	Nearshore reef / breakwater									Not recommended
	PR5	Seawall									Investigate
Do Nothing	DN	Do nothing									Not recommended

LA3: Lancelin Township Jetty to Lancelin Point



Asset types

Economic, 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	High	Very High
Road (Gingin Rd)	Low	Medium	Medium	Medium
Caravan Park (Lancelin North End)	Low	Medium	High	High
Hotel & Restaurant	Low	Medium	High	High
Park (Gingin Rd)	Low	Medium	High	High
Primary School	Low	Low	Medium	Medium
Tavern (Endeavour)	Low	Medium	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
Protect	PR1	Dune care / sand management									Recommended
	PR2	Beach nourishment									Investigate
	PR3	Groyne									Investigate
	PR4	Nearshore reef / breakwater									Not recommended
	PR5	Seawall									Investigate
Do Nothing	DN	Do nothing									Not recommended

LA4: Lancelin Township North of Lancelin Point



Asset types

Economic, 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
Coastal/dune vegetation	Low	Medium	Very High	Very High
Residential	Low	High	Very High	Very High
Beach Carpark (unsealed)	Low	Low	Low	Medium
Beach Access (Lancelin Island Point)	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									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
Protect	PR1	Dune care / sand management									Recommended
	PR2	Beach nourishment									Investigate
	PR3	Groyne									Investigate
	PR4	Nearshore reef / breakwater									Not recommended
	PR5	Seawall									Investigate
Do Nothing	DN	Do nothing									Not recommended

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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	PR1	PR2	PR3	PR4	PR5	DN			
SE1: Seabird Township South	R	NR	I	R	R	R	R	NR	I	NR	I	NR	High	Managed Retreat or Protect	Short term
SE2: Seabird Township North	R	NR	I	R	R	R	R	NR	I	NR	I	NR	Medium	Managed Retreat or Protect	Medium term
LP1: Ledge Point South of Township	R	R	N/A	R	R	R	R	NR	NR	NR	NR	NR	Low	Avoid	Not Required
LP2: Ledge Point Township South	R	NR	I	R	R	R	R	I	I	NR	I	NR	High	Managed Retreat or Protect	Short term
LP3: Ledge Point Township North	R	NR	I	R	R	R	R	I	I	NR	I	NR	Medium	Managed Retreat or Protect	Medium term
LP4: Ledge Point North of Township	R	R	N/A	R	R	R	R	NR	NR	NR	NR	NR	Low	Avoid	Not Required
LA1: Lancelin South of Township	R	NR	I	R	R	R	R	I	I	NR	I	NR	High	Managed Retreat or Protect	Short term
LA2: Lancelin Township South of Jetty	R	NR	I	R	R	R	R	I	I	NR	I	NR	Medium	Managed Retreat or Protect	Medium term
LA3: Lancelin Township Jetty to Lancelin Point	R	NR	I	R	R	R	R	I	I	NR	I	NR	Medium	Managed Retreat or Protect	Medium term
LA4: Lancelin Township North of Lancelin Point	R	NR	I	R	R	R	R	I	I	NR	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

PR1: Dune care program / Sand management

PR2: Beach Nourishment

PR3: Groyne

PR4: Nearshore Reef / Breakwater

PR5: (Maintain / extend) Seawall

NR	Not recommended
I	Investigate (High Priority Areas - see Adaptation Options in Chapter 5)
R	Recommended (See Implementation Plan - Chapter 6)

