Shire of Augusta Margaret River

Coastal Hazard Risk Management and Adaptation Plan

for Shire of Augusta Margaret River

November 2015

FINAL Report

SCR1507

Executive Summary

This Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) has been prepared by Shore Coastal for the Augusta-Margaret River Shire Council (AMRSC). This CHRMAP provides strategic guidance on management and adaptation in areas exposed to coastal processes within the key coastal settlements identified by the AMRSC. These settlements are Gracetown, Prevelly, Gnarabup, Hamelin Bay, Molloy Island, Augusta North (Blackwood River) and Augusta South (Flinders Bay).

This report follows a process outlined in the State Coastal Planning Policy of risk identification, risk analysis and risk evaluation; in order to make recommendations for risk management and adaptation. Two stakeholder consultation workshops were undertaken as part of this process, and stakeholder input incorporated into the process.

Key recommendations include:

1) *Limestone cliff stability:* The safety and stability of limestone cliffs in the various settlements requires immediate investigation. We recommend a geotechnical investigation and safety signage audit be undertaken on limestone cliffs (weakly lithified sedimentary rock coasts) as an initial priority. This should be followed by an investigation to evaluate the longer-term stability of the cliffs, especially those associated with significant assets and/or public use.

2) *Systematic coastal monitoring and inspections:* Risks such as movement of the coastline and undermining of coastal stairs and structures should be systematically monitored. This will allow threats to public safety and coastal assets to be identified in a timely manner. This relative absence of coastal monitoring data in the Shire presently limits informed consideration of coastal management and adaptation.

3) *Coastal adaptation of coastal stairs and platforms:* Coastal stairs and platforms, especially in Gracetown and Gnarabup, are frequently undermined by coastal processes. Designs that allow for coastal processes to be accommodated should be undertaken for these structures. It is recommended that works to implement these designs be undertaken in the next few years.

4) *Planning for high risk assets:* The Turner Caravan Park, Albany Terrace, Prevelly/ Gnarabup walkway and the carparks at South Point, Rivermouth, Gnarabup and Flinders Bay are relatively high cost assets in high coastal exposure areas (i.e. located close to the coast in relatively exposed areas). Site-specific adaptation plans should be developed for each of these sites. Design work should be considered for adaptation of the White Elephant café and changerooms, the Molloy Island car ferry and other boat ramps and marine infrastructure. This will allow timely adaptation of these assets to accommodate coastal processes should systematic coastal monitoring and inspections identify this requirement.

5) *Coastal investigations:* The coastal processes around Prevelly, Gnarabup and the Rivermouth, and the riverine flooding likely in the Blackwood River at Augusta are complex and relatively poorly understood. Investigations are recommended to improve understanding and facilitate responses to coastal processes in these areas.

A recommended coastal monitoring and adaptation program is included in Table 5.2.1, complete with cost estimates. The recommended works, design and studies have an estimated cost of under $1.2 million over 5 years. A significant proportion of this could be eligible for funding through Coastal Adaptation and Protection grants.

This study also identifies potential longer-term coastal management issues that will require strategic planning in the medium term. The coastal monitoring and adaptation program should both provide the data to inform these longer term strategic decisions, improve the understanding in the community of coastal processes and adaptation, and progressively improve the resilience of coastal areas to coastal change.

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Limitations of this Report

This report and the work undertaken for its preparation, is presented for the use of the client. The report may not contain sufficient or appropriate information to meet the purpose of other potential users. Shore Coastal does not accept any responsibility for the use of the information in the report by other parties.

Rev	Issues Description	By	Review	Date
A	Draft for internal review	OS/ML/SB	SB, Damara, Coastal Environment	07 Sep 2015
B	Draft for Issue to Client	SB	AMRSC	30 Sep 2015
C	Final Report	SB		20 Nov 2015

1. Introduction

1.1. Background

The Shire of Augusta-Margaret River is located in the south-west region of Western Australia and borders both the west and south coasts. This includes approximately 138 km of coastline under a mixture of private and public tenure, with a significant proportion within the Leeuwin Naturaliste Ridge National Park.

The Margaret River region is the most visited destination outside Perth in Western Australia, appealing to a wide range of visitors due to its natural attractions. The coastal foreshore areas are a major focus for recreation and low impact tourism enterprises, and include a number of coastal settlements. Considering the social, economic and environmental value of the coastline, it is important to preserve the coastal foreshore for future generations (AMRSC, 2011).

The Coastal Hazard Risk Management and Adaptation Planning (CHRMAP) process is recommended by Western Australia Planning Commission (WAPC, 2013a) (WAPC, 2014). This coastal planning process aims to provide strategic guidance on coordinated, integrated and sustainable management and adaptation for land use and development in the coastal zone likely to be affected by coastal hazards. It establishes the basis for present and future risk management and adaptation.

The coastal settlement areas or areas of significant tourism amenity (Coastal Management Areas) identified by the Augusta Margaret River Shire (AMRSC) for further consideration include Gracetown, Prevelly, Gnarabup, Hamelin Bay, Molloy Island, Augusta North (Blackwood River) and Augusta South (Flinders Bay). An overview of the study area including the location of each Coastal Management Area is shown in Figure 1.1.

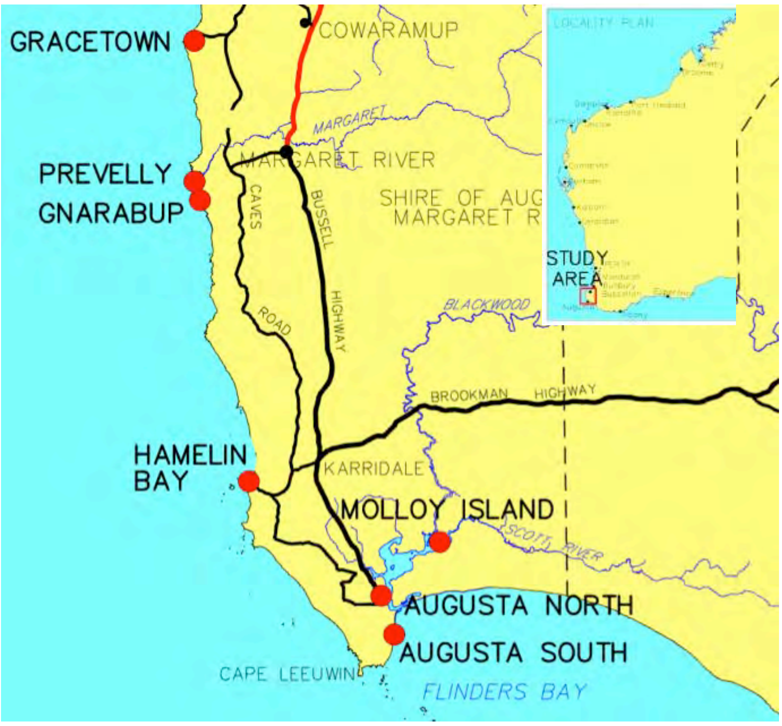

Figure 1.1 Overview of Shire of Augusta Margaret River showing CHRMAP Sites

The Shire is undertaking a broader climate change response plan, of which this study forms a component. The need for coastal hazard planning was emphasised during storm events in September 2013, which damaged some of the Shire's key recreation infrastructure along the Prevelly/Gnarabup coastline (see Figure 1.2). While most development is located well above the mean high water level there are some assets that are exposed to coastal processes. The CHRMAP has identified these assets and determined options for management and adaptation.

Figure 1.2 Coastal Erosion and Damage to Infrastructure in Gnarabup During September 2013 (Cristina Da Silva, DoT 2013)

1.2. Scope of Works

The Scope of Works for this CHRMAP was:

- Review existing information and planning controls.
- Community and stakeholder engagement (workshops).
- Development of the CHRMAP (Risk Identification, Analysis, Evaluation, Management and Adaptation) in accordance with CHRMAP guidelines.
- Reporting.

Shore Coastal was commissioned in November 2014 to prepare a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for the AMRSC based on the submitted proposal. This was for a targeted scope based on the Department of Planning's CHRMAP guidelines but necessarily limited by available data. This report has been structured to align with CHRMAP guidelines as shown in Figure 1.3.

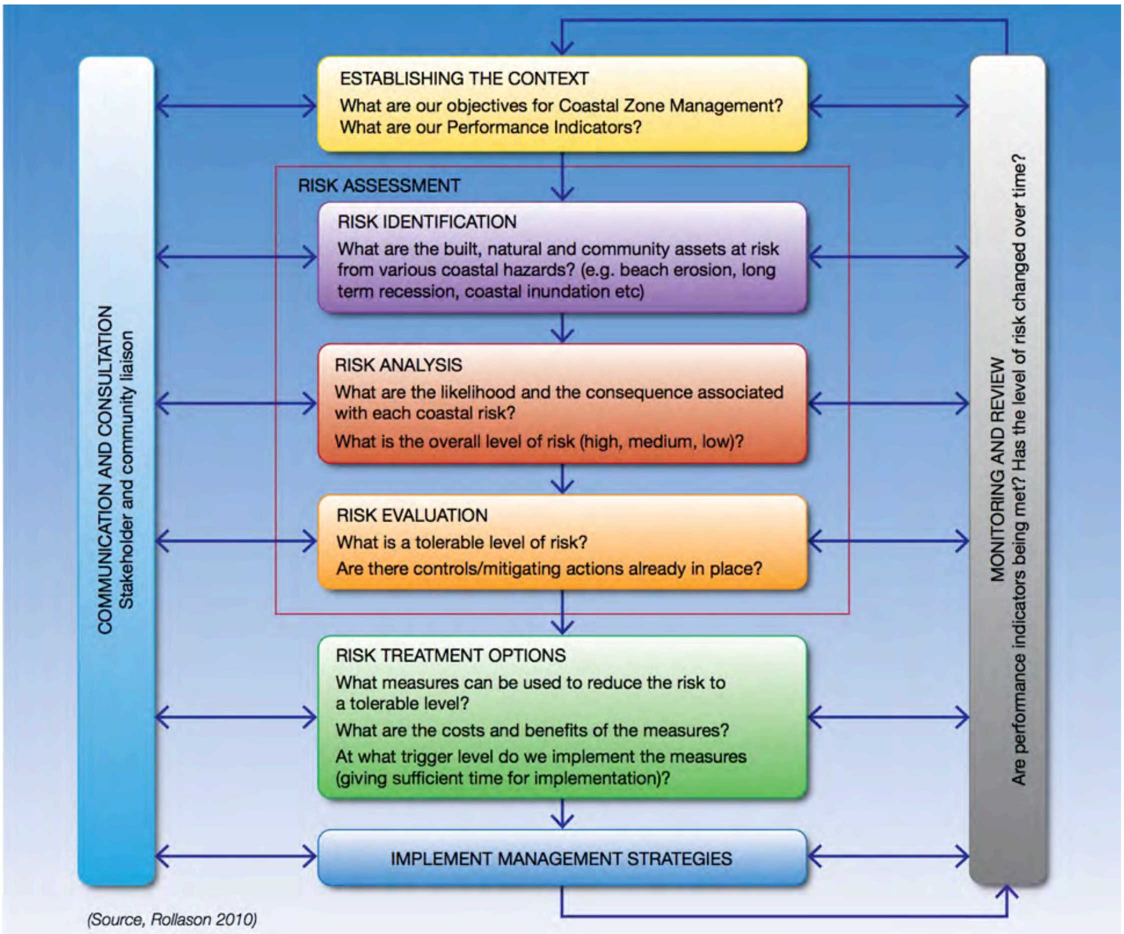

Figure 1.3 Coastal Hazard Risk Management and Adaptation Planning Process Diagram (WAPC, 2014)

1.3. Community Engagement

Two community engagement workshops were held at the Shire offices. The first workshop was followed initial completion of the Risk Analysis phase and was attended by the following key stakeholders and relevant community organisations:

- Shire officers.
- Shore Coastal.
- Shire Councillors.
- Transition Margaret River.
- Sustainability Advisory Committee.
- Tangaroa Blue.
- Margaret River Coastal Residents Association.
- Margaret River Environment Centre.
- Cape to Cape Catchments Group.

Key stakeholder input from the first workshop included identification of:

- The value of key coastal assets, including high value placed on the beaches; and
- Environmental, social and economic impacts to the community should key assets be impacted upon from coastal hazards (i.e. erosion, inundation, sea level rise etc.).

A summary of all inputs provided by stakeholders in workshop 1 is provided in the community workshop minutes in the appendices of the Socio-economic report in the Attachment 5 Socio Economic Evaluation (Attachment 5). Inputs then fed into the risk evaluation and risk management and adaptation stages.

The second workshop was held following the initial completion of the Risk Management and Adaptation phase and was also attended by the following key stakeholders and relevant community organisations:

- Lyn Serventy (Councillor – Deputy President).
- Jared Drummond (Sustainability Planning Officer).
- Gracetown Residents Association.
- Augusta Margaret River Tourism Association.
- Molloy Island Home Owners.
- Transition Margaret River.
- John McKinney – Shire.
- Augusta Community Environmental Group.
- Margaret River Coastal Residents Association.

Outputs from the resulting discussions are summarised in the Community Workshop 2 minutes. The Shire has also advised consultation was undertaken with Surfrider Foundation, Prevelly Wilderness Progress Association, Augusta and Margaret River Chambers of Commerce, Augusta Community Development Association, Curtin University, DPAW and Department of Fisheries.

The community engagement workshops provided a forum for communicating shared knowledge of the coastline, discussing the relative value of coastal assets (e.g. the asset value of the beach itself, in comparison to the value of the assets that provide access or amenity adjacent to the beach) and considering potential coastal adaptation measures. In particular, the workshops allowed the complexity of coastal processes influencing coastal settlements within the Shire, and the technical limitations of hazard assessment, to be communicated directly to key stakeholders.

1.4. Review of Existing Information and Planning Controls

Initially a review of relevant literature was used to *establish the context* of the CHRMAP. This process reviewed existing national, state and local planning policies, planning controls and management strategies to provide a framework for the later stages of the CHRMAP.

1.4.1. Local Government

The Shire of Augusta Margaret River strategic planning documents provide a framework for coastal planning and management.

The Augusta Margaret River Coastal Management Plan (Landform Research 2005) provides an assessment of the coastal and human environment in the Shire and provides recommendations and an implementation strategy for various planning measures and works. The plan was developed in the context of the Shires' Coastal Management Policy PE 15. Site specific coastal foreshore reserve management plans are available for Prevelly/Gnarabup (Tingay, 1993), Augusta Foreshore (Monaghan & Associates, 1997) and Hardy Inlet (Smithson Planning, 2003)

The local planning scheme (AMRSC, 2014a) provides direction for sustainable growth, environmental protection, biodiversity conservation, social advancement and economic prosperity. There is limited direct reference to coastal management in this scheme.

The local planning strategy (AMRSC, 2011) identifies coastal management (Section 3.6) as a key planning issue. The coast is identified in the strategy as a major attraction for residents and tourists, and there has been a lot of pressure exerted on the coast for residential and recreation uses. Key issues identified include erosion and accretion, climate change, human development pressures, recreational use and access to the coast, introduced pests and weeds. The aim is to ensure that the location of coastal facilities and development takes into account coastal processes including erosion, accretion, storm surge, tides, wave conditions, sea level change and biophysical values.

The local planning strategy identifies specific land use strategy areas for coastal management (Section 4.3) (AMRSC, 2011) to provide for the protection and enhancement of coastal attributes in the Shire. Coastal management areas are identified for Gracetown, Kilcarnup, Prevelly, Dead Finish, Flinders Bay and East Augusta (Figure 4 in AMRSC, 2011). Cadastral boundaries and a nominal coastline appear to be the basis of the boundary of the coastal management areas. The development of foreshore management plans for Gracetown, Kilcarnup[1] and Flinders Bay is recommended, together with use and progressive implementation of the existing Prevelly foreshore reserve management plan. It is noted:

- Development of additional recreational activity nodes or access routes within coastal reserves shall only be considered after a comprehensive assessment of the likely future impacts of such development, and consultation with affected user groups and the wider community.
- In the development of coastal reserve facilities, the local government shall take into account the potential impacts of climatic change and shoreline variability on risk to life and property.
- Applications for buildings, structures, community facilities, and specific purpose leases on coastal reserves shall be consistent with the purpose and vesting of the reserve, and the relevant management/development plan.

Corporate strategic documents for the Shire have been reviewed in the context of coastal planning and management. The Community Strategic Plan 2033 provides a *20-year* framework to protect the natural environment, strengthening communities, fostering local economic prosperity, and responsibly managing the community's infrastructure and assets (AMRSC, 2013a). The development of a Climate Change Response Plan is identified, one component of which is this CHRMAP. The Shires Asset and Long term Financial Management Plans (AMRSC, 2013b) provide *10-year* management frameworks.

The *10-year* and *20-year* planning periods have been adopted in the development of the CHRMAP. This will align the Shires' coastal management and planning timeframe with the broader strategic planning, asset management and financial management planning timeframes.

1.4.2. State Government

The State Coastal Planning Policy (SPP2.6) provides guidance for decision-making within the coastal zone including managing development and land use change; establishment of foreshore reserves; and to protect, conserve and enhance coastal values. The policy applies to the West Australian coast including tidal reaches of inland waters.

[1] The Shire have advised that Kilcarnup is now vested with Department of Parks and Wildlife.
[2] Consumer surplus is the amount that consumers would be willing to pay if a market price for

The Policy recommends that coastal hazards are avoided over a planning timeframe of 100 years, using coastal setbacks as the primary strategy for new developments. Section 5.5 refers to coastal hazard risk management and adaptation planning, with further guidelines for this process provided in the CHRMAP Guidelines (WAPC, 2014). A hierarchy of adaptation measures (avoid, managed retreat, accommodation, protection) is identified.

Schedule 1 of SPP2.6 provides guidance for calculating the component of a coastal foreshore reserve required to allow for coastal processes with further detail in accompanying guidelines (WAPC, 2013a). It is noted however that factors other than coastal processes may require additional width (). The guidelines are based on a 100 year timeframe.

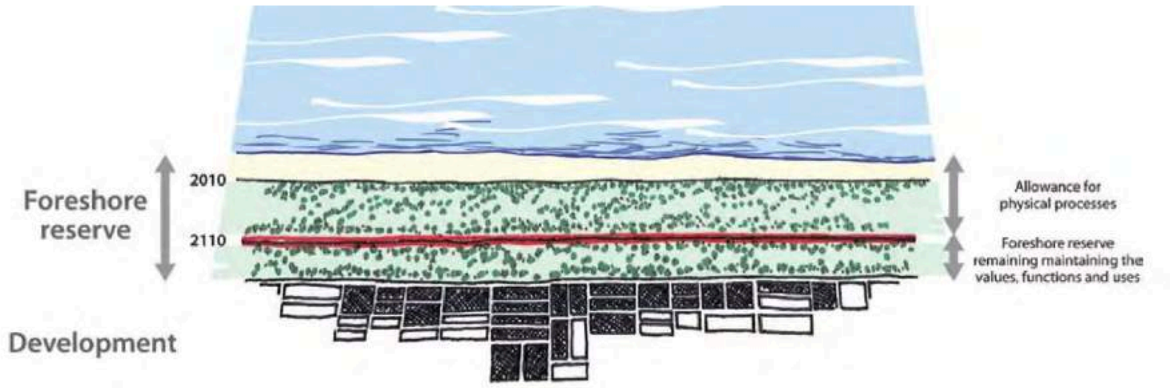

Figure 1.4 Coastal Foreshore reserve – Sandy Coast Example

Schedule 1 identified a Horizontal Shoreline Datum, which defines the active limit of the shoreline under storm activity. Procedures for calculating coastal setbacks, depending upon shoreline type, are identified and require consideration of:

- S1 Erosion: Allowance for the current risk of storm erosion
- S2 Erosion: Allowance for historic shoreline movement trends
- S3 Erosion: Allowance for erosion caused by future sea level rise.
- S4 Inundation: Allowance for the current risk of storm surge inundation.

Coastal types identified in Schedule 1 of SPP2.6 include:

- Sandy Coasts: unlithified/unconsolidated sediments, rock is either not present or not dominant.
- Rocky Coasts: continuous rocky substrate that extends to an elevation above the active limit of the shoreline. Three groups of rocks coast are identified:
  - Hard Rock Coast
  - Soft Sedimentary Rock Coast
  - Weakly Lithified Sedimentary Rock Coast
- Mixed Sandy and Rock Coasts
- Tidal Reaches of Inland waters

The Policy notes that the allowance for sea level rise should be based on a vertical sea level rise of 0.9 metres over a 100-year planning timeframe to 2110. The rationale for this 0.9m allowance is identified in Sea Level Change in Western Australia - Application to Planning (DoT, 2010) following review of, among other documents, the IPCC Fourth Assessment Report (IPCC, 2007). This 0.9m allowance has not been updated by WAPC following release of the IPCC Fifth Assessment Report (IPCC, 2014). Regional climate change assessments for Australia have been undertaken by CSIRO (CSIRO, 2007).

SPP2.6 also notes that the allowance for erosion caused by future sea level rise on sandy coast should be calculated as 100 times the adopted sea level rise value of 0.9m over a 100-year timeframe or 90 metres. This is largely based on adoption of the Bruun conceptual model for sandy coasts (Bruun, 1954).

In the south west, land use planning on the west coast is guided by the Leeuwin Naturaliste Ridge State Planning Policy SPP 6.1 (WAPC, 2013c), and on the south coast by the Augusta-Walpole Coastal Strategy (WAPC, 2009), where coastal erosion mapping has been previously undertaken. The management of the Leeuwin Naturaliste National Park is outlined in the Leeuwin – Naturaliste Capes Area Parks and Reserves Management Plan 2015 (DPaW, 2015). The adjacent coastal waters along this shoreline are gazetted as the Ngari Marine Mark and managed under the Ngari Capes Marine Park Management Plan 2013 – 2033 (DPaW, 2013).

1.4.3. Coastal Adaptation Plans

Western Australia

There are few examples of CHRMAP development in Western Australia as the recent policy was gazetted in July 2013 and CHRMAP guidelines released in Sep 2014. Whilst a large number of studies have applied Schedule 1 of SPP 2.6 (Oceanica and Shore Coastal, 2009) this has been primarily to site new development such that future coastal process impacts are likely to be avoided.

The City of Busselton has developed a number of coastal plans over recent years that follow the intent of the CHRMAP guidelines. In particular, interim coastal erosion modelling maps have been developed that provide an interpretation of development planning setbacks for coastal erosion under a set of possible climate change scenarios and are publically available on the City's website (http://www.busselton.wa.gov.au/Building-Planning/Future-Busselton/Coastal-Planning). The City also has a 5-year rolling coastal management program that identifies strategic coastal monitoring, investigations and coastal adaptation works (Shore Coastal, 2012).

A Coastal Hazard Adaptation and Management Plan has been developed for a master planning process at Scarborough Beach, an urban coastal node (Damara, 2009). The general approach was to minimise exposure of expensive and immobile infrastructure to coastal erosion by locating it relatively landward. Active management, adaptation pathways, coastal monitoring and management triggers were identified.

Coastal hazard mapping has been undertaken at a regional scale for the coastline from Cape Peron (Rockingham) to Cape Naturaliste (Dunsborough) This included mapping of coastal erosion and inundation for the 100 year planning period and an economic assessment of assets at risk (Damara, 2012).

Further regional scale coastal adaptation planning undertaken in Western Australia is identified in the Department of Planning's Coastal Vulnerability Assessment Western Australia project list (www.planning.wa.gov.au/dop_pub_pdf/CVA_WA_list.pdf).

Australia Wide

Geoscience Australia have completed a 'First-Pass' Australian National Coastal Vulnerability Assessment ((Department of Climate Change, 2011), (Cechet, Taylor, Griffin, & Hazelwood, 2011)). This report was commissioned by the Australian Government Department of

Climate Change (Department of Climate Change, 2009) to assess the vulnerability of coastal communities to rising sea-levels. This first-pass national assessment includes an evaluation of the exposure of infrastructure (residential and commercial buildings, as well as roads and major infrastructure such as airports) to sea-level rise and extreme storm water levels.

National coastal adaptation planning is presently being undertaken through the Australian Climate Change Adaptation Research Network for Settlements and Infrastructure (ACCARNSI). This will include the development of a National Coastal Adaptation Framework over the next few years. A database of current coastal adaptation planning is publically available through this network. (www.nccarf.edu.au/settlements-infrastructure).