Table G2 SE1: Seabird Township South

	MR2 - Remove / relocate	PR3 - Groynes	PR5 - Seawall
Effectiveness	Removal of houses to the west of the natural limestone ridge would be effective in lowering the risk of erosion.	The effectiveness of groynes in maintaining a beach would need to be assessed in greater detail. Ongoing sand renourishment may be required.	Maintenance of the seawall would be effective in lowering the risk of erosion impacts to assets landward of the seawall.
Legal / Approval 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 management unit SE2, thereby exposing responsible entities to future legal action in the event of injurious affection.	The presence of the seawall may increase the risk of long term erosion in management unit SE2, thereby exposing responsible entities to future legal action in the event of injurious affection.
Reversibility / Adaptability	Managed retreat of assets from the hazard zone is the best way of preserving future options for adaptation.	Protective structures tend to encourage investment and intensification of development based on the belief that property will be protected into the future (see Section 1.6). This option is therefore difficult to reverse and limits future adaptation options.	Protective structures tend to encourage investment and intensification of development based on the belief that property will be protected into the future (see Section 1.6). This option is therefore difficult to reverse and limits future adaptation options.
Environmental / Social Impact	Removal of assets and allowing erosion to occur may be considered to have the best environmental outcomes since this is the most natural course of action. Managed retreat would allow for public access to a foreshore reserve and restore use of the beach.	Groynes have the potential to result in negative impacts to benthic habitats, but also have the potential to create new habitat and substrate for marine flora and fauna. The potential environmental impacts from groynes would need to be assessed in greater detail. If successful in creating beach amenity then this would have positive social impacts.	Increased erosion of SE2 would be a negative environmental impact. Maintenance of the seawall would continue to reduce the public amenity of the coast in front of the seawall.
Community Acceptability	This option is likely to be highly unacceptable to the landowners west of the 2030 hazard line, and of limited acceptability to the rest of the Seabird community.	This option is likely to be acceptable to the landowners west of the 2030 hazard line as well as the rest of the Seabird community, however the level of cost contribution required may make this option unacceptable.	This option is likely to be most acceptable to the landowners west of the 2030 hazard line and the rest of the seabird community.
Financial Gain / Avoidance of Cost	This option avoids the cost of seawall maintenance.	This option does not provide immediate financial gain to the broader community, however it may make Seabird a more desirable area thereby stimulating development, increasing tourism potential and raising house values.	This option provides financial gain primarily for landowners west of the 2030 hazard line. Increased public amenity relating to the seawall would be required to broaden the beneficiary base.
Capital Cost	Compensation to the 16 landowners within the 2030 hazard zone could cost in the order of \$16 M.	This option is likely to be prohibitively expensive (estimated best practice approach: \$9M) for the ratepayer base of around 200.	N/A

	MR2 - Remove / relocate	PR3 - Groynes	PR5 - Seawall
Ongoing Cost	Expected to be negligible.	Ongoing cost is expected to be around twice that of a seawall alone (\$44,000 p/a)	Estimated \$24,000 p/a.

Table G3 LP2: Ledge Point Township South

	PR2 - Beach Nourishment	MR2 - Remove / relocate	PR3 - Groynes	PR5 - Seawall
Effectiveness	May reduce risk but residual risk from extreme events would remain. Ongoing nourishment would be required.	Removal of houses seaward of DeBurgh St would reduce the consequences of erosion.	Additional groynes are likely to be effective if sand renourishment is also carried out. The effectiveness of extension of the existing groynes needs to be assessed in greater detail.	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 the risk of long term erosion in adjacent management units, 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 and impact on boat launching activities.	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. Additional groynes may restrict vehicle access along the beach.	Increased erosion of adjacent management units would be a negative environmental impact. Construction of a seawall may reduce the public amenity of the coast in front of the seawall.
Community Acceptability	Moderate acceptability unless current beach use is significantly impacted.	This option is likely to be unacceptable to the specific landowners required to remove assets/relocate, and be of limited acceptability to the broader Ledge Point 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.

	PR2 - Beach Nourishment	MR2 - Remove / relocate	PR3 - Groynes	PR5 - Seawall
Financial Gain / Avoidance of Cost	Minimal financial gain anticipated.	This option avoids the cost of coastal protection works.	This option provides financial gain for landowners along DeBurgh Street. This option does not provide immediate financial gain to the broader community, but may raise property values.	This option provides financial gain primarily for landowners west of DeBurgh Street.
Capital Cost	\$1.46m for same volume as with groynes but could be considerably less	Compensation to the landowners west of DeBurgh St could cost in the order of \$23 million.	Estimated to be \$3.9 M for 2 groynes and sand nourishment.	Estimated \$1.2 M for 290 m long seawall.
Ongoing Cost	Estimated \$40,000 p/a	Expected to be negligible.	Estimated \$19,500 p/a.	Estimated \$13,500 p/a.