1.4.1. Coastal Planning Guidance for Weakly Lithified Sedimentary Rock Coasts

There is limited planning guidance on erosion allowances for weakly lithified sedimentary rock coasts in Western Australia. These coasts comprise poorly cemented or semi-lithified, discontinuous, relatively soft or highly weathered, weak rock. They typically feature low steep cliffs, which are easily undercut often forming wave cut platforms. Shoreline retreat is comparatively rapid compared to other types of rocky coasts and generally occurs by slumping, rock-falls, or slab collapse (SPP2.6 Section 3.2.3).

SPP2.6 (Section 4.5) notes a planning allowance for erosion should be based on a geotechnical assessment of shoreline stability, and should include consideration of slope elevation, slope angle, durability of material, consistency of material, angle of bedding layers and thickness of bedding layers.

In South Australia, the Coast Protection Board has developed a management strategy for coastal cliff erosion hazards (CPB, 2014)(CPB 2014). Management strategies are outlined including education and awareness training, controlling access, development control, land use regulation, stabilisation, monitoring, research and modelling. It is noted that

"Coastal cliff erosion is a natural process and so it is not feasible to prevent it entirely. Coastal cliff hazards need to be assessed on an individual basis by geotechnical experts, local councils, communities, businesses and other relevant stakeholders to explore not only the practicality of managing the hazard but the potential impacts of the management options."

The Australian Geomechanics Society (AGS) provides guidelines on slope management and maintenance, as part of the landslide risk management guidelines developed under the National Disaster Funding Program (AGS, 2007a). Landslides are identified as any movement of a mass of rock, debris, or earth, down a slope. AGS 2007 note:

"Landslides occur as a result of local geological and groundwater conditions, but can be exacerbated by inappropriate development (GeoGuide LR8), exceptional weather, earthquakes and other factors. Some slopes and cliffs never seem to change, but are actually on the verge of failing. Others, often moderate slopes, move continuously, but so slowly that it is not apparent to a casual observer. In both cases, small changes in conditions can trigger a landslide with serious consequences. Wetting up of the ground (which may involve a rise in ground water table) is the single most important cause of landslides (GeoGuide LR5). This is why they often occur during, or soon after, heavy rain. Inappropriate development often results in small scale landslides which are very expensive in human terms because of the proximity of housing and people."

1. Rotational or circular slip failures
2. Translational slip failures
3. Wedge Failures
4. Rock falls

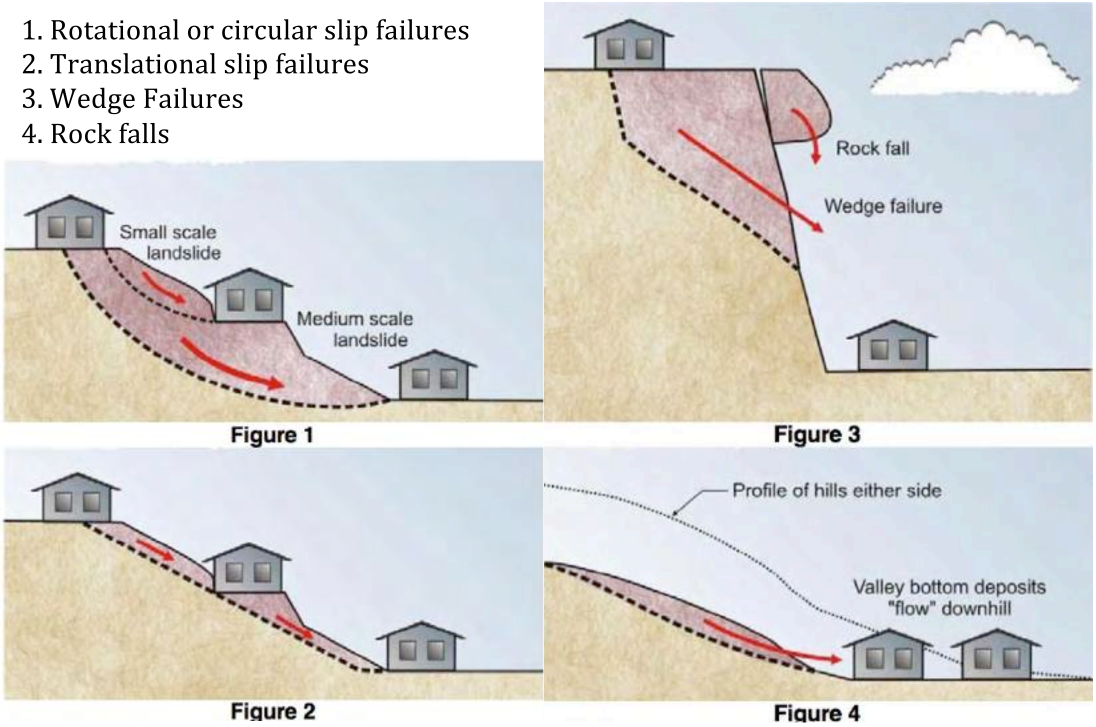

Figure 1.5 Slope Failure Modes (AGS, 2007b)

1.4.1. *Implications for CHRMAP*

The following is noted in regard to the review of planning controls and the implementation of this CHRMAP:

- The CHRMAP process is relatively new in Western Australia and requires a case-by-case application of the guidelines.
- The State Coastal Planning policy and guidelines provide methods for coastal risk assessment and have been adopted in this study.
- The *10-year* and *20-year* planning periods have been adopted in the development of the CHRMAP. This will align the Shires' coastal management and planning timeframe with the broader strategic planning, asset management and financial management planning timeframes.
- Guidance on assessing the potential stability of weakly lithified sedimentary rock coasts is limited.

2. Stage 1 - Risk Identification

Risk identification establishes an understanding of historic and potential impacts of erosion and storm surge inundation on the assets and their values, including from climate change and associated sea level rise. Erosion and inundation risks need to be considered (WAPC, 2014).

An initial review of coastal types (e.g. hard rock, weakly lithified sedimentary rock, sandy coast) within the Shire was undertaken, as the response to erosion and inundation risks varies with coastal type. These coastal types were classified using the online coastal landform and landform stability mapping (Smartline database), and guidance provided in Schedule 1 of the State Coastal Planning Policy regarding coastal types in Western Australia.

An evaluation of the coastal processes contributing to coastal change in the Shire was undertaken. This initially identified the exposure of the seven (7) study areas to variable coastal processes. For example, Gnarabup is exposed to ocean waves dissipating across offshore reefs, whilst Molloy Island is exposed to river flooding.

The assessment of coastal type and coastal processes allowed an initial identification of coastal infrastructure potentially exposed to coastal processes at each project site. Coastal infrastructure located close to the coast (within 200m) or relatively low lying (below 5m AHD) was identified through site inspections, analysis of aerial imagery and available topographic data (Attachment 1 Risk Identification Drawings). Shire cadastral information was assessed to identify the proximity of property and road reserve boundaries to the coast. This provided an initial list of coastal infrastructure potentially exposed to coastal processes for further analysis.

2.1. Coastal Classification

Coastal types have been assessed for the Shire using a publically available online database that provides preliminary coastal landform and landform stability mapping for the entire Australian. This is known as the Smartline database (University of Tasmania, 2009). Landform types for the Shire of Augusta Margaret River have been sourced from this database and imported into QGIS (Quantum GIS Development Team, 2015). This allowed coastal classification at study sites, which is a primary factor in identifying risk to coastal infrastructure.

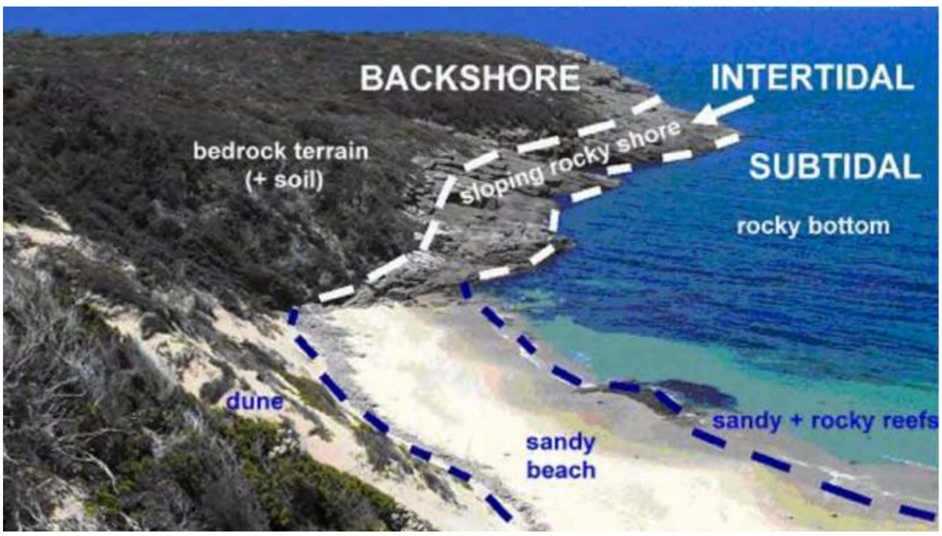

Figure 2.1 Landform Types in the Coastal Zone (Smartline database)

Site inspections were undertaken by a coastal engineer in December 2014 and March 2015 to confirm coast type, using classifications from SPP 2.6. A wide variety of coast types were observed throughout the Shire. Some differences in landform and coast type definitions and terminology are apparent between the Smartline database and SPP2.6. For example, the Smartline database does not specifically identify Weakly Lithified Sedimentary Rock Coast. High and Low Calcarenite Cliffs are identified in these areas at Prevelly. The Weakly Lithified Sedimentary Rock Coast at South Point in Gracetown is identified in the Smartline database as 'Foredune Eroding'.

Detailed drawings have been developed for each project site identifying the coast type along the foreshore (Intertidal) and foredune (Backshore proximal) and are provided in Attachment 1 Risk Identification Drawings. Further consideration of coast type, particularly weakly lithified sedimentary rock coasts, is undertaken in Stage 2 (Risk Analysis).

Examples of the variety of coast types around the shire are presented in Figure 2.2 to Figure 2.4.

Figure 2.2 Examples of Weakly Lithified Sedimentary Rock Coast Type

(a) South Point Carpark Access Stairs (Gracetown) (b) Southern end of Melaleuca Beach (Gracetown) (c) Base of the Cliffs at Surfers Point (Prevelly) (d) Beaches south of Gracetown.

Figure 2.3 Examples of Sandy Coast Type
(a) Gnarabup Coastal Path (b) Cowaramup Bay Swimming Beach, Gracetown (c) Hamelin Bay Beach and (d) Albany Terrace, Augusta South.

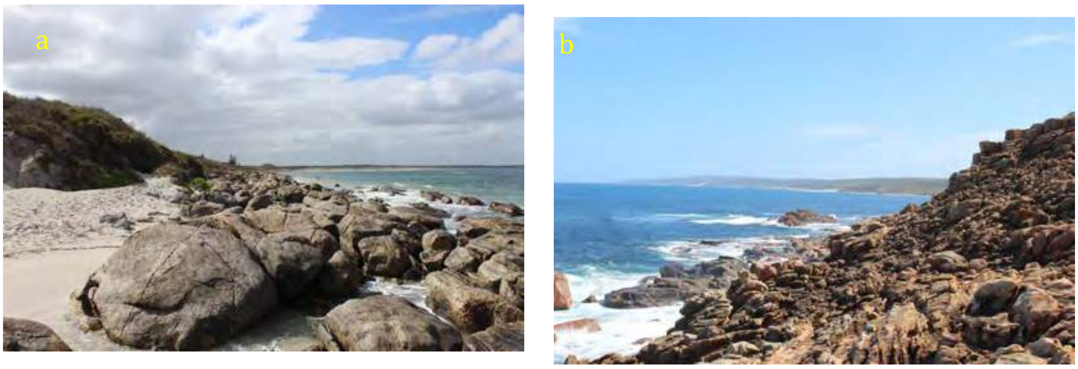

Figure 2.4 Examples of Hard Rock Coast Type
(a) Flinders Bay Coastline, Augusta South (b) North Point, Gracetown.

2.2. Regional Coastal Processes

The project brief notes there is minimal information in the Shire on the influence of natural processes on the coastal environment. However, available reports have been reviewed and metocean data collated and analysed to provide a succinct outline of regional coastal processes at the project sites (waves, water levels, sediment transport).

Coastal processes and the geomorphology of the southwest region are broadly outlined in Geoscience Australia Geomorphology and Sedimentology of the South Western Planning Area (Richardson, Mathews, & Heap, 2005) and the Shires coastal management plans (Landform Research & Coastwise, 2005), (Tingay, 1993). Limited additional information to the landform databases is provided in these reports regarding coastal types in the Shire.

Local coastal processes assessments are available for Gnarabup associated with the boat ramp (DoT, 1995a), (MRA, 2001) and more recently the erosion at Gnarabup (Shore Coastal, 2014). However, there is limited information on coastal processes for other exposed areas of the west coast.

Coastal processes assessments for the Augusta region are generally associated with the boat harbour planning and construction (MJ Paul & Associates, 2004), (DoT, 2012). Within the Blackwood River detailed estuarine processes studies and geomorphic mapping were undertaken in the 1970s (DEC, 1975). More recently flood modelling has been undertaken in the lower Blackwood River by the Department of Water (DoW, 2014).

2.2.1. Water Levels

The southwest region of Western Australia experiences mainly diurnal, microtidal conditions. Tide predictions are available for Flinders Bay and Cowaramup Bay. However the nearest tidal gauge with real time water level measurements is at Port Geographe in Busselton. The nautical chart (Aus 335) suggests limited regional variability in MHHW and MLLW levels between Flinders Bay and Busselton. No tidal plane data is indicated on this nautical chart for Cowaramup Bay.

Table 2.1 summarises the tidal planes and extreme water level distribution at Port Geographe based on data from 2002 to 2014. It is noted that inshore water levels along the Leeuwin Naturaliste coast are influenced by wave breaking, refraction and storm surge and the morphology of inshore lagoons and bays. Non-tidal water level processes inferred from Port Geographe observations are not considered representative of the fluctuations along the Leeuwin-Naturaliste coast, yet provide the best available regional data for coastal planning. Conditions at Augusta have been extrapolated by the Department of Transport (DoT) from the tide Gauge at Albany for the boat harbour design (DoT, 2012). Significant variance is noted between the 100yr Return Period water levels for Busselton and 100yr Return Period water levels Augusta provided by DoT. This is likely to be influenced by the increased exposure at Busselton to storm surge during northerly storms.

Table 2.1 Tidal Planes and Extreme Event Analysis

	Tidal Planes					**Extreme Event Analysis**			
Water Level	LAT	MLLW	MSL	MHHW	HAT	1yr RP	10yr RP	20yrRP	100yr RP
Busselton (mAHD)	-0.5	-0.1	0.0	0.4	0.8	1.1	1.5	1.6	2.0
Augusta (mAHD)	-0.6			0.4	0.8	0.9	1.1	1.1	1.1

Note: Water levels have been rounded to nearest 0.1m.

At Gnarabup, inshore water levels were recorded at the existing boat ramp and an alternate site adjacent to Georgette Way over a 3-week winter period (Aug & Sep 2000) and 3-week summer period (Dec 2000 / Jan 2001) (MRA, 2001). The length of recorded data is insufficient to provide a meaningful assessment of tidal constituents or extreme event analysis.

Both ocean conditions and runoff influence water levels within the lower Blackwood Estuary. Flood modelling has been undertaken for the lower Blackwood River estuary by the Department of Water (DoW, 2014). Figure 2.5 illustrates the typical flood plain management strategy and includes a representation of the key river flooding concepts and terminology.

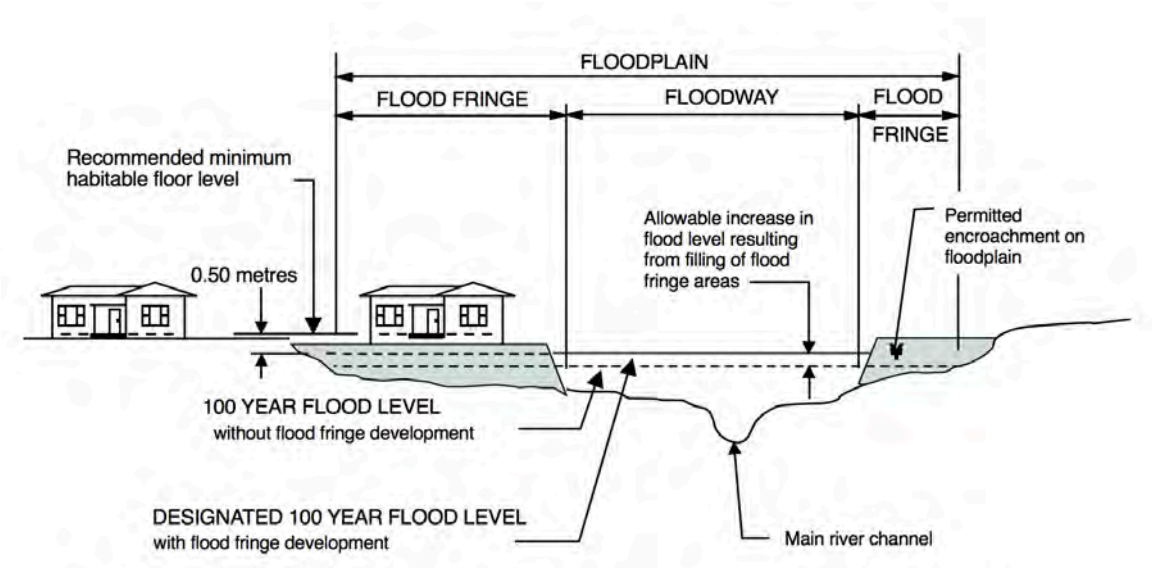

Figure 2.5 Typical Flood Plain Management Strategy (Water and Rivers Commission, 2000)

2.2.2. Sea Level Rise (SLR)

Coastal adaptation planning requires consideration of the potential impact of Sea Level Rise on the coast. Figure 2.6 shows the recommended allowance when planning for Sea Level Rise in Western Australia based on the report on Sea Level Change in Western Australia - Application to Planning (DoT, 2010). SPP2.6 Schedule 1 Section 4.4.3 provides an horizontal allowance for Sea Level Rise (SLR) as a component of the coastal setbacks

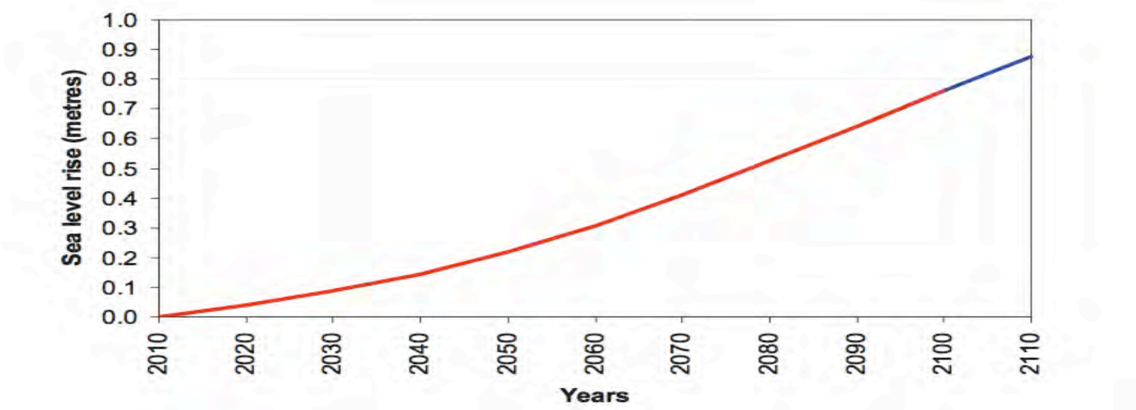

Figure 2.6 Recommended Allowance for Sea Level Rise in Coastal Planning for WA

Note: red line SRES scenario A1FI 95th percentile after Hunter (2009), normalised to 2010, blue line continuation of scenario to 2110)

The allowance for Sea Level Rise for the planning timeframes identified in Section 1.1 and 2.1.2 is summarised in Table 2.2. In addition this table outlines estimates of the 100 year average recurrence interval (ARI) water level, including SLR, for the relevant planning timeframes.

Table 2.2 Allowance for Sea Level Rise for Planning Timeframes

Planning Timeframe	Predicted Sea Level Rise (m)	100 Year ARI Water Level (m AHD) Busselton	100 Year ARI Water Level (m AHD) Augusta
Present Day (c2015)	0	2.0	1.1
10 years	0.04	2.04	1.14
20 years	0.1	2.1	1.2
100 years	0.9	2.9	2.0

Note: The 0.9m value for SLR has been adopted for the 100year planning period from 2015.

2.2.3. Waves

Regional Wave Climate

The regional wave climate has been described in Geoscience Australia Geomorphology and Sedimentology of the South Western Planning Area (Richardson, Mathews, & Heap, 2005). The Recherché Shelf is a high energy environment dominated by Southern Ocean swells (Figure 2.7) and storms.

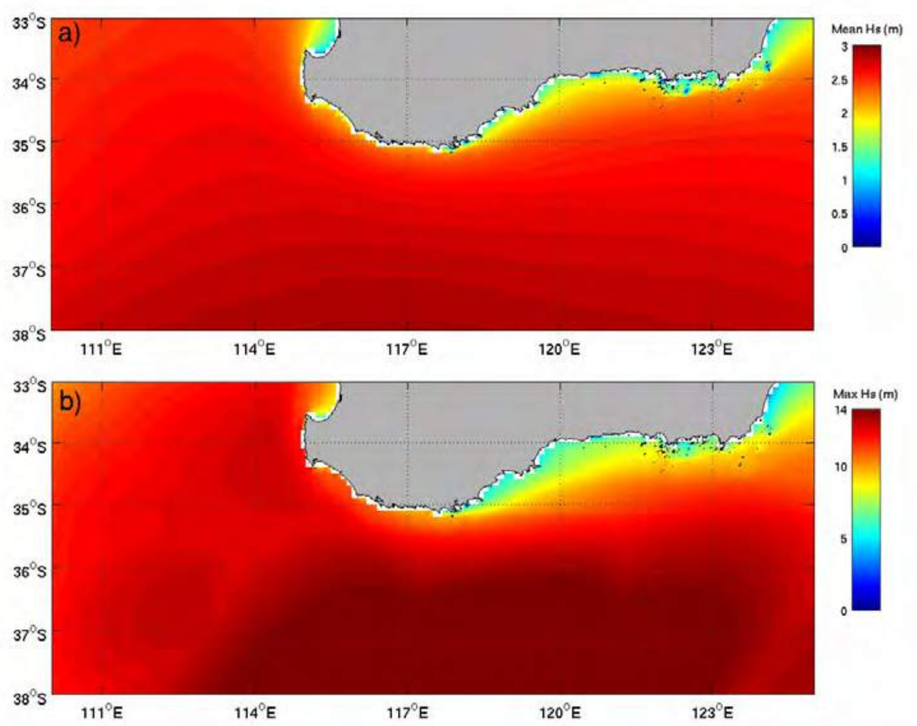

Figure 2.7 Map showing significant wave height for the SW region.

Mean wave height (a) is the height of the highest 1/3 if waves based on a seven year mean (Feb 1997 – Feb 2004), and (b) shows maximum wave height for the same period. The SW coastline is exposed to swell and storm waves from the Southern Ocean (Richardson, Mathews, & Heap, 2005).

Modal deep-water wave conditions along the southern margin are high energy long period swell waves from the southwest. Long period Indian Ocean swell generally finds landfall on the Leeuwin Naturaliste coast. Mean wave heights in the order of 2.5m and maximum wave heights in excess of 10m are evident immediately offshore, beyond the influence of wave refraction, diffraction, breaking and shoaling by nearshore reefs and platforms.

Offshore wave conditions are recorded at Cape Naturaliste in 48m water depths. Records are available since 1994 and are considered to be representative of offshore wave conditions along the Leeuwin Naturaliste coast. Extreme event analysis of this wave data was undertaken to assess offshore wave height return periods for modelling during the risk identification phase.

Seasonal Variability

Further analysis as part of this study of Cape Naturaliste wave data identified seasonal variability in wave height and direction (Figure 2.8),. Whilst increased wave heights during winter are evident, seasonal variability in offshore wave direction is also evident. For example, wave direction was predominantly from the southwest during summer period of 2013 (March 2013 and December 2013), while the winter period of 2013 (June and September 2013) had an increased prevalence of westerly waves. In addition there is greater range of wave directions during the summer period compared to the winter period.

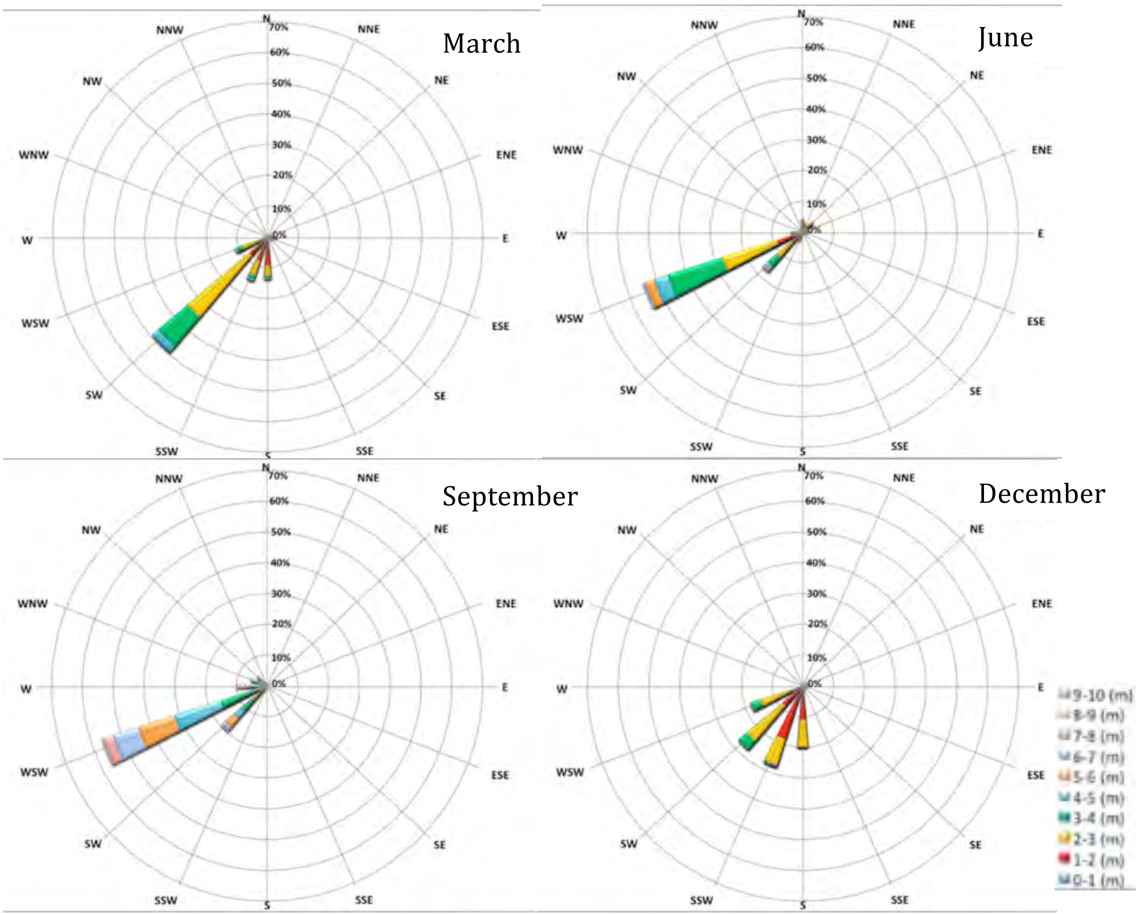

Figure 2.8 Seasonal variability in wave direction at the Cape Naturaliste offshore wave buoy.

Note wave direction primarily SW in March 2013 and WSW in June and September 2013.

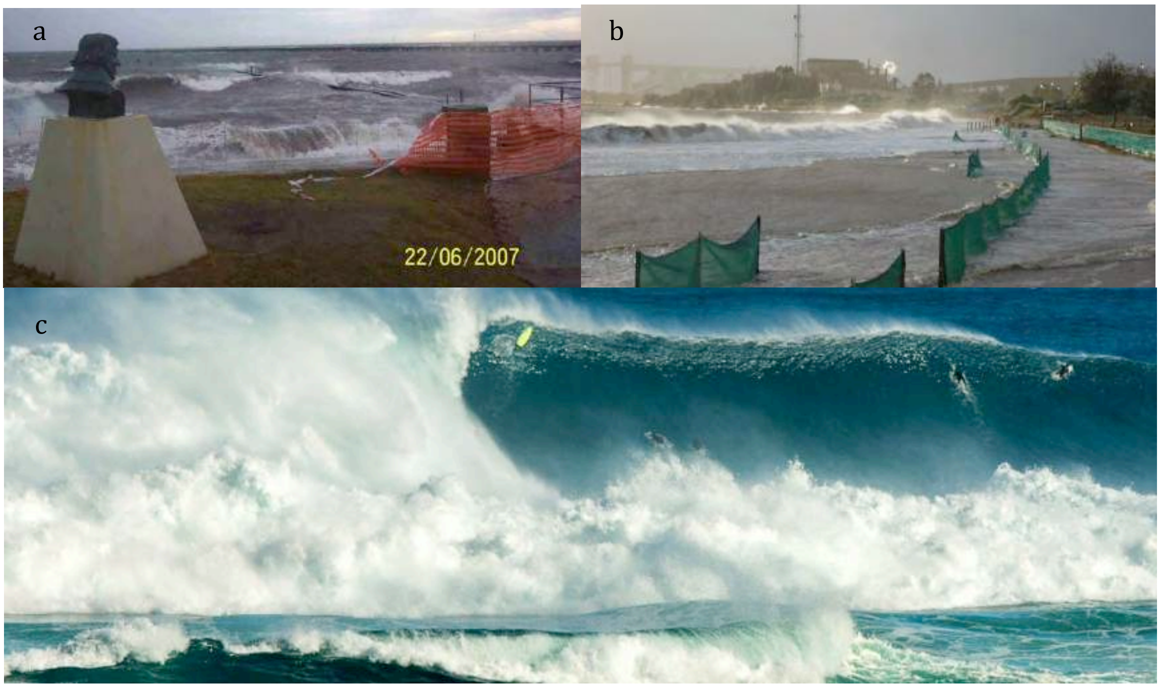

Figure 2.9 Types of Waves with Storm Seas at Busselton and Bunbury (a and b) and Large Swells at Gnarabup (c)

Nearshore Wave Processes

There are a number of processes in the nearshore that can limit the height of waves that impact on the beaches Figure 2.9. These include wave refraction, diffraction, friction, shoaling and breaking.

Nearshore reefs and rock platforms typically act to limit wave heights inshore due to wave breaking. With higher water levels, during to storm surges and high tides, the water depth over the nearshore reefs and platforms is greater resulting in larger waves inshore. Sea level rise will allow increased wave energy to penetrate to the beaches, which may result in a more dynamic coastline. Figure 2.10 shows how the reefs offshore of Gnarabup Back Beach break the wave energy offshore on reefs and platforms creating a calmer lagoon inshore and at the beaches.

Figure 2.10 Aerial Image Illustrating Wave Breaking on Reefs and Platforms at Gnarabup Back Beach

The orientation of the coastline and the direction of any sea/swell also have an influence on the inshore wave height. Along the Leeuwin-Naturaliste coast, beaches facing to the west and south west are more exposed to the predominantly southwest swell and storm direction, which can result in larger wave heights at the inshore areas. However beaches orientated to the north or that are sheltered by headlands have less exposure to the southwest swells and storms. This can result in smaller wave heights inshore. Figure 2.11 illustrates how the northerly orientation of Cowaramup Bay and sheltering from South Point affords Cowaramup Bay Swimming Beach shelter from the predominant swell direction.

Figure 2.11 Aerial Image Illustrating Wave Refraction and Breaking at Gracetown.

The coast south of Augusta experiences a different wave climate to that experienced along the west facing Leeuwin Naturaliste coast. Due to the coast's orientation it is largely sheltered from southwest swell and westerly storms that affect the southwest. Instead this coast is exposed to storms and swells from the south and east. It is also exposed to sea waves generated by the southerly sea breezes experienced in summer. Figure 2.12 shows the types of waves experienced along the east facing coast to the south of Augusta. Wave analysis within Flinders Bay has been undertaken by the Department of Transport for the Augusta Boat Harbour (DoT, 2012).

Figure 2.12 Wave Conditions Experienced within the Flinders Bay Area (South Augusta)

Wave heights at Molloy Island within the Blackwood River are influenced by wind driven waves on the exposed southern shores and boat wakes on the higher vehicle traffic shores (see Figure 2.13). There are, however, no known records of local wave heights.

Figure 2.13 Boat Wake Wave Conditions Experienced at Molloy Island

2.2.4. Sediment Characteristics

Sediment characteristics provide an indication of active coastal dynamics and may help to determine the extent of compartmentalisation that occurs on the Leeuwin-Naturaliste and Flinders Bay coasts. Compartmentalisation is an important factor in the potential for beach recovery after a period of erosion and may also influence the way in which the coast responds to long-term sea level rise. A 'sediment cells' hierarchy has been developed for parts of the Western Australia coast to describe the patterns of compartmentalisation, which is recommended in SPP 2.6 as a spatial framework for evaluation of coastal change.

Sediment cells have not yet been defined for the Leeuwin Naturaliste coastline or Flinders Bay. However, headlands at Cowaramup Point, Cape Mentelle, Cape Freycinet, Cosy Corner and Cape Leeuwin are expected to provide significant control on alongshore sediment transport and suggest natural sediment compartments.

Site inspections identify Gracetown as a relatively discrete sediment cell depending upon the capacity for sediments to be transported around South Point.

Sediment sampling in the Prevelly/Gnarabup area identified consistent medium/coarse sand with a high shell content from the Margaret River entrance to South Gnarabup. Visual analysis identified sediments south of Gas Bay as significantly finer with a lower observed shell content (see Figure 2.14). The nature of these sediments, and the capacity for beach material at Gnarabup to be transported around Gnarabup Headland and Surfers Point, requires consideration in understanding the potential recovery of the Gnarabup Beaches from storm erosion.

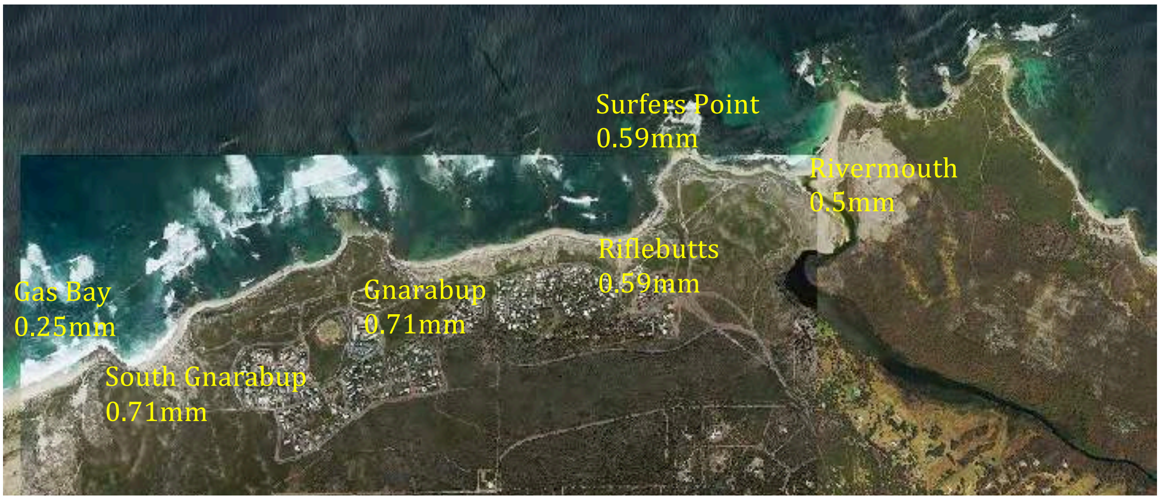

Figure 2.14 Distribution of Median Sediment Sizes from Gas Bay to the Prevelly Rivermouth

Sediment sampling in Flinders Bay identified coarse material between the water wheel on the west coast and Ringbolt Bay within Flinders Bay. North of the granite headland at Ringbolt Bay the observed sediments are significantly finer (Figure 2.15). The distinct differences in sediment size between the beaches in Flinders Bay and those closer to Cape Leeuwin requires further consideration. In particular, it suggests material on the Flinders Bay beaches is at the southern end of a local sediment cell that includes the sandy beach north of the Blackwood River mouth. Future coastal monitoring and investigation of these beaches should consider the influence of this local sediment cell on observed beach erosion.

Figure 2.15 Distribution of Median Sediment Sizes from Cape Leeuwin to the Blackwood River Cut

Figure 2.16 Sediment sampling showing sediment variability at adjacent sites (South Gnarabup/Gas Bay and Ringbolt Bay/Dead Finish).

2.3. Assets Potentially Exposed to Coastal Processes

The initial risk identification included a broad scale assessment of the wider Shire coastline, an initial assessment of assets potential exposed to coastal processes (inundation and erosion) and the potential coastal response to changes in environmental variables. This provided context and background to the detailed risk analysis of the project sites

2.3.1. Broad Scale Assessment

2.3.2. The scope of the present study focuses on seven identified study sites. However,

a broad scale assessment of the Shire's coast was undertaken to identify areas where coastal hazards may require consideration by management agencies at some time in the future, but are outside the scope of the present study. Site inspections and landform data were used to identify the following sites that may require consideration by relevant agencies in the future:

- Coastal nodes within the Leeuwin Naturaliste National Park managed by the Department of Parks and Wildlife. These nodes are primarily beach access points for surf breaks, swimming beaches and coastal walk trails. These include, but are not limited to, Gallows, Guillotines, Lefthanders, Ellensbrook, Redgate, Contos, South Beach, Cosy Corner and Elephant Rock. These sites are managed under the Management Plan for the Leeuwin Naturaliste National Park (DPaW, 2015).
- Kilcarnup Beach
- The coastline from Cape Leeuwin to the Augusta Boat Harbour. In particular there is a narrow dune buffer to the coastal road immediately south of the Harbour with recent evidence of erosion.
- East Augusta
- Recreational sites further upstream on the Blackwood River including the Alexander Bridge camping area.
- The coastline east of the Blackwood River Entrance. Coastal erosion setbacks have been assessed for this coastline in the Augusta Walpole Coastal Strategy (WAPC, 2009)

2.3.3. Assets Potentially Exposure to Coastal Processes (Study Sites)

The assessment of coastal type and coastal processes allowed an initial identification of coastal infrastructure potentially exposed to coastal processes at each project site.

Preliminary identification of coastal assets at risk of either erosion or inundation hazard was undertaken by considering spatial domains simply based on horizontal or vertical proximity to the coast:

- A nominal 200m horizontal allowance for coastal erosion was considered based upon the following nominal setback allowances:
    - S1: 40 meters (previous default value in state coastal planning policy)
    - S2: 50 meters (0.5m/yr over 100 years)
    - S3: 90 meters (SPP 2.6 allowance)
    - FOS: 20 meters (SPP2.6 allowance)

  This was undertaken prior to any detailed risk assessment of the project sites and was considered, based on experience at other sites, to be a reasonable allowance for the initial risk identification.
- Available topography was limited to 5m intervals, and therefore the 5mAHD contour line was used as a simple indicator of inundation hazard exposure. It was recognised that wave runup may reach a higher level, but only at the coastal margin and therefore it is incorporated within the horizontal limit.

Coastal assets either below the 5m AHD contour or within 200m of the coast were identified and documented using aerial imagery, Shire cadastral data and site inspections. The 5mAHD contour was the lowest available contour above a nominal 100yrRP water level, plus an allowance for sea level rise, at all project sites. The 200m represents an allowance for coastal processes for the 100 year planning timeframe a sandy coastline with an erosion trend of 0.5 meters per year.

Table 2.3 Summary of Risk Identification at the Project Sites

Project Site	Potential Exposure to Coastal Processes	Drawing Reference
Gracetown	-Single access road is within 200m setback and a few sections are below 5.0mAHD. -Public infrastructure at Gracetown swimming beach and Melaleuca Beach reasonable low lying with narrow dune with evidence of recent erosion. -Public infrastructure at Southpoint has narrow setbacks to high erodible cliffs. -Foundations of Huzzas access stairs piles exposed. -Private property seaward of Bayview Road and shop within 200m setback.	SC1411-1-1A
Prevelly	-Public infrastructure at River Mouth has narrow setbacks to an eroding foreshore influenced by the migration of the river mouth and river flow. -High value development of Surfers Point adjacent to high erodible cliffs. -Limestone coastal path has narrow dune setbacks and evidence of recent erosion. -Small number of private properties along Mitchel Drive within 200m setback.	SC1411-2-1A
Gnarabup	-Public infrastructure at Gnarabup has narrow dune setbacks and recent evidence of erosion. -Limestone coastal path has narrow dune setbacks and evidence of recent erosion. -Foundations of timber beach access stairs north of Cafe exposed. -Significant drop off from lower timber stair to beach at many timber beach access stairs along Gnarabup Beach. -White Elephant café has narrow dune setbacks and recent evidence of erosion. Timber deck recently adapted (wall removed, depth of timber piles extended). -Significant drop off from lower timber stair to dune at new composite beach access stairs at Grunters and Gas Bay. -Coastal carparks at Gnarabup and Gas Bay within 200m setback. -Cadastral boundaries for some development seaward of Wallcliffe Road within 200m setback.	SC1411-3-1A
Hamelin Bay	-Public infrastructure at Hamelin Bay has narrow setback but with some protection provided by a buried limestone revetment. -Caravan Park within 200m setback. Gnarabup has narrow dune setbacks and evidence of recent erosion.	SC1411-4-1A
Molloy Island	-Public infrastructure is primarily associated with recreational boating and has some resilience to coastal processes -Public infrastructure not well documented, but well understood and managed locally by Residents Association. -Large number of private properties within nominal 200m setback *and* below 5.0mAHD. It is noted however application of a 200m setback for inland waters likely to be conservative.	SC1411-5-1A
Augusta North (Blackwood River)	-Public access path along foreshore has narrow setbacks and low lying. -Public infrastructure associated with recreational boating and has some resilience to coastal processes -Large number of private properties within nominal 200m setback. It is noted however application of a 200m setback for inland waters likely to be conservative. - Large number of private properties below 5.0mAHD between Hillview Road and the Cut, including the Turner Caravan Park -Significant recent coastal changes at Blackwood River Mouth (the Cut)	SC1411-6-1A
Augusta South (Flinders Bay)	-Public access path along foreshore has narrow setbacks. -Large number of private properties seaward of Turner St and at Flinders Bay settlement within nominal 200m setback. - Modest number of private properties adjacent to Deere St below 5.0mAHD. - Flinders Bay Caravan Park and a small number of private properties in Flinders Bay below 5.0mAHD -Significant recent coastal changes at Blackwood River Mouth (the Cut)	SC1411-7-1A

2.3.4. Changes to Environmental Variables

Engineers Australia provides guidelines for responding to the effects of climate change in coastal and ocean engineering (EA 2013). A method is provided to assess the potential coastal response to changes to key environmental variables, which include mean sea level, ocean currents and temperature, wind climate, wave climate, rainfall / runoff and air temperature. Potential implications of changes to these variables on coastal behaviour in the Shire of Augusta Margaret River are summarized in Table 2.4.

Table 2.4 Potential Coastal Response to Changes to Environmental Variable.

Environmental Variable	Risk Identification	Potential Coastal Response
Mean Sea Level	Increase in Mean Sea Level of 0.9m over 100 years from 2010 to 2100	-Landward migration of shoreline. -Increased frequency of inundation in low-lying areas. -Increased inshore wave energy as nearshore reefs provide a lower level of protection to beaches. -Change to entrance sand bar heights in seasonally opened entrances.
Ocean Currents and Temperature	By 2030 the best estimate of sea surface temperature change is 0.4-1.0°C using the A1B scenario ((CSIRO, 2007)). Beyond 2030 the SST changes are dependent on the emission scenarios	-Influence of Capes and Leeuwin Currents uncertain. -Potential secondary response to mean sea level, primary production and sediment supply.
Wind Climate	Mean wind speeds are predicted to increase in southwest WA in summer and autumn by 2-5% under median scenarios and decrease in winter by 2-5%, with no changes in spring. Overall, the net effect is no less than +/- 2% change in annual means (CSIRO, 2007).	-Influence on local sea breezes and extreme wind events uncertain. -Changes to sea breeze regime may result in changes to presently observed seasonal variability of beaches.
Wave Climate	There are no recent scenarios of the implications of climate change on local or swell- driven waves. However, climate change scenarios move the swell-wave generation zone further south (Damara, 2009a)	-Increased inshore wave energy associated with increase in MSL.
Rainfall Runoff	Rainfall changes projected as a result of climate change suggest a continuing drying climate. Increases in the frequency of occurrence of high intensity precipitation events are possible.	-Potential changes to seasonal river and creek entrance openings. -Potential changes to Blackwood River flooding regime. -Secondary response to stability of weakly lithified sedimentary rock coast.
Air Temperature	Rise in land surface air temperature.	-Secondary response to coastal vegetation.

3. Stage 2 - Risk Analysis

A Risk analysis has been undertaken to consider the potential impact of coastal processes on the coastal settlements (study sites) in further detail using the procedures outlined in the State Coastal Planning Policy. This required consideration of storm erosion of beaches, longer-term coastal recession and the influence of sea level rise on the coast (Attachment 2 Risk Analysis Tables).

Planning timeframes of 10, 20 and 100 years were adopted to align coastal adaptation and planning with the Shire's broader strategic planning, asset management and financial management timeframes.

Drawings have been developed identifying planning allowances for coastal processes for the coastal settlements within a 10-year, a 20- year and a 100-year timeframe. (Attachment 3). Whilst the drawings are not predictions of future shoreline position, they do identify areas where exposure to coastal processes requires consideration in the relevant planning period.

The method applied to assess exposure to coastal processes is based on Schedule 1 of the State Coastal Planning Policy and is broadly summarised as follows:

- Sandy Coast
  - S1 Erosion: Allowance for Current Risk of Storm Erosion – cross-shore erosion modelling (SBEACH) using surveyed beach profiles.
  - S2 Erosion: Allowance for Historic Shoreline Movement Trends – Analysis of vegetation line movement from 2000 and 2013 aerial imagery
  - S3 Erosion: Allowance for Erosion Caused by Future Sea Level Rise – Procedure as outlined in SPP2.6 (100 x 0.9m Sea Level Rise)
  - Factor of Safety: 0.2m/year allowance for uncertainty in coastal setback assessments.
- Hard Rock Coast
  - S4 Allowance for the current risk of storm surge inundation.
  - Assessment of topographic data to determine if future sea levels could overtop rock layer and erode dune area behind (e.g. most of Augusta South Hard Rock Coast and Hard Rock Coast south of Grunters Beach).
- Weakly Lithified Sedimentary Rocky Coast
  - S1 Erosion: Nominal planning allowance for 1 vertical: 2 horizontal for slope failure.
  - S2 Erosion: Analysis of movement from 2000 and 2013 aerial imagery.
  - S3 Erosion: Procedure as outlined in SPP2.6 (100 x 0.9m Sea Level Rise), following review of available geotechnical information at each site.

3.1. Coastal Monitoring Data

The Shire of Augusta Margaret River supplied a range of spatial data to allow the risk analysis of coastal hazards. This has been supplemented by additional data sourced from the Department of Transport (DoT) and Department of Water (DoW). The available spatial data used for this study is summarised in Table 3.1.

Table 3.1 Available Spatial Data

	Gracetown	Prevelly	Gnarabup	Hamelin Bay	Molloy Island	Augusta North	Augusta South
Topographic Data (onshore)							
5m contours (AMRSC, Landgate)	✓	✓	✓	✓	✓	✓	✓
1m contours						✓	✓
Bathymetric Data (offshore)							
High resolution nearshore hydrosurvey (DoT)	✓	✓	✓				
Low resolution offshore bathymetry (charts)	✓	✓	✓	✓	✓	✓	✓
Water Levels							
Ocean water levels (Busselton)	✓	✓	✓	✓			
Ocean water levels (Augusta)							✓
River flood levels					✓	✓	
Wave Heights							
Offshore wave heights (Cape Naturaliste)	✓	✓	✓	✓			
Inshore wave heights			✓				✓
Shoreline Movements							
Rectified aerial photography	✓	✓	✓	✓	✓	✓	✓
Shoreline movements		✓	✓				
Geotechnical							
Smartline coastal type	✓	✓	✓	✓			✓
Landform maps	✓	✓	✓	✓	✓	✓	✓
Geotechnical reports	✓	✓	✓				
Geotechnical logs	✓						

3.1.1. Data limitations

The CHRMAP assessment has been completed with available data. However there are significant data gaps that limit the assessment of coastal asset risk. .