Table G4 LA1: Lancelin South of Township

	PR2 -Beach Nourishment	MR2 - Remove / relocate	PR3 - Groynes	PR5 - Seawall
Effectiveness	Ongoing nourishment would be required to be effective.	Removal of Grace Darling Park and chalets in the caravan park would reduce the consequences of erosion.	The effectiveness of groynes in this location would need to be assessed in greater detail.	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.	Minimal legal risk.	Implementing groynes may increase the risk of long term erosion in adjoining areas, thereby potentially exposing responsible entities to future legal action.	Construction of a seawall may increase the risk of long term erosion in adjacent areas, thereby potentially exposing responsible entities to future legal action.
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.	A rock sea wall option is difficult to reverse and limits future adaptation options. GSC are more easily reversible with fewer negative impacts.
Environmental / Social Impact	Environment impacts are likely to be minimal. Social impacts on beach use may be experienced	Managed retreat may be considered to have the best environmental outcomes since this is the most natural course of action.	The potential environmental impacts from groynes would need to be assessed in greater detail. Social impacts may occur if groynes have a negative impact on tourism due	Increased erosion of adjacent dune areas may result. Seawalls may reduce the public amenity of the beach in front of the seawall.

	PR2 -Beach Nourishment	MR2 - Remove / relocate	PR3 - Groynes	PR5 - Seawall
	during sand relocation activities.	Social impacts may occur if no allowance for a foreshore reserve with public/tourism access to key areas.	to changes to natural character of the area.	
Community Acceptability	High acceptability.	Community acceptability will depend on provision of a foreshore reserve with public access to key recreation areas.	This option is unlikely to be acceptable as it would substantively change the character of the area.	The GSC option may be acceptable so long as existing use of the beach can be maintained. The rock option is unlikely to be acceptable.
Financial Gain / Avoidance of Cost	Minimal direct financial gain, but some flow-on economic benefits.	This option avoids the cost of coastal protection works.	This option does not provide immediate financial gain to the broader community	This option may provide some financial gain to the broader community so long as the beach and connection to it can be maintained.
Capital Cost	\$5.88m for same volume as with groynes but could be less if no groynes constructed.	N/A	Estimated to be \$12 M for 4 groynes and sand renourishment. Smaller scale options in the vicinity of Grace Darling Park might cost considerably less.	Estimated \$2.7 M for 700 m long rock seawall or \$700 -\$900 K for 150 m long GSC revetment.
Ongoing Cost	\$48,000 or less if sand is sourced from the nearby salient sand spit.	Expected to be negligible.	Estimated \$39,000 p/a	Estimated \$29,700 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.

Deemed provision 15 of TPS 9 sets out when a structure plan may be prepared, in the following terms:

A structure plan in respect of an area of land in the Scheme area may be prepared if —

- (a) the area is —
 - (i) all or part of a zone identified in this Scheme as an area suitable for urban or industrial development; and
 - (ii) identified in this Scheme as an area requiring a structure plan to be prepared before any future subdivision or development is undertaken; or
- (b) a State planning policy requires a structure plan to be prepared for the area; or
- (c) the Commission considers that a structure plan for the area is required for the purposes of orderly and proper planning.

Other deemed provisions set 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.

In LPS 9, structure plans are required on land zoned 'Future Development'. It is for this reason that a structure plan was prepared for Moore River South and other areas further inland.

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 if/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.

Types of scheme amendments to achieve this outcome are discussed further in H4.

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 9 Recommendations

The following sections provide recommendations for incorporation into LPS 9 or any new planning scheme.

H4.1 Introduce a Special Control Area

LPS 9 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).

H4.2 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 9. Such a policy would cover matters such as the acceptable forms of 'temporary' construction within land forecast to be impacted by coastal processes. The existing LPPs 1.2 and 1.4 do not address these matters and should be updated or replaced with a more comprehensive policy that complements the State Coastal Policy.

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.

H4.3 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 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 Coastal Planning Policy which encourages urban development around existing settlements and discourages continuous linear urban development along the coast.