The 5m interval topographic data means the analysis of inundation hazard is limited to a very broad scale assessment. The lack of detailed geotechnical data has also lead to limitations in the ability to asses the influence of coastal processes, particularly in areas of weakly lithified limestone cliffs. As a result a more conservative approach has been adopted resulting in the consideration of a larger coastal exposure area and more coastal assets. More detailed geotechnical and topographic data may allow the coastal exposure areas and the list of vulnerable coastal assets to be refined.

There is good detail on bathymetry data at some sites, however other sites only have very coarse resolution bathymetric data. Consequently the understanding of how waves propagate in the nearshore is limited at these areas. Whilst beach survey profiles were undertaken as part of this study to allow SBEACH erosion modelling, greater resolution bathymetric data would allow a more detailed assessment of wave propagation and sediment transport processes.

There is also a relative paucity of metocean data for the study area. Water level information from Port Geographe has been used which is likely to be conservative.

Offshore wave height information is available from the Cape Naturalise wave buoy, however it is not clear how offshore wave heights relate to nearshore waves without nearshore wave data or wave modelling. Nearshore wave height information would be used to validate modelling of sediment transport and better inform the understanding of wave propagation across nearshore reefs and platforms. Nearshore wave information would also be useful in assessing design conditions for coastal assets.

A key recommendation of this report is to undertake a comprehensive monitoring and data collection exercise that will fill in data gaps and allow a more detailed assessment of coastal asset risk.

3.2. Risk Analysis Mapping

Risk analysis mapping has been undertaken using the procedures outlined in Schedule 1 of SPP2.6. Detailed notes on the assumption underlying the mapping for the 10, 20 & 100 year planning period is provided in Attachment 2 Risk Analysis Tables.

The wide variety of coastal characteristics and coastal types, between and within the project sites, has required a case-by-case application limited by the available data. The coastal characteristics of the project sites include north and west facing embayments exposed to high energy waves, east facing embayments sheltered from high energy waves, river entrances, tidal reaches of inland waterways and an estuarine island.

Coastal types within project sites include hard rock coast, weakly lithified sedimentary rock coast, sandy coast and estuarine shorelines. Within the sandy coastal type, additional sectors have been defined where the coastline behaviour is variable. Some sandy shorelines within project sites have been eroding whilst others are relatively stable.

The method and assumed coastal processes allowances for sandy coasts (S1 + S2 + S3) for the 100 year planning period for each project sites are shown in Figure 3.1 and detailed below. These allowances are the basis for the risk analysis mapping in Attachment 3 Risk Analysis Drawings.

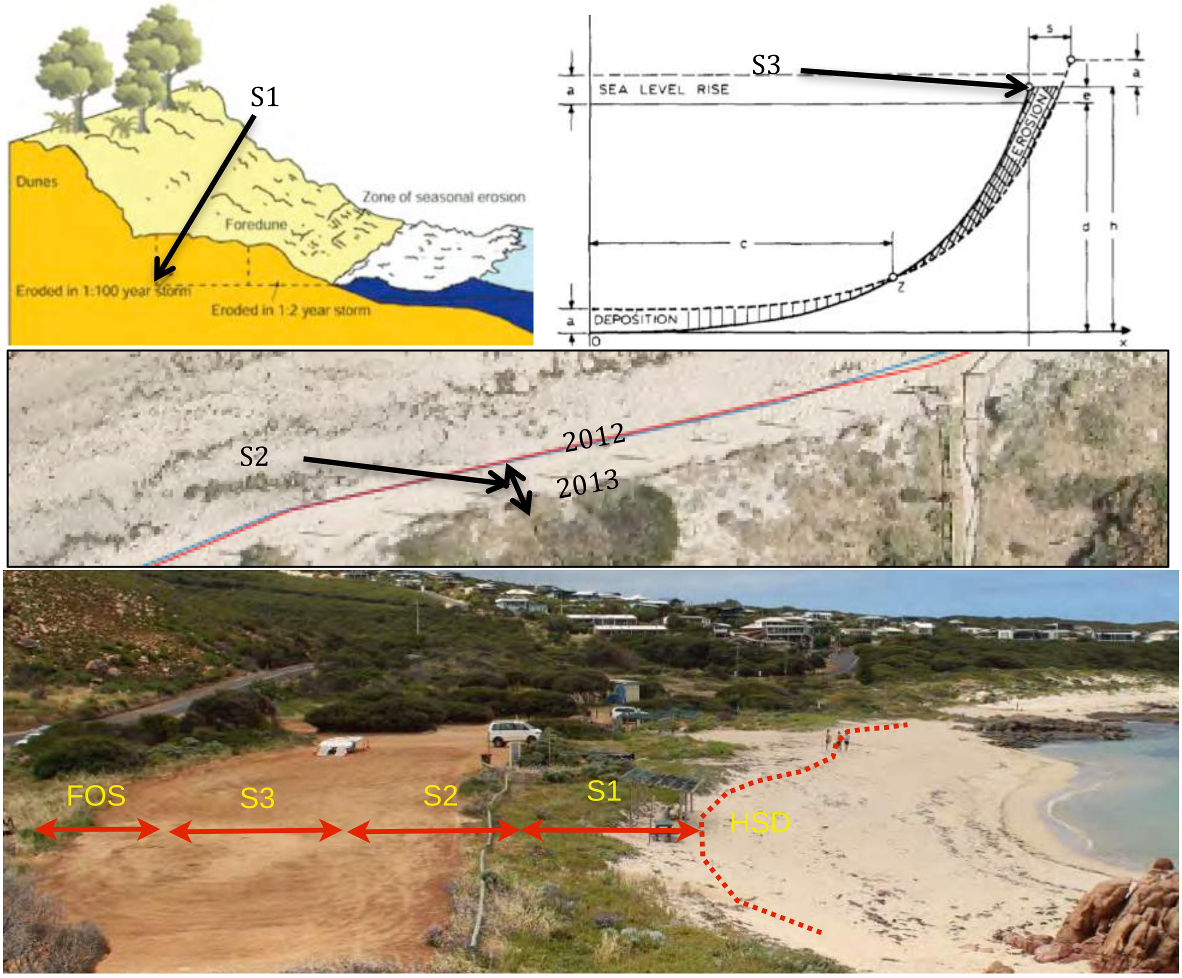

Figure 3.1 Representation of Allowance for Erosion on Sandy Coast Including HSD S1 + S2 + S3 + FOS
Note: HSD – Horizontal Setback Datum, S1 – Allowance for Current Risk of Storm Erosion, S2 – Allowance for Historic Shoreline Movement Trends, S3 – Allowance for Erosion Caused by Future Sea Level Rise, FoS – Factor of Safety (Allowance for Uncertainty)

It should be noted that the risk identification process identified most coastal areas as above the 5m AHD contour, whereas the assumed 100 year ARI water level plus SLR is approximately 3m AHD. As such the primary consideration on the Leeuwin – Naturaliste coast has been the exposure of the sites to coastal erosion. Notwithstanding this there are some low areas in Gracetown and Augusta South. These were surveyed during site inspections and the elevation was found to be at approximately 3.5m AHD in Gracetown and above 3m AHD in Augusta South. Inundation is still considered a key factor in defining the risk zones in Augusta North and Molloy Island, however insufficient data is available to determine the medium and low risk zones for these areas.

3.2.1. Gracetown

Gracetown is a northwest facing embayment exposed to high energy waves. The shoreline position is controlled by a granite headland to the north (North Point) and a lower elongated granite headland, overlaid by sand dunes and weakly lithified sedimentary rock to the south (South Point). Within the bay there are numerous reefs that cause wave refraction and wave breaking, and along the shoreline there are rocky outcrops that provide a secondary control on shoreline position. A small creek drains to the beach along this section of coast. The coastal type includes sandy beaches backed by low dunes from the boat ramp to Melaleucas, weakly lithified sedimentary rock cliffs fronted by boulder beaches, limestone rock fall or narrow, thin perched sandy beaches. Development is associated with the Gracetown townsite and various beach and boating access nodes.

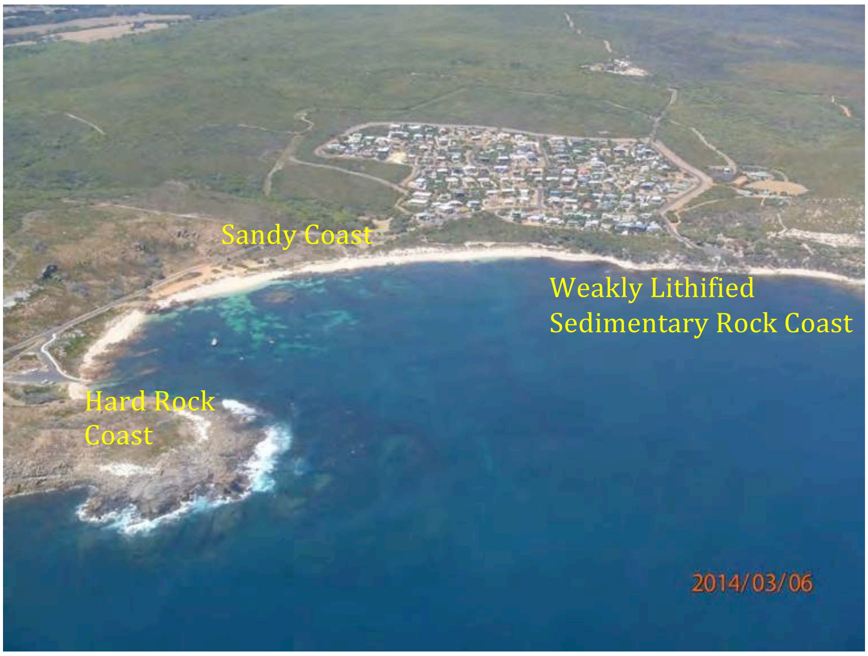

Figure 3.2 Gracetown Oblique Aerial (DoT, 2014)

Three coastal types and five distinct sectors were identified and summarised in Table 3.2. For example whilst the coastal type at the Swimming Beach sector and Melaleucas sector are both sandy beaches, the observed historic erosion rates at these beaches have been different. Coastal erosion allowances have been assessed for each of these five sectors.

Table 3.2 Coastal Processes Allowances – Gracetown (SC1412-1-2C)

Coastal node	**Cowaramup Bay Boat Ramp**	**Cowaramup Bay Swimming Beach**	**Melaleuca Beach**	**South Point Car Park**	**South Point**
Coastal Type[1]	Rocky Coast[2]	Sandy Coast	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast
Assumed Length of Coast (m)	275	300	400	275	550
10yr Coastal Processes Allowance (m)	0	15	20	25	25
20yr Coastal Processes Allowance (m)	0	30	35	35	35
100yr Coastal Processes Allowance (m)	0	130	150	130	130

Notes:
1. Refer Section 2.2. for more detail on coastal type.
2. Whilst there is no allowance for erosion on the rocky coast, areas seaward and lower than the 5.0mAHD contour have been nominally identified as subject to coastal processes for the 10-100year planning timeframe. The available survey data is at 5m intervals and does not allow more detailed assessment of this coastal inundation risk.

Sandy Coast (S1)

The storm erosion allowance (S1) for Gracetown is based on a surveyed profile and bathymetry offshore of the Swimming Beach. SBEACH modelling has been used to estimate S1 for the sandy coasts (US Army Corps of Engineers, 2006). Grain size was based on a visual classification of beach sand in the swash zone. The extent of storm erosion is averaged across the profile (Figure 3.3).

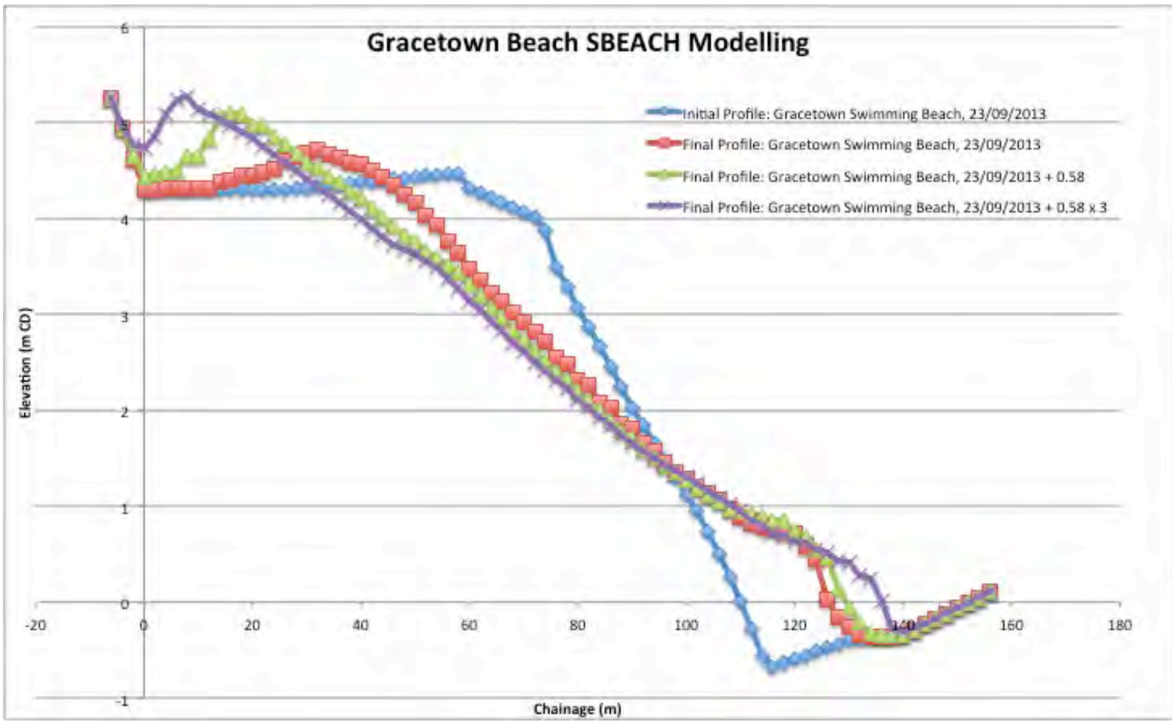

Figure 3.3 Gracetown SBEACH Modelling Output for 10 year, 20 year and 100 year Planning Period.

Weakly Lithified Sedimentary Rock Coast (S1)

Available geotechnical reports for Gracetown (Gordon 1997, Gordon 2002, Gordon 2005, GHD 2013) were reviewed to assess the geological structure of this coastal type and the allowance for storm erosion. There is limited information available and available logs show highly variable substrate of sand, soft rock and hard rock. Figure 3.4 shows the location of available borehole and test pit data for Gracetown.

Figure 3.4 Borehole and Test Pit Locations used for Geotechnical Assessment in Gracetown (GHD, 2013)

There is limited guidance on erosion allowances (S1) for weakly lithified sedimentary rock coasts. These coasts comprise poorly cemented or semi-lithified, discontinuous, relatively soft or highly weathered, weak rock. They typically feature low steep cliffs, which are easily undercut often forming wave cut platforms. Shoreline retreat is comparatively rapid compared to other types of rocky coasts and generally occurs by slumping, rock-falls, or slab collapse (SPP2.6 Section 3.2.3).

SPP2.6 (Section 4.5) notes the allowance for erosion should be based on a geotechnical assessment of shoreline stability, and should include consideration of slope elevation, slope angle, durability of material, consistency of material, angle of bedding layers and thickness of bedding layers. This level of assessment is beyond the scope of the CHRMAP, however Shore Coastal reviewed available reports for this coastal type in the Shire (Gordon 1997, Gordon 2002, Gordon 2005, Landform Research 2005, Baynes Geologic 2006, GHD 2013) and noted:

- The focus of the majority of these reports was rockfall risk to beach users.
- Limited guidance is provided in these reports on erosion allowance/setbacks for infrastructure on top of the cliffs.
- Gordon 2002 noted the angle of repose for "sand and calcarenite rubble" at one site at Gracetown as 36 degrees (1.5H:1.0V) (Gordon 2002).
- The presence of soft layers beneath surface rock and variability of substrate is noted.
- The need for current and ongoing geotechnical inspections and assessment is identified.

This level of geotechnical assessment outlined in AGS guidelines on slope managent (Section 1.4.4) has not been undertaken, is outside the scope of the study for the CHRMAP, and would require a "geotechnical practitioner (GeoGuide LR1) with specialist experience in slope stability assessment and slope stabilization".

However, in this context, the assumption for S1 adopted in the CHRMAP for the weakly lithified sedimentary rock coasts is slumping to an angle of 26.5 degrees (2.0h: 1.0v). This provides a 20m allowance for S1 behind the toe of the cliffs for a 10m high cliff and a basis for strategic coastal planning in these areas. This is flatter than the 36 degrees identified by Gordon 2002 but reflects the uncertainty in the ground conditions and potential modes of failure. Further geotechnical assessments in these areas are recommended.

Historic Shoreline Change (S2)

The historic shoreline change (S2) for each sector was assessed using available rectified aerial photography from 2000, 2012 and November 2013 (i.e. after the September 2013 storms). Historic shoreline change for the rock and weakly lithified sedimentary rocky coasts is limited. Historic erosion was observed at Melaleuca Beach (Figure *3.5*) and south of South Point.

Figure 3.5 *Shoreline Movement Analysis for Gracetown Melaleuca Beach Area*

Note: Figure shows the 2000 (red) and 2012 (blue) Vegetation Line on the 2013 Aerial Image

Allowance for Erosion Caused by Sea Level Rise (S3)

The allowance for erosion caused by future sea level rise (S3) is 90m for both sandy and weakly lithified sedimentary rocks coasts. SPP2.6 (Section 3.2.3) notes that weakly lithified sedimentary rocks coasts comprise poorly cemented or semi-lithified, discontinuous, relatively soft or highly weathered, weak rock. They typically feature low steep cliffs, which are easily undercut often forming wave cut platforms. Shoreline retreat is comparatively rapid compared to other types of rocky coasts and generally occurs by slumping, rock-falls, or slab collapse.

There is not considered to be enough geotechnical information, nor consistency in the substrate evident from existing geotechnical logs (GHD, 2013), to provide a lower allowance than 90m in the CHRMAP for this coastal type. There is considered to be a reasonable potential for this coastal type to have an erosive response to sea level rise within the Shire of Augusta Margaret River due to:

- The potential for unconsolidated material to be present at lower levels where it will be increasingly exposed to wave action (i.e. below 3m AHD).
- The reduction in wave attenuation by nearshore reefs with forecast sea level rise, i.e. higher sea levels will result in deeper water above nearshore reefs allowing more wave energy penetration to the base of the weakly lithified sedimentary rock cliffs (Figure 3.6).

Figure 3.6 Concept for Weakly Lithified Sedimentary Rock Coast Response to Sea Level Rise

3.2.2. Prevelly

Prevelly is a generally west facing coastline with inshore lagoons and offshore reefs exposed to high energy waves. Shoreline position is controlled by weakly lithified sedimentary headlands. Coastal types include the Margaret River mouth, weakly lithified sedimentary rock coast (Surfers Point) and sandy coast (Riflebutts). Thin, perched beaches overlaying rock are evident at Surfers Point whilst the beach at Riflebutts is relatively steep, high and narrow. There is evidence of recent erosion along the Riflebutts shoreline and at the Rivermouth. Development is associated with the Prevelly townsite and coastal nodes at Surfers Point and the rivermouth.

Figure 3.7 Prevelly Oblique Aerial (DoT, 2014)

Two coastal types and four distinct sectors were identified and erosion allowances have been assessed for each of these sectors. The storm erosion allowance (S1) is based on a surveyed profile and bathymetry offshore of the northern beach access at Riflebutts. SBEACH modelling has been used to estimate S1 for the sandy coast. Grain size was based on a visual classification of beach sand in the swash zone.

There are some geotechnical reports for the weakly lithified sedimentary rock coast at Surfers Point, Prevelly (Landform Research 2005, Gordon 1997, Baynes Geologic 2006). Whilst a detailed geotechnical assessment has not been undertaken at Prevelly for the CHRMAP, and is outside the scope of the study, the assumption for S1 adopted in the CHRMAP for the weakly lithified sedimentary rock coasts is slumping to an angle of 26.5 degrees (2.0h:1.0v). This provides a 20m allowance for S1 behind the toe of the cliffs for a 10m high cliff.

The historic shoreline change (S2) was assessed using available rectified aerial photography from 2000, 2012 and November 2013 (i.e. after the September 2013 storms) (see Figure 3.8). Earlier shoreline movement plans were also used to assess historic erosion. These included vegetation lines from 1943, 1965, 1975 and 1991.

Figure 3.8 Shoreline Movement Analysis for Prevelly Rivermouth Area

Note: Figure shows the 1991 (yellow), 2000 (red) and 2012 (blue) Vegetation Line on the 2013 Aerial Image

The allowance for erosion caused by future sea level rise (S3) is 90m to sandy and weakly lithified sedimentary rock coasts. The total combined allowance for coastal processes is outlined in Table 3.3 with more detail presented in Attachment 2 Risk Analysis Tables.

Table 3.3 Coastal Processes Allowances – Prevelly (SC1412-2-2C)

Coastal Node	**Rivermouth Beach**	**Rivermouth Road**	**Surfers Point**	**Riflebutts Beach**	**Prevelly Beach**
Coastal Type	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast	Sandy Coast
Assumed Length of Coast (m)	660	350	700	100	900
10yr Coastal Processes Allowance (m)	20	25	25	25	15
20yr Coastal Processes Allowance (m)	35	35	35	35	30
100yr Coastal Processes Allowance (m)	185	130	130	130	150

3.2.3. Gnarabup

Gnarabup is a generally west facing coastline with inshore lagoons and offshore reefs exposed to high energy waves. Shoreline position is controlled by weakly lithified sedimentary headlands. Coastal types include hard rock coast (Gas Point), weakly lithified sedimentary rock coast and sandy coast. The hard rock at Gas Point is overlayed with sand dunes. Steep high sandy beaches with coarse sediments are backed by high dunes with intermittent limestone outcrops and cliffs from Gas Point to Gnarabup Point. There is a popular sheltered swimming beach north of the White Elephant café with recent evidence of erosion.

Figure 3.9 Gnarabup Oblique Aerial (DoT, 2014)

Three coastal types and six distinct sectors were identified and erosion allowances have been assessed for each of these sectors. In particular, the observed historic erosion rates vary significantly between sandy beaches. A storm erosion allowance (S1) was estimated based on a surveyed profile and bathymetry offshore of the beach access immediately north of the boat ramp. However, the SBEACH modelling showed an erosion response that was highly mitigated by offshore reefs at this location, which is not considered to be representative of the wider shoreline. The modelling undertaken at Riflebutts was adopted to sandy beaches in this sector, with the grain size based on a visual classification of beach sand in the swash zone.

There are limited geotechnical reports for the weakly lithified sedimentary rock coast in this area. Whilst a detailed geotechnical assessment has not been undertaken at Gnarabup for the CHRMAP, and is outside the scope of the study, the assumption for S1 adopted in the CHRMAP for the weakly lithified sedimentary rock coasts is slumping to an angle of 26.5 degrees (2.0h:1.0v).

The historic shoreline change (S2) was assessed using available rectified aerial photography from 2000, 2012 and November 2013 (i.e. after the September 2013 storms). Earlier shoreline movement plans were also available north of Gnarabup Point including from 1943, 1965, 1975 and 1991.

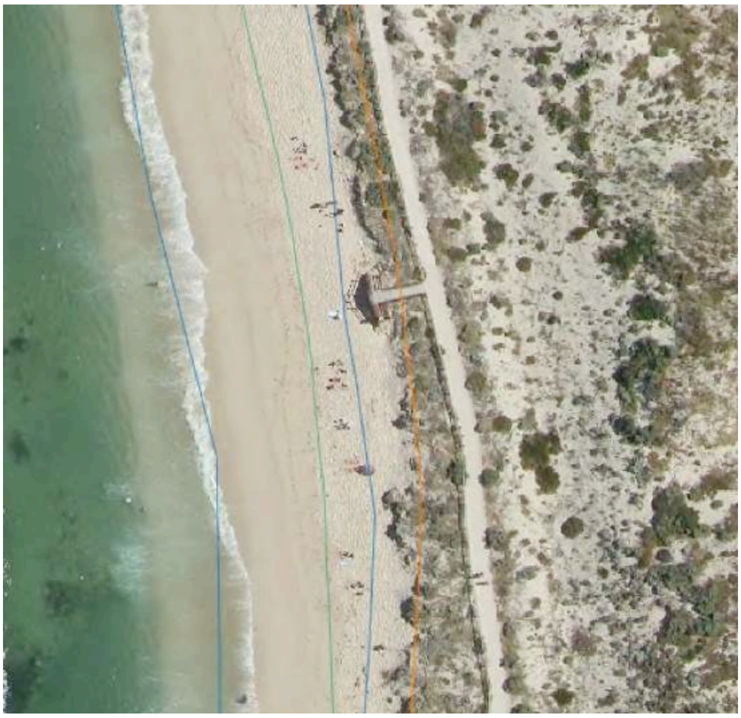

Figure 3.10 Shoreline Movement Analysis for Gnarabup Beach (North of the White Elephant Café)

Note: Figure shows the 1943 (orange) 1975 (green) and 2012 (blue) Vegetation Line on the 2013 Aerial Image

Further detail on how the vegetation line has changed since 1943 is shown in Figure 3.11. From this graph, it would appear that the beaches from Gnarabup to Prevelly accreted by approximately 10m between 1941 and 1965. Between 1965 and 1991 the beaches appear to have been relatively stable. Since 1991 the beaches from Gnarabup to Prevelly have eroded by approximately 10m. One interpretation from this analysis is that the beaches between Gnarabup and Prevelly are dynamically stable (the position of the vegetation line fluctuates about an average position over time).

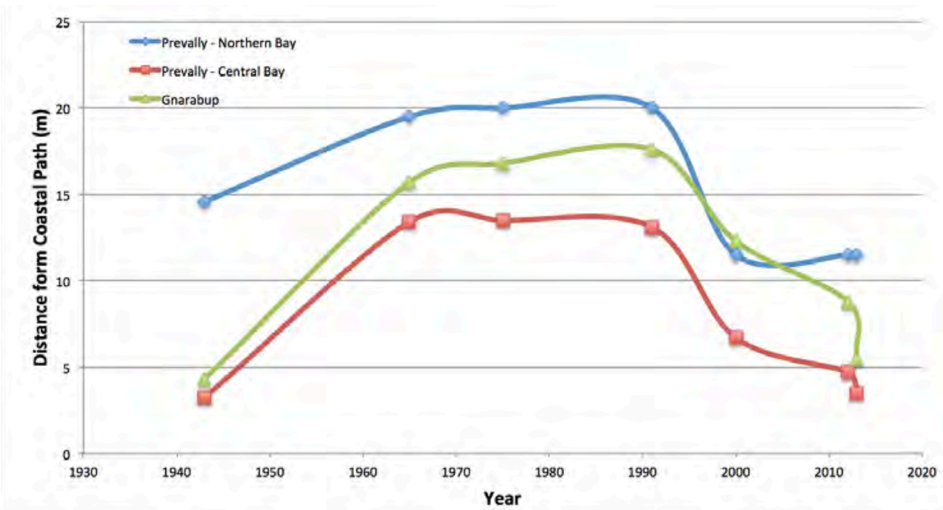

Figure 3.11 Shoreline Movement Assessment for Gnarabup Beach to Prevelly Beach

The allowance for erosion caused by future sea level rise (S3) is 90m to sandy and weakly lithified sedimentary rocks coasts. The combined allowance for coastal processes is outlined in Table 3.4 with more detail presented in Attachment 2 Risk Analysis Tables.

Table 3.4 Coastal Processes Allowances – Gnarabup (SC1412-3-2C)

Coastal Nodes	**Gnarabup Beach**	**Gnarabup Headland.**	**Back Beach (Reef Drive (Dog Beach))**	**Back Beach (Seagrass Place (Dog Beach))**	**Grunters Headland**	**Grunters Beach**	**Gas Point**
Coastal Type	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Sandy Coast	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Sandy Coast	Hard Rock Coast (low)
Assumed Length of Coast (m)	480	320	425	425	150	400	200
10yr Coastal Processes Allowance (m)	15	25	15	15	25	10	0
20yr Coastal Processes Allowance (m)	35	35	25	30	35	25	0
100yr Coastal Processes Allowance (m)	175	130	140	165	125	125	125

3.2.4. Hamelin Bay

Hamelin Bay is at the southern end of a west facing embayed sandy coastline. The shoreline position is controlled by a limestone headland to the south and granite headland to the north. The long sandy beach is sheltered at the southern end by Hamelin Island and is the site of an historic timber jetty. The beach to the north is backed by high dunes and exposed to high wave energy. Development is limited to a caravan park, coastal carparks and associated public infrastructure and an elevated boat ramp. There is a buried limestone revetment immediately north of the boat ramp providing protection to the road.

Figure 3.12 Hamelin Bay Oblique Aerial (DoT, 2014)

Two coastal types were identified and erosion allowances have been assessed for each of these types. A storm erosion allowance (S1) was estimated using SBEACH based on a surveyed profile and bathymetry offshore of the beach access immediately north of the boat ramp. There are limited geotechnical reports for the weakly lithified sedimentary rock coast in this area. Whilst a detailed geotechnical assessment has not been undertaken for the CHRMAP, and is outside the scope of the study, the assumption for S1 adopted in the CHRMAP for the weakly lithified sedimentary rock coasts is slumping to an angle of 26.5 degrees (2.0h:1.0v).

The historic shoreline change (S2) was assessed using available rectified aerial photography from 2000, 2012 and November 2013 (i.e. after the September 2013 storms). The allowance for erosion caused by future sea level rise (S3) is 90m to sandy and weakly lithified sedimentary rocks coasts.

Table 3.5 Coastal Processes Allowances – Hamelin Bay (SC1412-4-2C)

Coastal Node	**Hamelin Bay Caravan Park**	**Hamelin Bay Headland**
Coastal Type	Sandy Coast	Weakly Lithified Sedimentary Rock Coast
Assumed Length of Coast (m)	1800	330
10yr Coastal Processes Allowance (m)	10	25
20yr Coastal Processes Allowance (m)	20	35
100yr Coastal Processes Allowance (m)	120	130

3.2.5. Molloy Island

Molloy Island is a small estuarine island within the tidal reaches of the Blackwood River about 10km from the entrance. This shoreline is reasonably unique in Western Australia and the island accommodates around 276 residential blocks, roads and public boating infrastructure managed by the Residents Association. There is a vegetated foreshore reserve surrounding most areas of the island where boat ramps, public and private jetties are evident (see Figure 3.13). Access to the island is via a cabled vehicle ferry. The shoreline is generally vegetated with occasional estuarine beaches and limited visible rock controls. The shoreline is exposed to both wind waves from variable fetches and boat wakes. There is low-lying topography along the foreshore however many areas of the island are relatively elevated.

Preliminary investigations indicate the main coastal risk at Molloy Island is inundation under either elevated ocean tides coming up the river, or riverine floods coming down the river. The Department of Water have modelled the 100yr ARI floodway and fringe line for Molloy Island, which is the best available information for identifying risk to infrastructure. Further river flood modelling would be required to assess the change to flood levels at Molloy Island under sea level rise scenarios.

Topographical data held by the Shire is limited to 5 meter intervals at Molloy Island. A nominal allowance of 10 meters has been included for foreshore erosion to allow for risk evaluation and adaptation on a 10 year planning timeframe (SC1412-5-2C). It should be noted that erosion due to boat wake is not well modelled by SBEACH and consequently has not been evaluated for this site. However, the 10m offset from the riverbank allows for erosion by boat wakes and other processes. Table 3.6 outlines the allowances for the coastal nodes on Molloy Island.

Table 3.6 Coastal Processes Allowances – Molloy Island (SC1412-5-2C)

Coastal Nodes	**Western Foreshore – Blackwood River**	**Eastern Foreshore – Scott River.**	**Southern Foreshore – Blackwood River**	**Channel**
Coastal Type	Tidal Reaches of Inland Waters	Tidal Reaches of Inland Waters	Tidal Reaches of Inland Waters	Tidal Reaches of Inland Waters
Assumed Length of Coast (m)	1660	2760	1030	500
10yr Coastal Processes Allowance (m)	100 year flood fringe or 10m offset from riverbank.	100 year flood fringe or 10m offset from riverbank.	100 year flood fringe or 10m offset from riverbank.	100 year flood fringe or 10m offset from riverbank.
20yr Coastal Processes Allowance (m)	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
100yr Coastal Processes Allowance (m)	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data

Figure 3.13 Molloy Island Foreshore (Shore Coastal, 2015)

3.2.6. Augusta North

The Augusta north project site includes the Blackwood River shoreline of the Augusta townsite. This is an east facing estuarine shoreline within the tidal reaches of the Blackwood River. There is a mixed sand/rock shoreline although sediments include fine estuarine silts. In recent years a second river entrance was cut about 2,000m south of the main entrance channel and has maintained tidal exchange. This has resulted in shoreline change associated with the development and establishment of ebb and tidal deltas for this new entrance. Public infrastructure is located along low lying areas of the shoreline with both low lying and elevated residences. The Turner Caravan Park is a large foreshore landholding managed by the Shire in a relatively low lying area of the foreshore (between 1m AHD and 3m AHD).

Figure 3.14 Augusta North Oblique Aerial (DoT, 2014)

Preliminary investigations indicate the main coastal risk at Augusta North is inundation under either elevated ocean tides coming up the river, or riverine floods coming down the river. The DoW has modelled the 100yr ARI floodway and fringe line for the Augusta townsite, which is the best available information for identifying risk to infrastructure. Topographical data held by the Shire is available at 1 metre intervals and a nominal allowances of 10m has been allowed for foreshore erosion to allow for risk evaluation and adaptation on a 10 year planning timeframe.

Flood modelling undertaken by the DoW assumed a 'tail water' or ocean level near the entrance of 1.1m AHD. This is similar to the 100yrRP present day water level estimated by DoT for the Augusta Boat Harbour design, based on water level records for Albany. Significantly, this level is substantially lower than the 100yr Average Return Interval (ARI) water level adapted for the project sites along the ocean coastline (2.0mAHD) based on water level records at Busselton, which illustrates some of the level of uncertainty in applying elevated ocean levels to areas with limited local records.

The 100yr ARI floodway and fringe line does not allow for future sea level rise. Allowing for sea level rise it is not simply a matter of adding a 0.9m allowance to the predicted flood levels. There are more complex interactions between coastal and riverine processes. In the absence of further data, however, an interim level of 2.0mAHD has been considered in the CHRMAP as potentially subject to coastal processes over the 100 year planning period (SC1412-6-2A). It should be noted that erosion due to boat wake is not well modelled by SBEACH and consequently has not been evaluated for this site.

Table 3.7 Coastal Processes Allowances – Augusta North (SC1412-6-2C)

Coastal Nodes	**Ellis Street - North**	**Ellis Street - South**	**Turner Street Caravan Park**	**Colour Patch**
Coastal Type	Tidal Reaches of Inland Waters	Tidal Reaches of Inland Waters	Tidal Reaches of Inland Waters	Tidal Reaches of Inland Waters
Assumed Length of Coast (m)	1800	950	250	370
10yr Coastal Processes Allowance (m)	100 year flood fringe or 10m offset from riverbank.	100 year flood fringe or10m offset from riverbank.	100 year flood fringe or 10m offset from riverbank.	100 year flood fringe or 10m offset from riverbank.
20yr Coastal Processes Allowance (m)	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
100yr Coastal Processes Allowance (m)	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data

Figure 3.15 Turner Street Caravan Park Overview

3.2.7. Augusta South

The Augusta South project site includes the Flinders Bay shoreline of the Augusta townsite and the Flinders Bay settlement. This is an east facing embayment sheltered from high energy Indian Ocean waves but with significant exposure to the south east. Coastal types include hard rock coast and sandy coast. The development and establishment of ebb and tidal deltas for the new Blackwood River entrance influence shoreline change. Public infrastructure and a coastal road are located along modest dunes with narrow setbacks. There are a number of thin perched sandy beaches controlled by granite outcrops in the Flinders Bay area. The newly constructed Augusta Boat Harbour, along the rocky coastline south of Flinders Bay, marks the southern extent of this project site.

Figure 3.16 Augusta South Oblique Aerial (DoT, 2014)

Two coastal types and four distinct sectors were identified and erosion allowances have been assessed for each of these sectors. A storm erosion allowance (S1) was estimated based on a surveyed profile and bathymetry offshore of Albany Terrace. SBEACH modelling has been used to estimate S1 for the sandy coasts based on a moderated storm wave height to account for sheltering from Cape Leeuwin. Grain size was based on a visual classification of beach sand in the swash zone. The extent of storm erosion is averaged across the profile (Figure 1).

The historic shoreline change (S2) was assessed using available rectified aerial photography from 2000, 2012 and November 2013 (i.e. after the September 2013 storms). Interpretation and caution is required due to the large scale changes observed at the new river entrance. Rates of change of more than 20m per year were observed as the new river entrance morphology evolves. Interim coastal processes allowances have been applied in this area, but further monitoring of the new river entrance is required to refine these allowances.

Figure 3.17 Shoreline Movement Analysis for Augusta South, Albany Terrace – Blackwood River Cut Area

Figure shows the 2000 (red) and 2012 (blue) Vegetation and Water Lines on the 2013 Aerial Image

The allowance for erosion caused by future sea level rise (S3) is 90m.

Table 3.8 Coastal Processes Allowances – Augusta South (SC1412-7-2C)

Coastal Nodes	Albany Terrace – Blackwood River Cut	Albany Terrace – Rocky Coast	Albany Terrace – Sandy Coast	Flinders Bay Caravan park	Flinders Bay
Coastal Type	Sandy Coast	Hard Rock (low)	Sandy Coast	Sandy Coast	Sandy Coast/Rocky Coast
Assumed Length of Coast (m)	1100	320	340	460	650
10yr Coastal Processes Allowance (m)	10	0	10	10	10
20yr Coastal Processes Allowance (m)	20	0	20	20	20
100yr Coastal Processes Allowance (m)	120	120	120	120	120

Figure 3.18 shows the 10, 20 and 100 year coastal processes allowances from the Horizonal Setback Datum9HSD) for the different coastal nodes across the Shire including a representation of the breakdown of the S1, S2, S3 and FoS components.

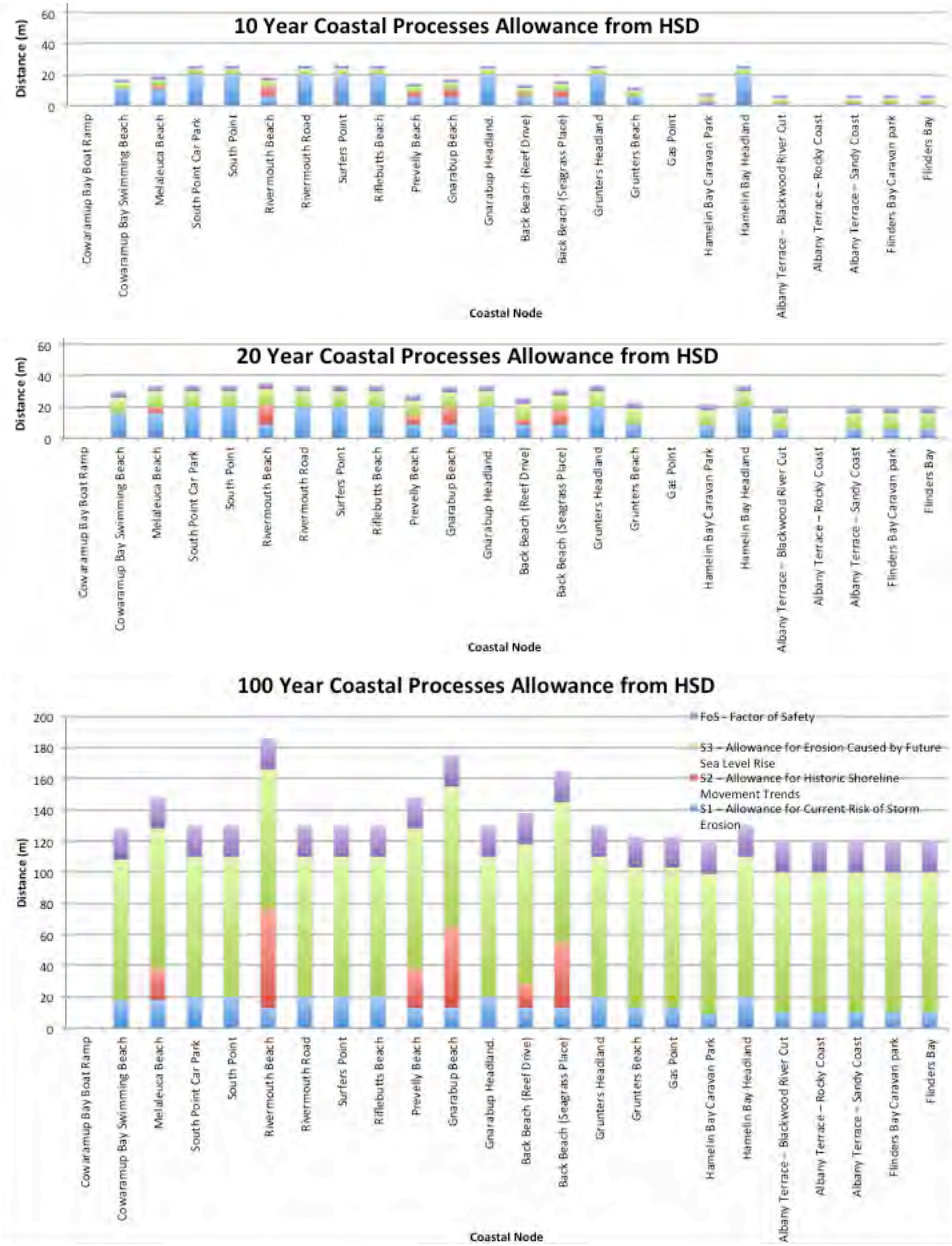

Figure 3.18 Summary of 10, 20 and 100 Year Coastal Processes Allowances

4. Stage 3 - Risk Evaluation

The Risk Evaluation phases incorporates the information from the risk analysis to identify the relative exposure of coastal assets to coastal processes. High (<10-year), medium (10-20 year) and low (20-100yr) coastal exposure areas were identified (Figure 1). Coastal assets considered included coastal stairs and platforms, carparks, buildings, roads and adjacent paths, coastal walkways and access paths, marine structures, private residences, landscaping, playgrounds and shelters and caravan parks.

An estimate has been made of the cost for each of these assets. The asset cost (the consequence of losing this asset to coastal erosion) and asset exposure (likelihood of this occurring) was input into a coastal risk evaluation matrix to identify coastal assets at low, medium, high and very high risk. In general high cost assets located close to the coast in areas exposed to coastal processes are identified as high risk. (Attachment 4).

The risk evaluation provides are strategic assessment of the relative investment in coastal infrastructure in the Shire and its relative exposure to coastal processes. Much of this infrastructure is an integral part of providing access to the coast. The identification of assets as high or very high risk does not mean they are necessarily at immediate risk of damage. Coastal adaptation measures may include prioritising monitoring, inspections, maintenance and strategic longer term planning for these assets.

The very high risk public coastal assets identified through this process include Prevelly-Rivermouth Carpark, Gnarabup Beach Carpark, White Elephant Café and associated structures, Molloy Island Car Ferry Infrastructure, Ellis St Jetty and Augusta South- Albany Terrace. A small number of private residences in Molloy Island and Augusta were also identified.

Socio-economic analysis of coastal nodes was undertaken for this plan using extant estimates of the benefit value of coastal tourism and recreation and the associated costs of public assets, which facilitate access to those sites. The socio economic value of beaches to the Shire was quantified and annualised benefit-cost ratios were calculated for each site (Attachment 5).

4.1. Asset Cost

Coastal nodes have been identified for each of the 7 project sites. These coastal nodes are based on a length of coastline where there is either a distinct coastal type (i.e. sandy beach, rocky shoreline), local recreational beach (e.g. Cowaramup Bay Swimming Beach) or distinct consolidation of coastal assets (e.g. Cowaramup Bay Boat Ramp). The boundaries of these coastal nodes are generally based on local coastal features (e.g. headlands). There were a total of 29 Coastal Nodes identified throughout the Shire. The asset cost at each of these coastal nodes has been evaluated.

In determining the asset cost, there were 11 *coastal asset types* identified including:

- Coastal stairs and platforms
- Carparks
- Buildings (large structures, toilets, change rooms etc.)
- Roads and Adjacent Paths
- Coastal Walkways
- Coastal Access Paths

- Public Marine Structures (Boat Ramps/Jetties)
- Private Residential Properties
- Landscaping, Playgrounds and Shelters
- Private Jetties
- Caravan Parks

The cost of each coastal asset type has been estimated at each coastal node based on data provided by the Shire and/or based on assumed rates and quantities for typical assets. These approximate present day replacement costs. The assets have been classified based on

- Low value (<$100K).
- Medium value ($100-500K).
- High value (>$500K).

The classification of asset value has been based on their relative distribution (i.e. $100K ~ 35th percentile, $500K ~ 80th percentile).

There were approximately $26.5M of public assets identified within the 100 year allowances for coastal processes for the 7 sites. Private asset values are estimated at approximately $158M, and are predominantly located in relatively low coastal exposure areas. The highest level of public infrastructure is in the Prevelly project site with an estimated value of $6.5M. Table 4.1 provides further detail on the cost of assets at the study sites.

Table 4.1 Cost of Asset Potentially Exposed to Coastal Processes within 100 Year Planning Period

Coastal Study Site	Cost of Public Coastal Assets	Cost of Private Coastal Assets	Total Cost of Coastal Assets
Gracetown	$3,382,000	$25,335,000	$28,717,000
Prevelly	$6,435,000	$0	$6,435,000
Gnarabup	$3,468,000	$0	$3,468,000
Hamelin Bay	$2,296,000	$0	$2,296,000
Molloy Island	$1,433,000	$4,000,000	$5,433,000
Augusta - North	$4,096,000	$5,400,000	$9,496,000
Augusta South	$4,872,000	$97,500,000	$102,372,000
Total	$25,983,000	$132,235,000	$158,217,000

A summary of asset cost associated with each coastal node and for each asset is presented in the first table for each site in Attachment 4 Risk Evaluation Tables.

4.2. Asset Exposure to Coastal Processes

Asset exposure to coastal processes has been assessed based on the outcomes of the risk analysis phase. These assets have been classified based on:

- Low coastal exposure (20-100yr allowance for coastal processes).
- Medium coastal exposure (10-20yr allowance for coastal processes).
- High coastal exposure (within 10 year allowance for coastal processes).

It has been assumed that if the front edge of the asset is within a coastal exposure area, and its functionality may be affected by coastal erosion or inundation, it is classified within that area, i.e. if the front edge of a toilet block is within the 10yr area it is classified as high exposure.

For Augusta North and Molloy Island the focus has been on the high exposure area identified by the flood fringe area or the 10m setback. Whilst there is not sufficient data to identify limits of medium and low coastal exposure at these sites (this would require further river flood modelling), adaptation measures are considered more generally in Stage 4. Table 4.2 provides a summary of the number of assets and their relative exposure with Table 4.3 outlining the value of the assets within the different coastal exposure areas.

Table 4.2 Coastal Asset Exposure

Coastal Management Area	Number of Assets with High Coastal Exposure	Number of Assets with Medium Coastal Exposure	Number of Assets with Low Coastal Exposure
Gracetown	9	4	10
Prevelly	8	4	15
Gnarabup	9	0	6
Hamelin Bay	3	0	3
Molloy Island	6	1	0
Augusta - North	12	2	0
Augusta - South	7	1	10
Total	54	12	44

Table 4.3 Coastal Asset Cost

Coastal Management Area	High Coastal Exposure Asset Cost	Medium Coastal Exposure Asset Cost	Low Coastal Exposure Asset Cost
Gracetown	$1,084,999	$599,440	$27,032,138
Prevelly	$1,834,590	$479,400	$4,121,395
Gnarabup	$2,248,820	$0	$1,219,420
Hamelin Bay	$855,000	$0	$1,441,000
Molloy Island	$5,393,500	$50,000	$0
Augusta - North	$7,086,000	$2,410,000	$0
Augusta - South	$1,861,100	$502,200	$100,008,537
Total	$20,364,009	$4,041,040	$133,822,490

4.3. Asset Risk

The asset risk has been assessed based on the Asset Cost and the Asset Exposure (Sections 4.1 and 4.2 respectively) and the matrix shown in Figure 4.1, which includes a Very High Risk category (assets >$500K value in high exposure (10 year) area).

This process provides a strategic assessment of the relative investment in coastal infrastructure throughout the Shire and its relative exposure to coastal processes. Much of this infrastructure is an integral part of providing access to the coast (e.g. beach access stairs) and/or is required to be located at the coast (jetties/boat ramps etc.).

The identification of assets as very high risk or high risk does not necessarily mean they are at immediate risk of damage and/or should be removed. Coastal adaptation measures may include prioritizing inspections, maintenance and strategic planning regarding the long term use and maintenance of these assets. This will be discussed further in Section 5. Table 4.4 provides a summary of the high risk assets with the very high risk assets listed below.