H4.4 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 9 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 Gingin
Coastal Hazard Risk Management
and Adaptation Plan

APPENDIX

I

LONG TERM PATHWAYS

SE1: Seabird Township South



Timeframe	2016	2030	2070	2110
Vulnerability Ratings				
Beach	Medium	High	Very High	Very High
Coastal/dune vegetation	Medium	High	Very High	Very High
Residential (houses and land)	Very High	Very High	Very High	Very High
Carparks and roads	Medium	High	High	High
Asset lifecycle	Estimated end of Seabird Seawall lifecycle			
Indicative Pathway				
Undeveloped Areas	Avoid			
Developed Areas	Protect		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	PR5 - Protection by seawall		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 prepare emergency plans, apply notification on title	Retorfit seawall, commence dune care program	Remove damaged assets and relocate assets at risk	Remove assets
Responsibility	Shire of Gingin and State Government	Shire of Gingin	Shire of Gingin	Shire of Gingin

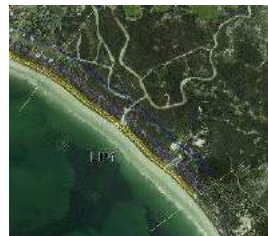
SE2: Seabird Township North

SE2: Seabird Township North

Timeframe	2016	2030	2070	2110
Vulnerability Rating				
Beach	Low	High	High	High
Coastal/dune vegetation	Low	Medium	High	Very High
Caravan Park (Seabird Private)	Low	Medium	Very High	Very High
Tavern	Low	Medium	Medium	High
Asset lifecycle			Estimated end of Caravan Park lifecycle	
Pathways				
Undeveloped Areas	Avoid			
Developed Areas	Protect		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, AC2, PR1 - Implement planning controls and emergency plans to accommodate coastal risk and dune care and sand management		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 prepare emergency plans, apply notification on title	Commence dune care program and sand management	Remove damaged assets and relocate assets at risk	Remove assets
Responsibility	Shire of Gingin and State Government	Shire of Gingin	Shire of Gingin	Shire of Gingin


LP1: Ledge Point South of Township



Timeframe	2016	2030	2070	2110
Vulnerability Rating				
Beach	Low	Low	Low	Low
Coastal/dune vegetation	Low	Medium	Medium	High
Beach Carpark (unsealed)	Low	Low	Low	Medium
Road (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			
Developed Areas	AC1, MR3 - Implement planning controls and emergency plans to accommodate coastal risk			
Minor Infrastructure	PR1 - Dune care and sand management			MR1, MR2 - Remove minor infrastructure as it becomes damaged, irreparable and/o 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 prepare emergency plans, apply notification on title	Commence dune care program and sand management	Commence dune care program and sand management	Remove assets
Responsibility	Shire of Gingin and State Government	Shire of Gingin	Shire of Gingin	Shire of Gingin


LP2: Ledge Point Township South of Jetty



Timeframe	2016	2030	2070	2110
Vulnerability Rating				
Beach	Medium	Medium	High	High
Foreshore recreation area	Low	Low	Medium	High
Residential	High	Very High	Very High	Very High
Roads	Low	Low	High	Very High
Asset lifecycle		Estimated end of residential properties lifecycle		
Pathways				
Undeveloped Areas	Avoid			
Developed Areas	Protect		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	PR3 - Protection by groyne		MR2 - Remove assets as their risk becomes intolerable	
Minor Infrastructure	MR1, MR2 - Remove minor infrastructure as it becomes damaged, irreparable and/or unsafe			

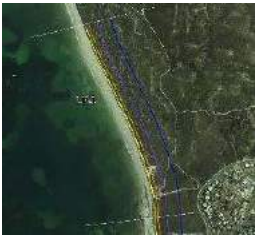
Management Pathway Triggers	Trigger 1	Trigger 2	Trigger 3	Trigger 4
Trigger	CHRMAP recommendation	HSD plus S1 reaches 2030 vulnerability line	HSD plus S1 reaches 2070 vulnerability line	Minor infrastructure becomes damaged or unsafe
Action	Implement planning controls and prepare emergency plans, apply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

LP3: Ledge Point Township North

	Timeframe	2016	2030	2070	2110
	Vulnerability Rating				
	Beach	Low	Low	Medium	High
	Coastal/dune vegetation	Low	Medium	Medium	Very High
	Carpark (De Burgh St)	Low	Low	Medium	High
	Road (De Burgh St)	Low	Low	Medium	High
	Holiday Village	Low	Low	High	Very High
	Residential	Low	Low	Very High	Very High
	Key Biscoyne Park	Low	Low	Medium	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 prepare emergency plans, apply notification on title	Commence dune care program and sand management	Remove damaged assets and relocate assets at risk	Remove assets
Responsibility	Shire of Gingin and State Government	Shire of Gingin	Shire of Gingin	Shire of Gingin

LP4: Ledge Point North of Township

Timeframe	2016	2030	2070	2110
	Vulnerability Rating			
Beach	Low	Low	Low	Low
Coastal/dune vegetation	Low	Medium	Medium	Medium
Carpark (unsealed)	Low	Low	Low	Low
Road (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			
Developed Areas	AC1, MR3 - Implement planning controls and emergency plans to accommodate coastal risk			
Minor Infrastructure	PR1 - Dune care and sand management			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 prepare emergency plans, apply notification on title	Commence dune care program and sand management	Commence dune care program and sand management	Remove assets
Responsibility	Shire of Gingin and State Government	Shire of Gingin	Shire of Gingin	Shire of Gingin

LA1: Lancelin South of Twonship


EA1: Lancelin South of Township

Timeframe	2016	2030	2070	2110
Vulnerability Rating				
Beach	Low	Low	Low	Low
Coastal/dune vegetation	Low	Low	Medium	Medium
Carpark (Back Beach)	Low	Low	Low	Low
Caravan Park (Lancelin South End)	Medium	Medium	High	Very High
Sea Rescue	High	High	Very High	Very High
Grace Darling Park	High	High	Very High	Very High
Asset lifecycle		End of Grace Darling Park 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	PR2 - Implement beach nourishment to accommodate risk		MR1, MR2 - Remove minor infrastructure as it becomes damaged, irreparable and/c 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 prepare emergency plans, apply notification on title	Implement beach nourishment, commence dune care program and sand management	Remove damaged assets and relocate assets at risk	Remove assets
Responsibility	Shire of Gingin and State Government	Shire of Gingin	Shire of Gingin	Shire of Gingin

LA2: Lancelin Township South of Jetty

LA2: Lancelin Township South of Jetty

Timeframe	2016	2030	2070	2110	
	Vulnerability Rating				
	Beach	Low	Medium	High	Very High
	Coastal/dune vegetation	Low	Medium	High	Very High
	Residential	Low	Low	High	Very High
	Road (Cunliffe St)	Low	Low	Medium	High
	Jetty	Low	Medium	High	High
	Light Industrial	Low	Low	Medium	High
	Café	Low	Low	Medium	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 prepare emergency plans, apply notification on title	Commence dune care program and sand management	Commence dune care program and sand management	Remove assets
Responsibility	Shire of Gingin and State Government	Shire of Gingin	Shire of Gingin	Shire of Gingin

LA3: Lancelin Township Jetty to Lancelin Point




	Timeframe	2016	2030	2070	2110
Vulnerability Rating					
Beach	Low	Medium	High	Very High	
Coastal/dune vegetation	Low	Medium	High	Very High	
Road (Gingin Rd)	Low	Medium	Medium	Medium	
Caravan Park (Lancelin North End)	Low	Medium	High	High	
Hotel & Restaurant	Low	Medium	High	High	
Park (Gingin Rd)	Low	Medium	High	High	
Primary School	Low	Low	Medium	Medium	
Tavern (Endeavour)	Low	Medium	High	High	
Residential	Low	High	Very High	Very High	
Asset lifecycle			Estimated end of 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 prepare emergency plans, apply notification on title	Commence dune care program and sand management	Commence dune care program and sand management	Remove assets
Responsibility	Shire of Gingin and State Government	Shire of Gingin	Shire of Gingin	Shire of Gingin

LA4: Lancelin Township North of Lancelin Point

LA4: Lancelin Township North of Lancelin Point



Timeframe	2016	2030	2070	2110
Vulnerability Rating				
Beach	Low	Medium	Very High	Very High
Coastal/dune vegetation	Low	Medium	Very High	Very High
Residential	Low	High	Very High	Very High
Beach Carpark (unsealed)	Low	Low	Low	Medium
Beach Access (Lancelin Island Point)	Low	Medium	Medium	Medium
Asset lifecycle			Estimated end of 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 prepare emergency plans, apply notification on title	Commence dune care program and sand management	Commence dune care program and sand management	Remove assets
Responsibility	Shire of Gingin and State Government	Shire of Gingin	Shire of Gingin	Shire of Gingin