		Exposure to Coastal Processes (Likelihood)		
		High (within 10yr area)	**Medium (10-20 year area)**	**Low (20-100yr area)**
Asset Cost (Consequence)	**High**	Very High	High	Med
	Medium	High	Med	Low
	Low	Med	Low	Low

Figure 4.1 Coastal Risk Evaluation Matrix

The very high risk coastal assets identified through this process include:

- Prevelly - Rivermouth Carpark.
- Gnarabup - Beach Carpark, White Elephant Cafe and associated structures.
- Molloy Island - Private Property (6 buildings) and Car Ferry Infrastructure.
- Augusta North - Private Property between Ellis St and the Caravan Park (6 buildings) and Ellis St Jetty
- Augusta South - Albany Terrace

Table 4.4 Summary of High Risk Assets

Coastal Management Area	Asset Type	Description
Gracetown	Coastal Stairs and Platforms	South Point Car Park lookout platform and Huzzas access stairs
	Coastal Stairs and Platforms	South Point lookout platforms and beach access stairs
	Carparks	South Point Car Park, front edge of 36 bay car park
	Public Marine Structures (Boat Ramps/Jetties)	Cowaramup Bay Boat Ramp and Jetty
Prevelly	Coastal Stairs and Platforms	Rivermouth Beach access stairs and lookout platforms
	Coastal Stairs and Platforms	Surfers Point beach access stairs and lookout platforms
	Coastal Walkways	Prevelly to Gnarabup coast path
Gnarabup	Coastal Stairs and Platforms	Gnarabup Beach access stairs
	Coastal Stairs and Platforms	Gnarabup Headland lookouts and access stairs
	Coastal Stairs and Platforms	Grunters Beach access stairs
	Public Marine Structures (Boat Ramps/Jetties)	Gnarabup Beach boat ramp and jetty
Hamelin Bay	Coastal Stairs and Platforms	Hamelin Bay beach access stairs
	Carparks	Hamelin Bay beach car park
	Public Marine Structures (Boat Ramps/Jetties)	Hamelin Bay boat ramp
Molloy Island	Public Marine Structures (Boat Ramps/Jetties)	Molloy Island ferry landing
	Private Jetties	Private jetty in the channel at the south end of the island
Augusta North	Coastal Walkways	Boardwalks and paths on foreshore in front of Colour Patch café
	Coastal Walkways	Boardwalks and paths on foreshore in front of Turner Street Caravan Park
	Public Marine Structures (Boat Ramps/Jetties)	Boat ramp and jetty in front of Colour Patch café
	Public Marine Structures (Boat Ramps/Jetties)	Boat ramp and jetty in front of Turner Street Caravan Park
	Private Jetties	Private Jetty in front of Turner Street Caravan Park
	Private Jetties	Private Jetty associated with the facilities near Ellis Street Old Town Jetty and Commercial Jetties
	Private Jetties	Private Jetties associated with private residences near Irwin Street and Temperley Place
	Caravan Park	The northern edge of the Turner Street Caravan Park
Augusta South	Coastal Stairs and Platforms	Flinders Bay beach access stairs and lookouts
	Roads and Adjacent Paths	Albany Terrace between Trigg Street and Flinders Bay Caravan Park
	Roads and Adjacent Paths	Flinders Bay Boat Ramp access road
	Coastal Walkways	Albany Terrace footpath between Blackwood River Cut and Trigg Street
	Public Marine Structures (Boat Ramps/Jetties)	Flinders Bay boat ramp and jetty.

4.4. Socio Economic Analysis

A socio economic analysis of beaches within the Shire has been undertaken by Dr Jack Carlsen as part of this CHRMAP and is provided in Attachment 5.

4.4.1. Background

The Margaret River region is renowned for its coastal amenity and the marine activities (swimming, surfing, diving, boating and beach walking) that it provides for both residents and visitors. The *Beach and Surf Tourism and Recreation in Australia: Vulnerability and Adaptation* study estimated that the non-market consumer surplus[2] of beach recreation is valued at $3.7 million p.a. for residents of the Shire. The Shire also receives more than 600,000 domestic, international and day-trip visitors annually, the vast majority of whom visit the beach during their stay. The proportion of their expenditure that can be attributed to these visits is in the order of $24.6 million p.a. (Carlsen, 2015).

Hence the coastal areas of the Shire produce significant socio-economic benefits for both residents and visitors and any loss of access or beach amenity due to inundation, erosion and loss of infrastructure could impact on these values (Carlsen, 2015).

4.4.2. Socio Economic Value

In order to estimate the order of magnitude of the value of the benefits of each node within the seven case study sites, extant studies and methods (Attribution[3], Travel Cost[4] and Benefit Transfer[5]) were used to assign socio-economic values for each node (Carlsen, 2015).

Additionally, feedback from the Workshop held at the Shire on March 31st 2015 was used to inform the asset values associated with each node. Asset replacement costs have been estimated for all identifiable assets within each node and were compared with the value of economic benefits from beach use in each node in order to estimate the net economic benefits and benefit cost ratio of each node (Carlsen, 2015).

The socio-economic evaluation of coastal nodes in the seven study sites was based on extant estimates of the benefit value of coastal tourism and recreation and the associated cost of the public assets that facilitate access to those sites. It should be noted that some use values associated with some sites (such as surfing and boating) could not be estimated as no data is available. Future studies of coastal tourism and recreation benefits and costs should include estimates of the value of these, as well as other cultural and environmental values identified in the stakeholder workshops. The socio economic value of these beaches are summarised in Table 4.5.

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[2] Consumer surplus is the amount that consumers would be willing to pay if a market price for beach use existed. As beach use is free, there is no market and consumer surplus is referred to as a non-market estimate.

[3] Attribution is a method for assigning a proportion of tourism expenditure to a specific asset or place (see (Carlsen, 2015))

[4] Travel Cost Method uses travel time and cost as an indicator of the value placed by visitors to a specific location (in this case, a beach)

[5] Benefit Transfer uses the results of valuation studies in comparable locations to estimate the value of a specific study site (see (Carlsen, 2015))

4.4.3. Management Prioritisation

For the purposes of this study, the annualised benefit-cost ratios with the coastal nodes within each site provide a decision-support tool for coastal management (refer Attachment 5). Coastal nodes with high benefit-cost ratios generally have large areas of sandy beach and relatively low asset costs. For example, beaches immediately south of Gnarabup have high benefit cost ratios as they are long sandy beaches with coastal infrastructure generally limited to beach access stairs. Maintenance of these coastal access stairs allows the socio economic value of these beaches to be realised.

This approach also provides guidance in strategic planning of future coastal investment (i.e. beaches with low asset cost and high socio economic value provide opportunities as future coastal nodes).

The consideration of the socio economic value of beaches is also important in prioritising coastal adaptation measures. For example, coastal nodes at Prevelly (Rivermouth Beach, Surfers Point and Prevelly Beach), Gnarabup Beach and Ellis St in Augusta have both high public asset costs and socio economic value. In particular, it should be recognised that the protection of public assets, such as carparks and roads, from coastal erosion may result in the reduction and potential loss of socio economic value of the adjacent public beach.

The socio economic valuation of beaches is limited by available data and the scope of the study. Whilst it acknowledged that anecdotally Gnarabup Beach would have higher visitation than the Back Beach, beach-by-beach visitor numbers are not available to allow a quantitative comparison on this basis (refer Attachment 5). This was noted at the second community workshop and further research could be undertaken by the Shire in this regard.

In this context, the annualised cost benefit ratio should be *considered* when prioritising management, but not independently of the risk analysis based on coastal exposure and asset value. However, based of stakeholder feedback, the economic value of the beach outlined in this study should be considered highly in prioritising adaptation measures during the implementation phase of this plan. For example, construction of a seawall in response to persistent erosion may reduce the socio economic value of the beach in front of the seawall, whilst a managed retreat response would largely maintain this socio economic value.

Table 4.5 Socio Economic Value of Beaches and Benefit Cost Ratios

Study Site	Coastal Node	Beach Area (m^2)	Socio-economic Value	Public Asset Cost	Annualised Benefit-Cost Ratio
Gracetown	Cowaramup Bay Boat Ramp	4,125	$825,000	$1,003,410	0.8
Gracetown	Cowaramup Bay Swimming Beach	6,000	$1,200,000	$878,085	1.4
Gracetown	Melaleuca Beach	4,000	$800,000	$683,028	1.2
Gracetown	South Point Car Park	1,375	$275,000	$453,404	0.6
Gracetown	South Point	1,100	$220,000	$162,500	1.4
Prevelly	Rivermouth Beach	26,400	$5,280,000	$1,479,590	3.6
Prevelly	Rivermouth Road	5,250	$1,050,000	$595,255	1.8
Prevelly	Surfers Point	14,000	$2,800,000	$2,873,540	1
Prevelly	Riflebutts Beach	2,000	$400,000	$677,791	0.6
Prevelly	Prevelly Beach	18,000	$3,600,000	$928,000	3.9
Gnarabup	Gnarabup Beach	7,200	$1,440,000	$2,758,520	0.5
Gnarabup	Back Beach	12,750	$2,550,000	$233,300	10.9
Gnarabup	Grunters Beach	3,000	$600,000	$170,000	3.5
Gnarabup	Gas Bay Beach	10,000	$2,000,000	$185,000	10.8
Augusta North	Ellis St South	4,750	$950,000	$3,125,000	0.3
Augusta North	Turner Caravan Park	500	$100,000	$220,000	0.5
Augusta North	Colour Patch	1,850	$370,000	$751,000	0.5
Augusta South	Albany Terrace - Blackwood River Cut	11,000	$2,200,000	$1,128,600	1.9
Augusta South	Albany Terrace - Rocky Coast	640	$128,000	$562,100	0.2
Augusta South	Flinders Bay Caravan	4,600	$920,000	$1,656,137	0.6
Augusta South	Flinders Bay	6,500	$1,300,000	$1,154,200	1.1

5. Stage 4 - Risk Management and Adaptation

Following assessment of the risk to the coastal assets, risk management and adaptation options have been identified for each coastal node. Adaptation measures have been considered for High or Very High risk assets identified through the Risk Evaluation phase.

The general *sensitivity* of coastal assets to coastal erosion or coastal inundation has been assessed. Assets with high sensitivity to coastal erosion, based on the visual inspections (e.g. stairs already being undermined) are identified.

Potential impacts of erosion or inundation under rising sea levels and variable climatic conditions are outlined. The adaptive capacity has then been assessed in terms of the risk management and adaptation hierarchy as outlined below and as shown in Figure 5.1.

Figure 5.1 Risk Management and Adaptation Hierarchy (WAPC, 2014)

- **Avoid** the presence of new development within an area identified to be affected by coastal hazards.
- **Planned** or **Managed Retreat** or the relocation or removal of assets within an area identified as likely to be subject to intolerable risk of damage from coastal hazards over the planning time frame.
- **Accommodation:** design and/or management strategies that render the risks from the identified coastal hazards acceptable.
- **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.

Examples of this hierarchy are worked through for key assets including the South Point Carpark and the Prevelly-Gnarabup walking path. Recommended actions for assets at high or very high risk at each of the coastal settlements are outlined.

5.1. Risk Management and Adaptation Strategies

Risk management and adaptation strategies are outlined in the tables in in Attachment 6 Risk Management Tables, which outline management and adaptation strategies for the assets identified as high risk or very high risk in the risk evaluation.

The medium and low risk assets have also been considered. The measures required to manage the current coastal risk for these assets are restricted to monitoring and investigating measures discussed in the management of higher risk assets. Future development in the medium and low risk areas will need to consider the management and adaptation hierarchy outlined above.

The more significant management and adaptation needs are summarised below. A proposed schedule for these management works is included in Section 5.2.

Please note that these recommendations are based on the information currently available. As monitoring and investigation work is implemented, this may identify different assets as requiring priority adaptation planning and work.

5.1.1. Management and Adaptation on Sedimentary Rock Coast

The Shire's coastline includes significant lengths of weakly lithified sedimentary rock (mostly limestone). This includes areas with significant coastal assets. As outlined in section 3.2, historically these cliffs have been unstable.

Geotechnical inspections of the limestone cliff stability are recommended as an immediate priority. Inspections must examine all trafficked areas including stairs, lookouts and South Point Car Park. Inspections should also be made of other limestone cliffs and an audit undertaken of safety signage. Blank safety signs (wording had worn off) adjacent to limestone caves in popular beach areas (Grunters) were observed during inspection (see Figure 5.2). This is recommended to take place immediately.

Figure 5.2 Blank Safety Sign Observed at Grunters Beach (left) and Safety Signage at South Point (right)

Following this urgent monitoring of the safety risks, an investigation should be undertaken into the stability of the sedimentary rock coastline to determine the required set-backs for assets constructed near limestone cliffs. The results of this information will inform planning policy and allow planning of adaptation options for assets already located in these areas. This is recommended for 2016/17.

Information from the geotechnical investigation will allow planning for adaptation options for the South Point, Gnarabup and Ocean View carparks. This planning work is recommended for 2017/18.

Example: The car park at South Point provides parking next to a number of popular surf breaks. The seaward edge of the carpark has a high exposure to coastal processes, and is adjacent to a weakly lithified sedimentary rock (limestone) cliff. Footings on the adjacent coastal access stairs are exposed and there is a cave forming beneath the lookout platform.

An immediate inspection by a geotechnical engineer of cliff stability should be undertaken. Coastal monitoring including survey and inspections should be progressively implemented as part of a wider coastal monitoring program.

The design and implementation of long-term solutions to maintain the structural integrity of stairs and lookouts and ensure they can ACCOMODATE present and future slope instability at this location will be required. In addition consideration will need to be given to public safety with regard to how access to and along the beaches is managed.

Should the coastal monitoring program identify future slope instability the adaptation hierarchy would then be applied to determine a suitable course of action for the carpark. As the car park is already in existence and could not be located elsewhere and still provide parking for South Point the AVOID option would not considered practical. Planning would need to then focus on MANAGED RETREAT of the car parking to position it in an area with lower exposure to coastal processes. It is apparent that there is land behind the car park that is currently not developed. The investigation would need to determine the tenure of this land and the feasibility of relocating part of the car park into this area.

5.1.2. Management and Adaptation on Sandy Coastline

The sandy coast undergoes cycles of accretion and erosion. Without systematic monitoring, it is difficult to determine the medium and long term trends, and therefore difficult to effectively plan adaptation measures. Systematic monitoring is particularly important in the vicinity of the Blackwood River Cut, where the coast is responding to human interventions.

It is recommended that a program of systematic beach profile surveys and photo monitoring be established to enable objective comparison of known points along the coast from year to year. Locations would be identified for surveys of beach profile and photo monitoring to be undertaken at the same locations every 6 or 12 months in accordance with the Department of Transport's "How to Photo Monitor Beaches" (DoT, 2012).

A sediment budget would assist with understanding of coastal response in the future and would help with adaptation and management planning. In order to derive a sediment budget the Shire should plan to undertake a detailed beach and hydrographic survey every 5 years. A detailed topographic survey would also assist with the delineation of inundation extents within the coastal management areas. This would then assist with defining the coastal processes allowance for the S4 component.

It is recommended that adaptation planning be undertaken for the White Elephant Café and changerooms to identify options for adaptation to coastal change under a range of scenarios.

Following several years of coastal monitoring, it will be appropriate to develop coastal adaptation options for the Rivermouth Carpark in Prevelly and Albany Terrace in South Augusta.

Flinders Bay beach car park and foreshore layout will require consideration from a planning perspective by 2018/2019. The planning process would need to confirm the need for this facility and determine the ability for relocation or removal of these facilities within the next 20 years. This would require consideration of the relative value of this asset compared to the cost for maintaining it in its current form. It would also require investigation into the feasibility of relocating the infrastructure with regards to cost, approvals and land tenure.

5.1.3. Management and Adaptation for Coastal Stairs and Retaining Walls

Monitoring of stairs would include assessment of fall distance from lower stairs. This would involve measurements of the distance between the bottom step and the beach at all beach access stairs throughout the Coastal Management Areas. This would highlight any beach access stairs that have become unsafe and no longer meet Australian Standards. It would also inform the beach access stairs maintenance and adaptation requirements.

In addition monitoring of stairs would include structural inspections of beach access stairs. This includes all beach access stairs and would determine the stability of the stairs and the risk of undermining of any foundations. Regular inspections would detect when the stairs become unsafe for public use and would highlight when works are required. In addition these inspections should focus on how to improve the stairs so they can adapt to increased scour and wave exposure.

Example: The coastal stairs and lookouts at Gnarabup Beach provide access to popular swimming beaches and they are currently located within the high coastal exposure zone. Undermining of timber footings has been observed together with large fall distances from the lower stair to the beach.

Following a structural inspection, monitoring of these stairs and the adjacent beach would occur on at least a 6 monthly basis. Monitoring of the stairs and lookouts would identify if and when these stairs are damaged, start to fail and/or become vulnerable to coastal processes.

Working through the adaptation hierarchy it may not be practical to AVOID having some form of access to the beach, which is a highly valued and popular asset.

The next option the MANAGED RETREAT of these stairs to an area with lower exposure to coastal processes. The relocation of the stairs may be considered when the coastline outflanks the stairs and they no longer serve their purpose and should a suitable site be available. This would be determined based on the coastal monitoring.

Assuming the stairs cannot be relocated the preferred option would be to consider altering the stairs so they can ACCOMMODATE the risk of undermining. This would involve a structural assessment of the stairs and designing suitable options for any modifications. The modifications would need to consider the depth of any foundations/piling, bracing of the structure, the depth of the bottom step and the cause of erosion (i.e. foot traffic or beach erosion).

The management and adaptation works for retaining walls refers specifically to the retaining wall in front of the Rivermouth Beach Car Park. This should be inspected at the same time as the inspections of the stairs in this location. This inspection would focus on the risk of this wall undermining, the structural integrity of the wall and it would also assess the capacity to modify the wall to provide a seawall (i.e. make the foundations deeper to provide some scour protection). An investigation into the dynamics of the rivermouth sand bar and channel would then inform the most suitable management strategy for this area.

5.1.4. Management and Adaptation Planning

Following the inspections, monitoring and investigation works design, planning and adaptation works should be undertaken on relevant coastal assets. In the short term the design, planning and adaptation works should be focused on upgrading and adapting the beach access stairs and platforms to accommodate coastal processes. The works will initially need to focus on areas and structures already identified as at high risk of failure and with high perceived asset value (i.e. Huzzas Beach access stairs). The first year monitoring will then identify the assets requiring further works for the following year.

Planning will also be needed to assess the feasibility of the adaptation of assets in lower risk zones. This is to ensure that a suitable adaptation option is available if and when it is required.

The Prevelly/Gnarabup coastal walkway runs parallel to the sandy coastline and is under threat from coastal erosion. It is recommended that adaptation planning be undertaken for the managed retreat of this asset.

Example: The coastal path between Gnarabup and Prevelly is within an area with high exposure to coastal processes and provides access along the rear of the beaches between Prevelly and Gnarabup. It is also part of the Cape to Cape walk. Monitoring of the buffer between the beach and the path should occur on a 6 monthly basis.

If monitoring identified that the buffers to the path were progressively reducing, adaptation measures would need to be undertaken. However, prior to this point planning would have identified the most suitable option for adaptation of the coastal path using the adaptation hierarchy. This would include assessment of the relative cost for relocation of all or part of the path, a preferred location from the communities perspective, the timing of the relocation and the tenure of the area to which the path is to be relocated.

In addition any future developments will need to consider the adaptation hierarchy at the planning stage. This is to ensure that they are suitably sited and with due consideration to the risk from coastal processes.

Planning should also look at the adaptive capacity of boat ramps and jetties, both on the exposed Leeuwin-Naturaliste coast and within the Blackwood River Estuary. This will involve assessment of the jetty deck levels for current facilities and the consideration of the phased raising of jetty deck levels in line with Sea Level Rise during future maintenance and upgrade works. Consideration will also need to be given to the car ferry for Molloy Island.

5.1.5. Management and Adaptation for Estuarine Flooding

Existing proposals to modify the layout of the Turner Caravan Park will need to be considered in terms of the inundation risk. At present the eastern side of the caravan park is at an elevation of between 1m AHD and 2m AHD with the western side between 2m AHD and 3m AHD as shown in Figure 3.15. Consideration should be given to placing new infrastructure with high sensitivity to inundation within the higher elevation area to the west of the caravan park, minimising the inundation risk as much as practicable.

Survey and inspection of private residences within the 100 year flood fringe line in Augusta North and Molloy Island should be undertaken in 2016/2017. This would involve the confirmation of topographic and floor levels for the six private residences in Dawson Terrace, North Augusta shown exposed to river flooding. In addition topographic and floor levels of the six buildings on Molloy Island also shown as exposed to river flooding. The assessment would determine if these buildings could maintain access and egress during a river flood event.

Currently the modelled river inundation extents only consider a tail water level of 1m AHD. This is equivalent to the current day 1-year ARI ocean water level in Augusta (DoT, 2012). A detailed river flood modelling study is therefore proposed in order to assess how a higher ARI ocean water level event would influence flooding within the estuarine areas. In addition this investigation would also consider the influence of sea level rise on river flooding with the Blackwood River estuary.

The output from the modelling would then be used to refine the asset risk analysis and evaluation for the 20 and 100 year planning timeframes within the Blackwood River estuary. This would then be used to further refine management and adaptation options for the Blackwood River Estuary.

5.1.6. Future Development

In general, the principals of the State Coastal Planning Policy should guide future development. For private residential development the 100-year allowance for coastal processes in the CHRMAP provides an indication of potential coastal setbacks. However, further investigations may be required on a case-by-case basis. For future public development, the general principal would be to, where practicable, avoid the potential future impact of coastal processes for the design life of the asset. This would generally preference siting of assets in the areas with low exposure to coastal process, or further landward where feasible.

5.2. Implementation

This section includes the program for implementing the management and adaptation options identified through the CHRMAP Process. It also includes detail on who is responsible for implementing the management and adaptation options, funding options for implementing the program of works, the typical approvals required for the works and the likely review and updating of the works program and CHRMAP.

5.2.1. Coastal Monitoring and Adaptation Program

A five-year coastal adaptation and monitoring program is outlined in Figure 5.3. Nominally the start date for this program has been identified as July 2016 (2016/17 Financial Year) in recognition of local government budgeting timeframes, although higher priority should be given to the recommended geotechnical inspections of limestone cliffs (refer Section 5.1.1). This program would be subject to available funding.

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Task	Effort	Start	Task Cost
1) 2015/16 (Year 1)	147w	**10/08/2015**	$295,000.00
1.1) Monitoring: Inspections of fall distance from lower stair to beach (regular / post storm inspections)	39w	1/10/2015	$5,000.00
1.2) Monitoring: Structural inspections of timber/composite stairs/retaining walls (annual inspections)	4w	1/10/2015	$10,000.00
1.3) Monitoring: Beach profile surveys and photo monitoring, incl. Blackwood River cut migration (at least annual surveys)	4w	1/10/2015	$20,000.00
1.4) Monitoring: Geotechnical inspection of limestone cliffs and safety signage audit (Yr1)	4w	1/10/2015	$30,000.00
1.5) Monitoring: Detailed baseline coastal survey of beaches and limestone cliffs	4w	1/12/2015	$30,000.00
1.6) Investigation: Gnarabup/Prevally/Rivermouth Coastal Processes	46w	10/08/2015	$50,000.00
1.7) Design: Coastal adaptation of beach access stairs and platforms (GR, GN)	8w	1/10/2015	$20,000.00
1.8) Planning: Turner Caravan Park layout.	26w	4/07/2016	$30,000.00
1.9) Works: Coastal adaptation of beach access stairs and platforms – Phase 1	12w	1/12/2015	$100,000.00
2) 2016/17 (Year 2)	180w	**1/07/2016**	$285,000.00
2.1) Monitoring: Inspections of fall distance from lower stair to beach (regular / post storm inspections)	52w	1/07/2016	$5,000.00
2.2) Monitoring: Structural inspections of timber/composite stairs/retaining walls (annual inspections)	4w	3/10/2016	$10,000.00
2.3) Monitoring: Beach profile surveys and photo monitoring, incl. Blackwood River cut migration (at least annual surveys)	4w	3/10/2016	$20,000.00
2.4) Monitoring: Boat ramp and jetty inspections (GR, GN, HB, AS, AN)	4w	1/12/2016	$20,000.00
2.5) Design: Coastal adaptation of Whilte Elephant cafe and Changerooms (AC, PR)	26w	26/12/2016	$20,000.00
2.6) Investigation: Weakly Lithified Sedimentary Rock Coast Investigation	26w	2/01/2017	$50,000.00
2.7) Planning: Prevally/Gnarabup coastal walkway managed retreat, access stair relocation and consolidation. (MR)	26w	2/01/2017	$30,000.00
2.8) Planning: Survey and inspection of private residences within 100yr floodway and fringe line. (AN, MI)	26w	26/12/2016	$30,000.00
2.9) Works: Coastal adaptation of beach access stairs and platforms – Phase 2	12w	1/12/2016	$100,000.00
3) 2017/18 (Year 3)	189w	**3/07/2017**	$365,000.00
3.1) Monitoring: Inspections of fall distance from lower stair to beach (regular / post storm inspections)	52w	3/07/2017	$5,000.00
3.2) Monitoring: Structural inspections of timber/composite stairs/retaining walls (annual inspections)	4w	3/10/2017	$10,000.00
3.3) Monitoring: Beach profile surveys and photo monitoring, incl. Blackwood River cut migration (at least annual surveys)	4w	3/10/2017	$20,000.00
3.4) Investigation: Blackwood River flood modelling under Sea Level Rise scenario.	26w	10/07/2017	$100,000.00
3.5) Design: Coastal adaptation of jetties, boat ramp and marine infrastructure incl. Molloy Is. car ferry (GR,GN,HB,AS, AS,MI)	13w	2/10/2017	$40,000.00
3.6) Planning: South Point Carpark Layout (MR)	26w	1/01/2018	$30,000.00
3.7) Planning: Gnarabup and Ocean View carpark layouts (GN)	26w	25/12/2017	$30,000.00
3.8) Planning: Albany Terrace realignment or protection options (MR, AC, PR).	26w	25/12/2017	$30,000.00
3.9) Works: Coastal adaptation of beach access stairs and platforms – Phase 3	12w	27/11/2017	$100,000.00
4) 2018/19 (Year 4)	112w	**3/07/2018**	$95,000.00
4.1) Monitoring: Inspections of fall distance from lower stair to beach (regular / post storm inspections)	52w	3/07/2018	$5,000.00
4.2) Monitoring: Structural inspections of timber/composite stairs/retaining walls (annual inspections)	4w	3/10/2018	$10,000.00
4.3) Monitoring: Beach profile surveys and photo monitoring, incl. Blackwood River cut migration (at least annual surveys)	4w	3/10/2018	$20,000.00
4.4) Planning: Flinders Bay beach carpark and foreshore layout (MR, AC, PR).	26w	31/12/2018	$30,000.00
4.5) Planning: Rivermouth Carpark Layout (MR, AC, PR)	26w	8/10/2018	$30,000.00
5) 2019/20 (Year 5)	68w	**3/07/2019**	$95,000.00
5.1) Monitoring: Inspections of fall distance from lower stair to beach (regular / post storm inspections)	52w	3/07/2019	$5,000.00
5.2) Monitoring: Structural inspections of timber/composite stairs/retaining walls (annual inspections)	4w	3/10/2019	$10,000.00
5.3) Monitoring: Beach profile surveys and photo monitoring, in particular Blackwood River cut migration (at least annual surveys)	4w	3/10/2019	$20,000.00
5.4) Monitoring: Geotechnical inspection of limestone cliffs and safety signage audit (Yr5)	4w	1/10/2019	$30,000.00
5.5) Monitoring: Detailed coastal survey of beaches and limestone cliffs (Yr5)	4w	2/12/2019	$30,000.00

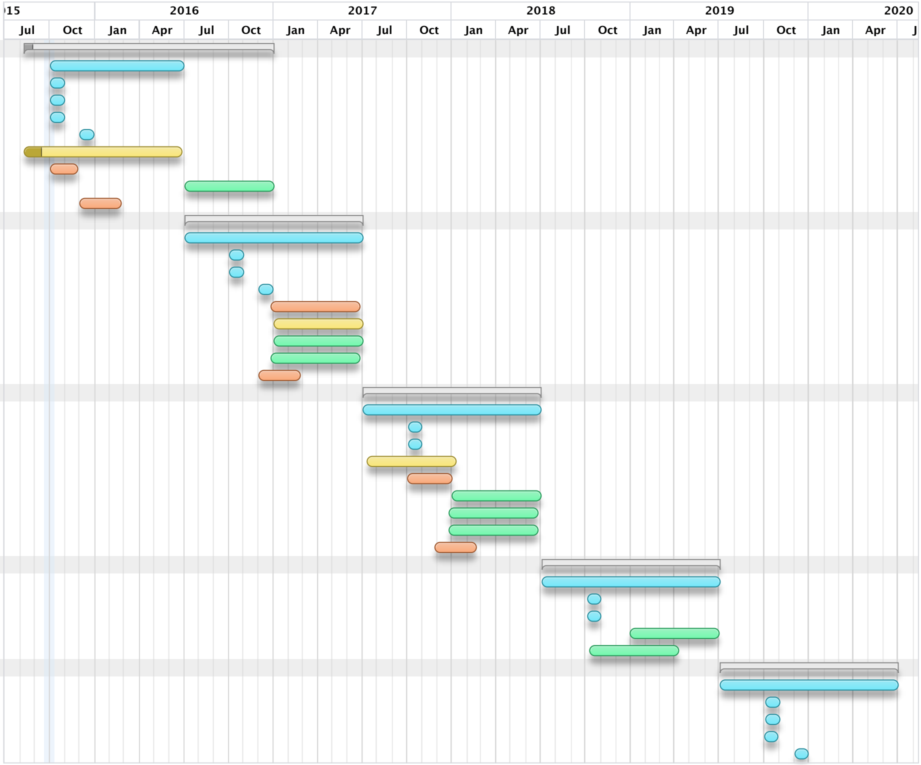

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Figure 5.3 AMRSC CHRMAP Coastal Monitoring and Adaptation Program

5.2.2. Roles and Responsibilities

The responsibility for the implementation of the Management and Adaptation Plan is with the Shire of Augusta Margaret River. Notwithstanding this the DoT and the DoP also take an active role in management and planning of the State's coast.

The majority of the works outlined in the program would be implemented by the Shire. However, additional expertise for investigations, survey and monitoring is also available from the Department of Transport..

5.2.3. Funding

The works outlined in the coastal program are subject to the Shire's planning and works department annual budgets. There are a number of funding avenues open to help with coastal management and adaptation works. These should be explored to assist with funding for the works program outlined in Figure 5.3.

The majority of coastal management and adaptation works in other shires throughout Western Australia are funded through the Department of Transport Coastal Adaptation and Protection Scheme (CAPS) grants. This funding scheme is available for investigations, monitoring, maintenance and capital works on coastal protection and adaptation structures and strategies. Funding should therefore be sought for all works within the program other than for those specifically related to boat ramps. More detail on the CAPS grant scheme is provided on the DoT website at:
http://www.transport.wa.gov.au/imarine/coastal-adaption-and-protection-cap-grants.asp

The other funding avenue specifically open to works associated with boat ramps is the Department of Transport Recreational Boating Facilities Scheme (RBFS) grants. This grant scheme is aimed at improving boating facilities within Western Australia and should be considered for the boat ramp and jetty inspections and any upgrades identified as a result. Again more detail is available on the DoT website at:
http://www.transport.wa.gov.au/imarine/recreational-boating-facilities-scheme-rbfs-grants.asp

Coastwest is a State Government initiative aimed at providing opportunities for Western Australians to learn about, conserve and protect our coast. The Department of Planning administers the Coastwest program on behalf of the West Australian Planning Commission.

The objectives of Coastwest grants are to:

- contribute to the implementation of local and regional coastal plans and strategies especially those devised in accordance with SPP2.6
- assist in the identification, protection and maintenance of environmental values, aesthetic qualities, biodiversity and water quality in the coastal zone
- foster sustainable recreational and tourist use of the coast by assisting in the maintenance of the recreational amenity and provision of public access to the coast
- build capacity in Western Australian communities in order to increase their involvement in coastal zone management activities, through joint coastal research activities, education and training.

For more detail refer to the WAPC website at:
http://www.planning.wa.gov.au/4977.asp

5.2.4. Approvals

The Leeuwin-Naturaliste Capes region was gazetted as part of the Ngari Capes Marine Park in June 2012. This classified the waters and seabed for 3km offshore of the low water mark as a Marine Park under the jurisdiction of the Marine Parks and Reserves Authority (MPRA) and managed by the Department of Parks and Wildlife (DPaW) (DPaW, 2013). As such any works within the Marine Park and adjacent beaches, which may impact on the marine park and associated flora and fauna require a regulation 4 authority.

There are additional approvals processes required should clearing be required (clearing permit) and should funding be obtained through the schemes outlined in Section 5.2.3. In addition land tenure should also be investigated prior to the commencement of any works and approval sought from relevant authorities (including Department of Planning). Consideration will need to be given to Indigenous and European heritage issues and native title.

Whilst the majority of the works outlined in the program are for monitoring and investigation and would not require any approvals, it will be appropriate to consider this approvals process should any capital or maintenance works be required in the future.

5.2.5. Review and Update

In order to allow for the continued and effective management of the coastal zone it is proposed that the program outlined in Section 0 is updated on an annual basis. This would be undertaken following the completion of the works program for that year. This would allow for the integration of any works resulting from the monitoring and investigation exercises in the future program.

In addition it is proposed that the CHRMAP is re-evaluated following the 2019/2020 program of works (in Year 5). This would allow the inclusion of the investigations proposed over the next 3 years allowing for a more detailed assessment and re-evaluation of the coastal risks and hazards. It would also allow a re-evaluation of local, state and federal policies and the most effective adaptation and management options for the coastal assets.

5.3. Longer Term Coastal Adaptation

This plan has identified a range of coastal management and adaptation measures that can be implemented in the 5-year planning horizon to manage potential coastal change over a 20-year planning horizon. The coastal monitoring and adaptation measures identified in this plan provide a foundation for longer-term coastal management and adaptation. This will however require progressive implementation of adaptation pathways.

For example, although modification of coastal stairs and platforms will be required to maintain public beach access in the medium term (accommodation), stairs on an eroding coast will need to be relocated landward in the future (managed retreat). Similarly, whilst the Shire may decide to protect strategic buildings and carparks threatened by erosion to maintain beach access and public amenity in the medium term, in the longer term a managed retreat approach is likely to be required to allow beach retreat in response to sea level rise. Potential planning horizons where these 'switches' may be required are outlined in Table 5.1.

Table 5.1 Longer Term Coastal Adaptation

	Planning Horizon (years)										
Coastal Asset Type	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
Coastal stairs and platforms	Accommodate			Managed Retreat							
Carparks	Monitoring	Protect		Managed Retreat							
Buildings (large structures, toilets, change rooms etc)		Protect		Managed Retreat							
Coastal Walkways		Managed Retreat									
Coastal Access Paths		Managed Retreat									
Public Marine Structures (Boat Ramps/Jetties)		Accommodate							Managed Retreat		
Landscaping, Playgrounds and Shelters		Managed Retreat									

Additionally, whilst the 100yr allowance for coastal processes is not a prediction of the future shoreline position, it provides some guidance to potential longer term planning issues. Importantly, the monitoring identified in the coastal monitoring and adaptation program will better inform decisions in regard to these longer term planning issues. These strategic planning issues include, but may not be limited to:

- The adaptation of low lying sections of the coastal access road to Gracetown, to accommodate future coastal flooding events.
- The geotechnical structure and long-term stability of slopes immediately adjacent to Percy Street at Gracetown.
- The longer term stability of the dune field adjacent the Mitchell Drive, which provides coastal protection to lower lying areas of the Prevelly townsite.
- The response of lower lying foreshore areas in the Blackwood River to sea level rise and a potentially different river flood regime.
- The adaptation of Albany Terrace to erosion of the Flinders Bay beaches.
- Response of river and creek entrances to variable sea levels and flooding regimes.

6. Conclusions

The CHRMAP provides an indication of the potential area of influence of coastal processes within the Shire for the next 10, 20 and 100 years. The resulting areas should be considered and integrated with other Shire planning policies to ensure development is suitably located and well planned within the coastal area.

The coastline around the Shire includes significant variation in terms of topography, value of assets and exposure to coastal processes. The risk associated with the Shire's coastal assets has been assessed based on available information, guidance from SPP2.6 and the CHRMAP guidelines.

The CHRMAP shows that the Shire has significant value assets at the coast, the major value assets are the beaches and consequently the facilities provided to support beach use. The majority of assets are located outside high coastal exposure areas, however a number of these assets have to be located within this area due to their function (e.g. beach access stairs.). Continued monitoring and further investigations will assist with development of suitable adaptation options and will inform the Shire when adaptation strategies require implementing.

Some consideration of assets within the medium and low coastal exposure areas is also required. There is substantial asset value located within the medium and low risk areas. Further development within these areas should consider the potential impact of coastal processes and planning should consider how future coastal development can be sited and designed to reduce risk.

There is a relative lack of information available for the assessment of coastal hazard risk within the Shire of Augusta Margaret River. This has limited the assessment of the risk associated with coastal assets, notably along weakly lithified limestone coast. However, the future collection of more detailed data, as recommended by this report, would allow the CHRMAP and subsequent risk assessment to be refined. This would further refine the management and adaptation strategies for the AMRSC coastline.

Notwithstanding the lack of data there are some obvious issues that require immediate attention along the AMRSC coastline. In particular the lack of regular geotechnical assessments of the weakly lithified sedimentary rock coast has resulted in poor understanding of the stability of these coasts and the risk of failure of these sections of coast.

This CHRMAP and the associated program of works will need to be reviewed regularly in light of more detailed information and monitoring to assess its relevance and allow for updating of the plan and program. The Shire will need to determine the most suitable process for implementing the recommendations of the plan and program. In addition the funding mechanisms identified will need to be explored further.

7. Glossary

Source: Modified from USACE 2003 Glossary of Coastal Terminology, EM1110-2-1100

Accretion	May be either natural or artificial. Natural accretion is the buildup of land, solely by the action of the forces of nature, on a beach by deposition of water- or airborne material. Artificial accretion is a similar buildup of land by reason of an act of man, such as the accretion formed by a GROYNE, BREAKWATER, or beach fill deposited by mechanical means.
Artificial Nourishment	The process of replenishing a beach with material (usually sand) obtained from another location.
Bar	A submerged or emerged embankment of sand, gravel, or other unconsolidated material built on the sea floor in shallow water by waves and currents.
Bathymetry	The measurement of water depths in oceans, seas, and lakes; also information derived from such measurements.
Beach	The zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation (usually the effective limit of storm waves). The seaward limit of a beach--unless otherwise specified--is the mean low water line. A beach includes foreshore and backshore.
Beach Berm	A nearly horizontal part of the beach or backshore formed by the deposit of material by wave action. Some beaches have no berms, others have one or several.
Beach Erosion	The carrying away of beach materials by wave action, tidal currents, littoral currents, or wind.
Breakwater	A man-made structure protecting a shore area, harbour, anchorage, or basin from waves. A harbour work.
Chart Datum	The plane or level to which soundings (or elevations) or tide heights are referenced (usually LOW WATER DATUM). The surface is called a tidal datum when referred to a certain phase of tide. To provide a safety factor for navigation, some level lower than MEAN SEA LEVEL is generally selected for hydrographic charts, such as MEAN LOW WATER or MEAN LOWER LOW WATER.
Coast	A strip of land of indefinite width (may be several kilometres) that extends from the SHORELINE inland to the first major change in terrain features.
Coastal Processes	Collective term covering the action of natural forces on the SHORELINE, and near shore seabed
Coastal Protection	Coastal managements works to protect the coast. This may include sand nourishment, maintenance of coastal structures (groynes, seawalls) or the construction of new coastal structures. Works are generally undertaken to protect foreshore infrastructure or beach amenity and access..
Cusp	One of a series of short ridges on the FORESHORE separated by crescent-shaped troughs spaced at more or less regular intervals. Between these *cusps* are hollows. The *cusps* are spaced at somewhat uniform distances along beaches. They represent a combination of constructive and destructive processes.
Crest	CREST Highest point on a beach face, BREAKWATER, or SEAWALL.
Downdrift	The direction of predominant movement of littoral materials.
Erosion	The wearing away of land by the action of natural forces. On a beach,

	the carrying away of beach material by wave action, tidal currents, littoral currents, or by deflation.
Groyne	Narrow, roughly shore-normal structure built to reduce longshore currents, and/or to trap and retain littoral material. Most groins are of timber or rock and extend from a SEAWALL, or the backshore, well onto the foreshore and rarely even further offshore
Littoral Drift	The movement of beach material in the littoral zone by waves and currents. Includes movement parallel (long shore drift) and sometimes also perpendicular (cross-shore transport) to the shore.
Nourishment	The process of replenishing a beach. It may occur naturally by longshore transport, or be brought about artificially by the deposition of dredged materials or of materials trucked in from upland sites.
Overtopping	Passing of water over the top of a structure as a result of wave runup or surge action.
Recession	A continuing landward movement of the shoreline. (2) A net landward movement of the shoreline over a specified time.
Runup	The upper level reached by a wave on a beach or coastal structure, relative to still-water level.
Salient	A bulge in the coastline projecting towards an offshore island or breakwater, but not connected to it as in the case of a TOMBOLO - see also Ness and Cusp. Developed by WAVE REFRACTION and diffraction and long shore drift.
Sand	Sediment particles, often largely composed of quartz, with a diameter of between 0.062 mm and 2 mm, generally classified as fine, medium, coarse or very coarse. Beach sand may sometimes be composed of organic sediments such as calcareous reef debris or shell fragments.
Scarp, Beach	An almost vertical slope along the beach caused by erosion by wave action. It may vary in height from a few cm to a meter or so, depending on wave action and the nature and composition of the beach. (See Figure A-1) See also ESCARPMENT.
Scour	Removal of underwater material by waves and currents, especially at the base or toe of a shore structure.
Scour Protection	Protection against erosion of the seabed in front of the toe.
Seawall	A structure, often concrete or stone, built along a portion of a coast to prevent erosion and other damage by wave action. Often it retains earth against its shoreward face. (2) A structure separating land and water areas to alleviate the risk of flooding by the sea. Generally shore-parallel, although some reclamation SEAWALLS may include lengths that are normal or oblique to the (original) shoreline.
Shore	The narrow strip of land in immediate contact with the sea, including the zone between high and low water lines. A shore of unconsolidated material is usually called a BEACH. Also used in a general sense to mean the coastal area (e.g., to live at the shore).
Shoreline	The line that forms the boundary between the coast and the shore. Commonly, the line that forms the boundary between the land and the water, esp. the water of a sea or ocean.
Still Water level	The surface of the water if all wave and wind action were to cease. In deep water this level approximates the midpoint of the wave height. In shallow water it is nearer to the trough than the crest. Also called the UNDISTURBED WATER LEVEL.
Storm Surge	A rise above normal water level on the open coast due to the action

	of wind stress on the water surface. Storm surge resulting from a hurricane also includes that rise in level due to atmospheric pressure reduction as well as that due to wind stress.
Updrift	The direction opposite that of the predominant movement of littoral materials.

A	13/02/15	PRELIMINARY	OS	SB
REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL

ORIG SIZE A3 | ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS | PROJECT No 1411

NOTES:

1. 200m SHORELINE OFFSET BASED ON CADASTRE COASTLINE
2. FOREDUNE AND FORESHORE CLASSIFICATION BASED ON SMARTLINE DATABASE
3. COASTAL ASSETS BASED ON COASTAL & FORESHORE FACILITIES ASSET MANAGEMENT PLAN
4. AERIAL IMAGE AUGUST 2012
5. 0-5m AHD ZONE BASED ON 2007 5m CONTOURS FROM LANDGATE
6. CALCARENITE CLIFFS OBSERVED BETWEEN SOUTH POINT CAR PARK AND ACCESS STAIRS DURING SITE INSPECTIONS

SCALE 1:5,000

50 0 50 100 150 200

DATUM

VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)

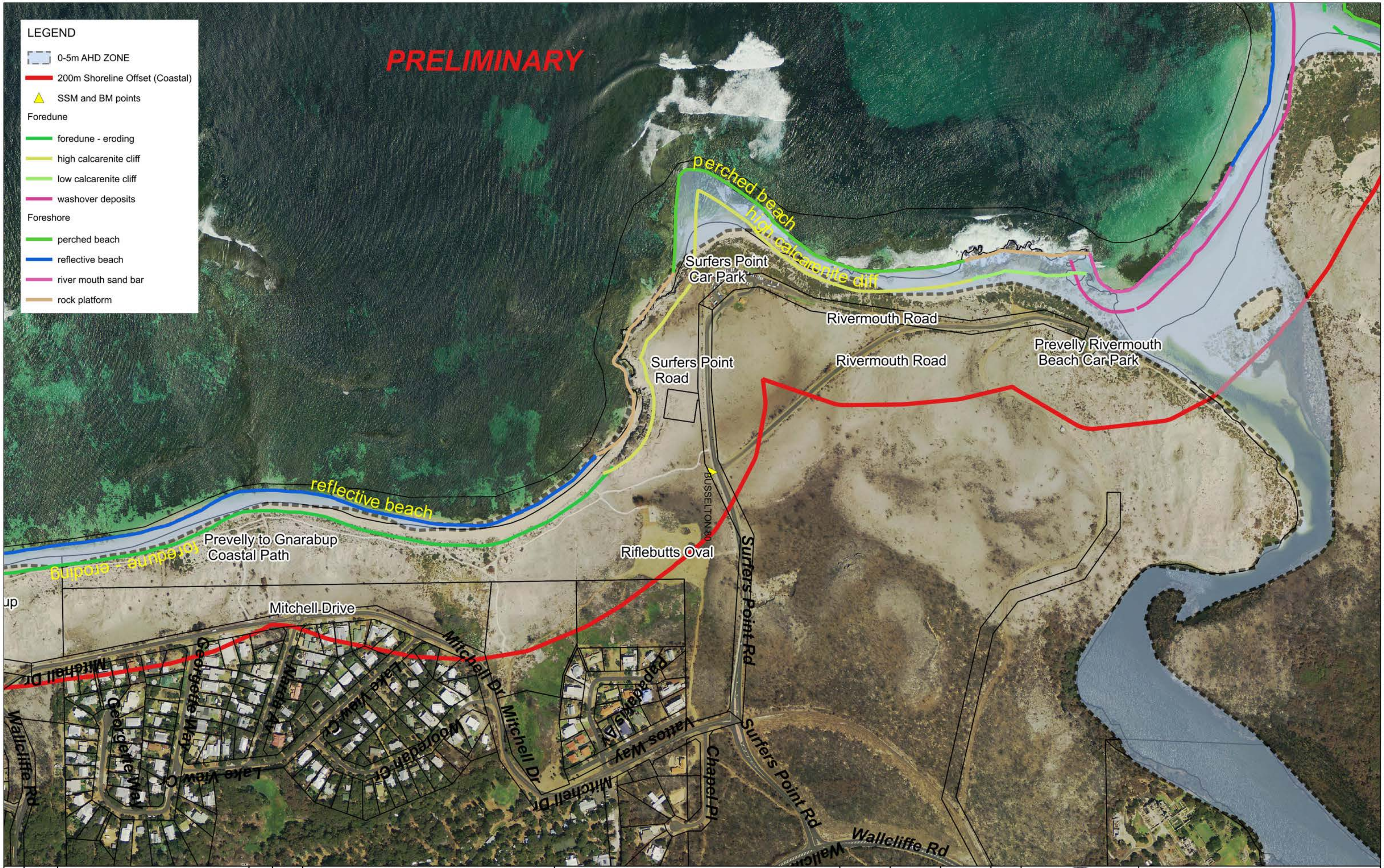
HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

N

ACTION	NAME	SIGNATURE	DATE
ENGINEER	OS		13/02/15
DRAWN	SB		13/02/15
ENGINEERING CHECK			
DRAFTING CHECK			
APPROVED PROJECT MANAGER	SB		13/02/15

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
GRACETOWN
SITE OVERVIEW

DRAWING NUMBER SC1411-1-1 REVN A



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ORIG SIZE A3 — ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS — PROJECT No 1411

NOTES:
1. 200m SHORELINE OFFSET BASED ON CADASTRE COASTLINE
2. FOREDUNE AND FORESHORE CLASSIFICATION BASED ON SMARTLINE DATABASE
3. COASTAL ASSETS BASED ON COASTAL & FORESHORE FACILITIES ASSET MANAGEMENT PLAN
4. AERIAL IMAGE AUGUST 2012
5. 0-5m AHD ZONE BASED ON 2007 5m CONTOURS FROM LANDGATE

SCALE 1:5,000
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DATUM
VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)
HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

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ACTION	NAME	SIGNATURE	DATE
ENGINEER	OS		13/02/15
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APPROVED PROJECT MANAGER	SB		13/02/15

SHIRE OF AUGUSTA MARGARET RIVER

SHORE COASTAL

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
PREVELLY
SITE OVERVIEW

DRAWING NUMBER SC1411-2-1 REVN A

A	13/02/15	PRELIMINARY	OS	SB
REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL

ORIG SIZE A3 | ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS | PROJECT No 1411

NOTES:
1. 200m SHORELINE OFFSET BASED ON CADASTRE COASTLINE
2. FOREDUNE AND FORESHORE CLASSIFICATION BASED ON SMARTLINE DATABASE
3. COASTAL ASSETS BASED ON COASTAL & FORESHORE FACILITIES ASSET MANAGEMENT PLAN
4. AERIAL IMAGE AUGUST 2012
5. 0-5m AHD ZONE BASED ON 2007 5m CONTOURS FROM LANDGATE

SCALE 1:5,000
50 0 50 100 150 200

DATUM
VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)
HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

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ENGINEER	OS		13/02/15
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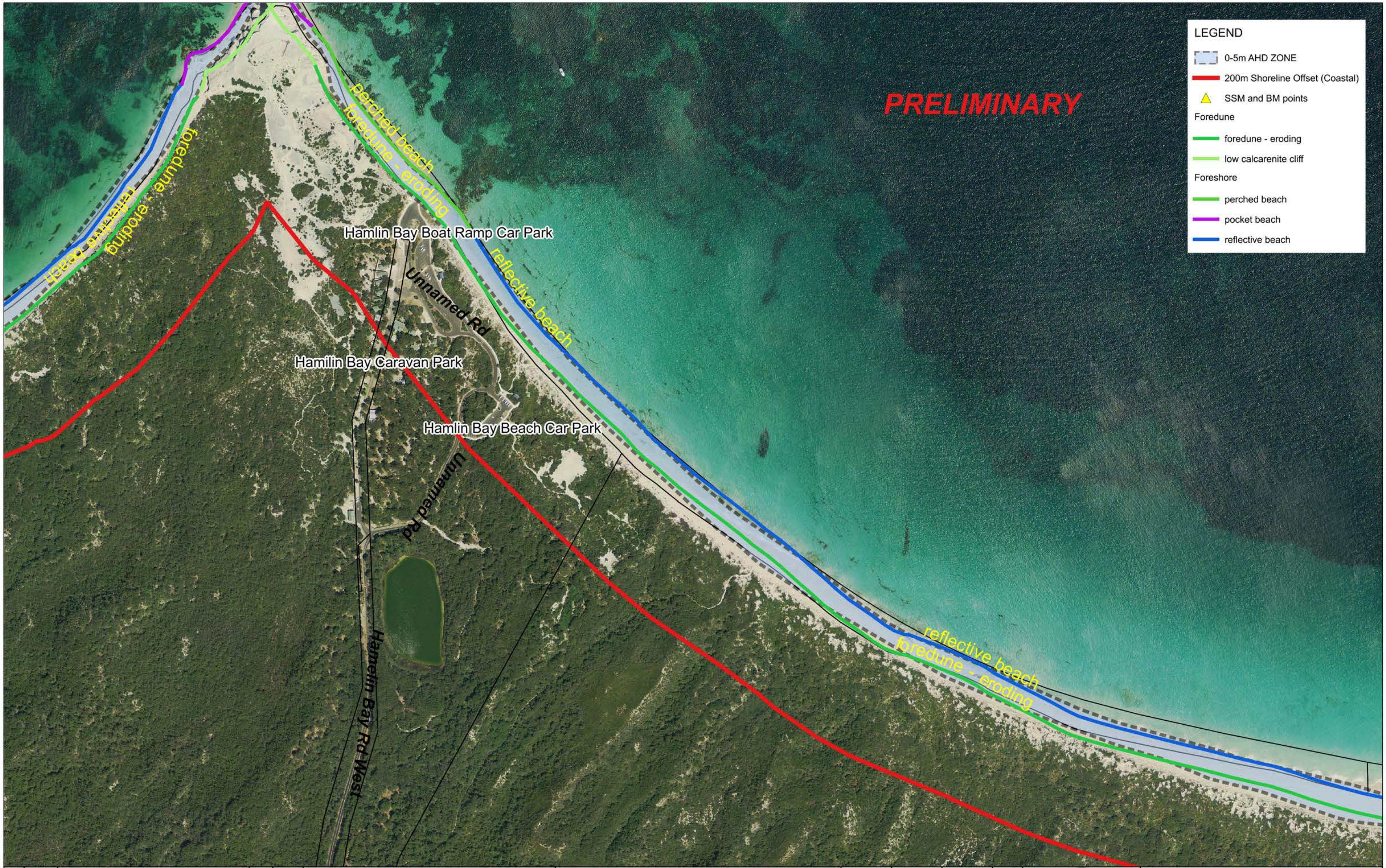
SHORE COASTAL

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
GNARABUP
SITE OVERVIEW

DRAWING NUMBER SC1411-3-1 REVN A



A	13/02/15	PRELIMINARY	OS	SB
REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL

ORIG SIZE A3 | ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS | PROJECT No 1411

NOTES:
1. 200m SHORELINE OFFSET BASED ON CADASTRE COASTLINE
2. FOREDUNE AND FORESHORE CLASSIFICATION BASED ON SMARTLINE DATABASE
3. COASTAL ASSETS BASED ON COASTAL & FORESHORE FACILITIES ASSET MANAGEMENT PLAN
4. AERIAL IMAGE AUGUST 2012
5. 0-5m AHD ZONE BASED ON 2007 5m CONTOURS FROM LANDGATE

SCALE 1:5,000
50 0 50 100 150 200

DATUM
VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)
HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

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ACTION	NAME	SIGNATURE	DATE
ENGINEER	OS		13/02/15
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APPROVED PROJECT MANAGER	SB		13/02/15

SHIRE OF AUGUSTA MARGARET RIVER

SHORE COASTAL

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
HAMELIN BAY
SITE OVERVIEW

DRAWING NUMBER SC1411-4-1 REVN A

REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL
A	13/02/15	PRELIMINARY	OS	SB

ORIG SIZE A3 | ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS | PROJECT No 1411

NOTES:
1. 200m SHORELINE OFFSET BASED ON CADASTRE COASTLINE
2. FOREDUNE AND FORESHORE CLASSIFICATION BASED ON SMARTLINE DATABASE
3. COASTAL ASSETS BASED ON COASTAL & FORESHORE FACILITIES ASSET MANAGEMENT PLAN
4. AERIAL IMAGE AUGUST 2012
5. 0-5m AHD ZONE BASED ON 2007 5m CONTOURS FROM LANDGATE

SCALE 1:7,500
75 0 75 150 225 300

DATUM
VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)
HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

N

GDA

ACTION	NAME	SIGNATURE	DATE
ENGINEER	OS		13/02/15
DRAWN	SB		13/02/15
ENGINEERING CHECK			
DRAFTING CHECK			
APPROVED PROJECT MANAGER	SB		13/02/15

SHIRE OF AUGUSTA MARGARET RIVER

SHORE COASTAL

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
MOLLOY ISLAND
SITE OVERVIEW

DRAWING NUMBER SC1411-5-1 REVN A

B	13/02/15	PRELIMINARY (REFINMENT OF 0-5m AHD CONTOUR)	OS	SB
A	10/02/15	PRELIMINARY/FOR INFORMATION	OS	SB
REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL

ORIG SIZE A3 — ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS — PROJECT No 1411

NOTES:
1. 200m SHORELINE OFFSET BASED ON CADASTRE COASTLINE
2. FOREDUNE AND FORESHORE CLASSIFICATION BASED ON SMARTLINE DATABASE
3. COASTAL ASSETS BASED ON COASTAL & FORESHORE FACILITIES ASSET MANAGEMENT PLAN
4. AERIAL IMAGE AUGUST 2012
5. 0-5m AHD ZONE BASED ON 2009 1m CONTOURS FROM LANDGATE

SCALE 1:7,500
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DATUM
VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)
HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

GDA

ACTION	NAME	SIGNATURE	DATE
ENGINEER	SB		13/02/15
DRAWN	OS		13/02/15
ENGINEERING CHECK			
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APPROVED PROJECT MANAGER	SB		13/02/15

SHIRE OF AUGUSTA MARGARET RIVER

SHORE COASTAL

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
AUGUSTA NORTH
SITE OVERVIEW

DRAWING NUMBER SC1411-6-1 REVN B

B	13/02/2015	PRELIMINARY (REFINEMENT OF 0-5m AHD CONTOUR)	OS	SB
A	10/02/2015	PRELIMINARY/FOR INFORMATION	OS	SB
REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL

ORIG SIZE A3 — ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS — PROJECT No 1411

NOTES:
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2. FOREDUNE AND FORESHORE CLASSIFICATION BASED ON SMARTLINE DATABASE
3. COASTAL ASSETS BASED ON COASTAL & FORESHORE FACILITIES ASSET MANAGEMENT PLAN
4. AERIAL IMAGE AUGUST 2012
5. 0-5m AHD ZONE BASED ON 2009 1m CONTOURS FROM LANDGATE

SCALE 1:7,500
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DATUM
VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)
HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

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ACTION	NAME	SIGNATURE	DATE
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DRAFTING CHECK			??/??/????
APPROVED PROJECT MANAGER	SB		10/02/15

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
AUGUSTA SOUTH
SITE OVERVIEW

DRAWING NUMBER SC1411-7-1 REVN B

8. References

University of Tasmania. (2009). *The Australian Coastal Smartline Geomorphic and Stability Map Version 1: Project Report.* for Geoscience Australia & Department of Climate Change, University of Tasmania, School of Geography & Environmental Studies (Spatial Sciences).

US Army Corps of Engineers. (2006). *Coastal Engineering Manual.* Washington, D.C.: US Army Corps of Engineers.

WAPC. (2009). *Augusta - Walpole Coastal Strategy.*

WAPC. (2014). *Coastal Hazard Risk Management and Adaptation Planning Guidelines.* Western Australia Planning Commission.

WAPC. (2013b). *State Coastal Planning Guidelines.* Western Australia Planning Commission.

WAPC. (2003). *Statement of Planning Policy 2.6 (State Coastal Planning Policy).* Western Australia Planning Commission.

WAPC. (2013a). *Statement of Planning Policy 2.6 (State Coastal Planning Policy).* Western Australia Planning Commission.

WAPC. (2013c). *Statement of Planning Policy No. 6.1 Leeuwin-Naturaliste Ridge Policy.*

Water and Rivers Commission. (2000). *Water Facts - Flood Plain Management.* Government of Western Australia.

AGS. (2007b). Australian Geoguide LR2 (Landslides). *Australian Geomechanics , 42* (1).

AGS. (2007a). Guideline for Landslide Susceptibility, Hazard and Risk Zoning for Land Use Planning. *Journal and News of the Australian Geomechanics Society , 42* (1).

AMRSC. (2013b). *Asset Management Plan 2033.*

AMRSC. (2013a). *Community Strategic Plan 2033.*

AMRSC. (2014a). *Local Planning Scheme Number 01,.* Gazetted 24th September 2010 Amended 7th April 2014.

AMRSC. (2011). *Local Planning Strategy.* 9th March 2011 Endorsed by WAPC 14th April 2011.

Baynes Geologic. (2006). *Surfers Point Redevelopment Geotechnical Constraints.* Report 166/1.

Bruun, P. (1954). *Coast Erosion and the Development of Beach Profiles. Beach Erosion Board Technical Memorandum 44.* Washington DC: US Army Corps of Engineers.

Carlsen, J. (2015). *Socio-economic Benefits of Beaches (for the AMRSC CHRMAP).* Tourism Research Services.

Cechet, B., Taylor, P., Griffin, C., & Hazelwood, M. (2011). Australia's coastline: adapting to climate change: Assessing infrastructure vulnerability to rising sea-levels. *AusGeo News* (101).

CPB. (2014). *Developing a Management Strategy for Coastal Cliff Erosion Hazards in South Australia.*

CSIRO. (2007). *Climate Change in Australia, Technical Report.*

Damara. (2012). *Coastal Hazard Mapping for Economic Analysis of Climate Change Adaptation in the Peron-Naturaliste Region .*

Damara. (2009). *Scarborough Beach Urban Design Master Plan Review: Coastal Zone Climate Change Vulnerability & Risk Assessment: FIRST PASS SUMMARY REPORT .*

Damara. (2009a). *Shire of Busselton Local Environmental Planning Study Coastal Impacts of Climate Change.* Damara WA Pty Ltd.

DEC. (1975). *An Environmental Study of the BlackwoodRiver Estuary, Western Australia 1974 - 1975.* Department of Environment and Conservation.

Department of Climate Change. (2009). *Climate Change Risks to Australia's Coast A FIRST PASS NATIONAL ASSESSMENT .* Australian Government.

Department of Climate Change. (2011). *Climate Change Risks to Coastal Buildings and Infrastructure A Supplement to the FIRSt pASS nAtIonAl ASSeSSment.* Australian Government.

Department of Parks and Wildlife. (2015). *Leeuwin-Naturaliste Capes Area Parks and Reserves Management Plan 2015.* Perth: Department of Parks and Wildlife.

DoW. (2014, December). *Geographic Data Atlas*. Retrieved September 2015 from Department of Water: http://atlases.water.wa.gov.au/idelve/dowdataext/

DoT. (2012). *Augusta Boat Harbour Design Wave and Water Level Analysis.* DoT Report #487.

DoT. (1995a). *Gnarabup Beach Boat Launching Ramp.* 372/95.

DoT. (2012). *How to Photo Monitor Beaches.* Department of Transport.

DoT. (2010). *Sea Level Change in Western Australia - Application to Planning.* Department of Transport.

DPaW. (2015). *Leeuwin - Naturaliste Capes Area Parks and Reserves Management Plan 2015.*

DPaW. (2013). *Ngari Capes Marine Park Management Plan 2013 – 2033.* Perth: Department of Parks and Wildlife.

GHD. (2013). *Gracetown Residential Land Development - Additional Geophysical and Drilling Investigation.* Report for Landcorp.

Gordon Geological Consultants. (1997). *Inspection of Coastal Hazards at Gracetown, Prevelly and Grunters.* Shire of Augusta Margaret River.

Gordon Geological Consultants. (2002). *Huzzas Beach Gracetown Memorial Site and Huzzas Beach Gracetown Stability of Steps.* Shire of Augusta Margaret River.

Gordon Geological Consultants. (2005). *Report of Huzzas Cliffs.* Report to Department of Conservation and Land Management.

IPCC. (2007). *Intergovernmental Panel on Climate Change - Climate CHange 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.*

IPCC. (2014). *Intergovernmental Panel on Climate CHange 2014 Climate Change 2014 Synthesis Report - Summary for Policymakers, Fifth Assessment Report.*

Landform Research & Coastwise. (2005). *Augusta - Margaret River Coastal Management Plan.* Shire of Augusta Margaret River & WAPC.

NOAA. (2015, August 27). *National Oceanic and Atmospheric Administration*. Retrieved August 27, 2015 from Glossary: http://forecast.weather.gov/glossary.php?letter=s

MJ Paul & Associates. (2004). *Investigation of Options that Provide Safe Navigable Access to the Ocean Waters at Augusta.*

Monaghan & Associates. (1997). *Augusta Foreshore Management and Landscape Concept Final Plan.* Report for AMRSC.

MRA. (2001). *Wave Climate Analysis and Site Comparison Study.* AMRSC.

Oceanica and Shore Coastal. (2009). *Review of Application of Schedule 1 of SPP2.6.* Draft Report to DPI.

Quantum GIS Development Team. (2015). *Quantum GIS Geographic Information System.* From Open Source Geospatial Foundation Project.: http://qgis.osgeo.org

Shore Coastal. (2012). *Busselton Coastal Management Program.* Report SCR1211.

Shore Coastal. (2014). *Gnarabup Beach Coastal Engineering Assessment.* SCR1306.

Smithson Planning. (2003). *Hardy Inlet Management Plan.*

Richardson, L., Mathews, E., & Heap, A. (2005). *Geomorphology and Sedimentology of the South Western Planning Area of Australia: Review and Synthesis of Relevant Literature in Support of Regional Marine Planning.* Geoscience Australia.

Tingay. (1993). *Prevelly Foreshore Reserve Management Plan.* for Cedarvale Investments Pty Ltd.

9. Attachment 1 Risk Identification Drawings

Risk identification establishes an understanding of historic and potential impacts of erosion and storm surge inundation on the assets and their values, including from climate change and associated sea level rise. Erosion and inundation risks need to be considered (WAPC, 2014).

The assessment of coastal type and coastal processes allowed an initial identification of coastal infrastructure potentially exposed to coastal processes at each project site within the Shire. Coastal infrastructure located close to the coast (within 200m) or relatively low lying (below 5m AHD) was identified through site inspections, analysis of aerial imagery and available topographic data. Shire cadastral information was assessed to identify the proximity of property and road reserve boundaries to the coast. This provided an initial list of coastal infrastructure potentially exposed to coastal processes for further analysis.

The following is noted in regard to these drawings:

- These plans provide an initial interpretation of areas exposed to coastal processes using the procedures of the state coastal planning policy. These plans do not have the precision required to define the erosion risk to individual properties.
- Allowances are not a prediction of the future shoreline position.
- Coastal hazards in the vicinity of limestone cliffs require further assessment by a geotechnical engineer.
- The 200m shoreline offset is based on cadastre coastline.
- The 5m contours were sourced from Landgate 2007.
- Foredune and foreshore classification based on Smartline database.
- Aerial image August 2012

A	13/02/15	PRELIMINARY	OS	SB
REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL

ORIG SIZE A3 — ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS — PROJECT No 1411

NOTES:

1. 200m SHORELINE OFFSET BASED ON CADASTRE COASTLINE
2. FOREDUNE AND FORESHORE CLASSIFICATION BASED ON SMARTLINE DATABASE
3. COASTAL ASSETS BASED ON COASTAL & FORESHORE FACILITIES ASSET MANAGEMENT PLAN
4. AERIAL IMAGE AUGUST 2012
5. 0-5m AHD ZONE BASED ON 2007 5m CONTOURS FROM LANDGATE
6. CALCARENITE CLIFFS OBSERVED BETWEEN SOUTH POINT CAR PARK AND ACCESS STAIRS DURING SITE INSPECTIONS

SCALE 1:5,000 (50 0 50 100 150 200)

DATUM

VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)

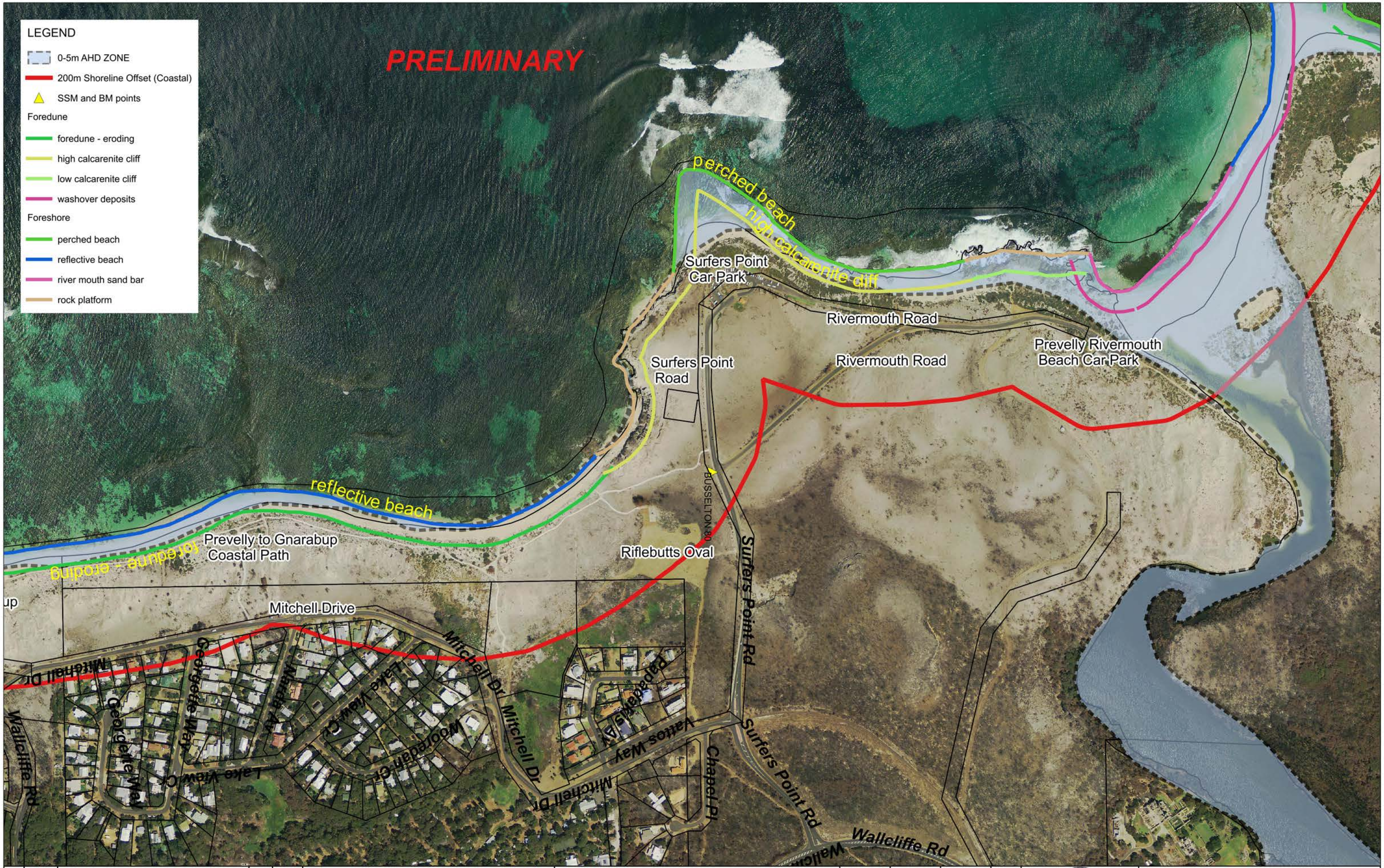
HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

ACTION	NAME	SIGNATURE	DATE
ENGINEER	OS		13/02/15
DRAWN	SB		13/02/15
ENGINEERING CHECK			
DRAFTING CHECK			
APPROVED PROJECT MANAGER	SB		13/02/15

SHORE COASTAL

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
GRACETOWN
SITE OVERVIEW

DRAWING NUMBER SC1411-1-1 REVN A



A	13/02/15	PRELIMINARY	OS	SB
REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL

ORIG SIZE A3 — ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS — PROJECT No 1411

NOTES:

1. 200m SHORELINE OFFSET BASED ON CADASTRE COASTLINE
2. FOREDUNE AND FORESHORE CLASSIFICATION BASED ON SMARTLINE DATABASE
3. COASTAL ASSETS BASED ON COASTAL & FORESHORE FACILITIES ASSET MANAGEMENT PLAN
4. AERIAL IMAGE AUGUST 2012
5. 0-5m AHD ZONE BASED ON 2007 5m CONTOURS FROM LANDGATE

SCALE 1:5,000

50 0 50 100 150 200

N

DATUM

VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)

HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

GDA

ACTION	NAME	SIGNATURE	DATE
ENGINEER	OS		13/02/15
DRAWN	SB		13/02/15
ENGINEERING CHECK			
DRAFTING CHECK			
APPROVED PROJECT MANAGER	SB		13/02/15

SHIRE OF AUGUSTA MARGARET RIVER

SHORE COASTAL

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
PREVELLY
SITE OVERVIEW

DRAWING NUMBER SC1411-2-1 REVN A

A	13/02/15	PRELIMINARY	OS	SB
REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL

ORIG SIZE A3 | ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS | PROJECT No 1411

NOTES:
1. 200m SHORELINE OFFSET BASED ON CADASTRE COASTLINE
2. FOREDUNE AND FORESHORE CLASSIFICATION BASED ON SMARTLINE DATABASE
3. COASTAL ASSETS BASED ON COASTAL & FORESHORE FACILITIES ASSET MANAGEMENT PLAN
4. AERIAL IMAGE AUGUST 2012
5. 0-5m AHD ZONE BASED ON 2007 5m CONTOURS FROM LANDGATE

SCALE 1:5,000
50 0 50 100 150 200

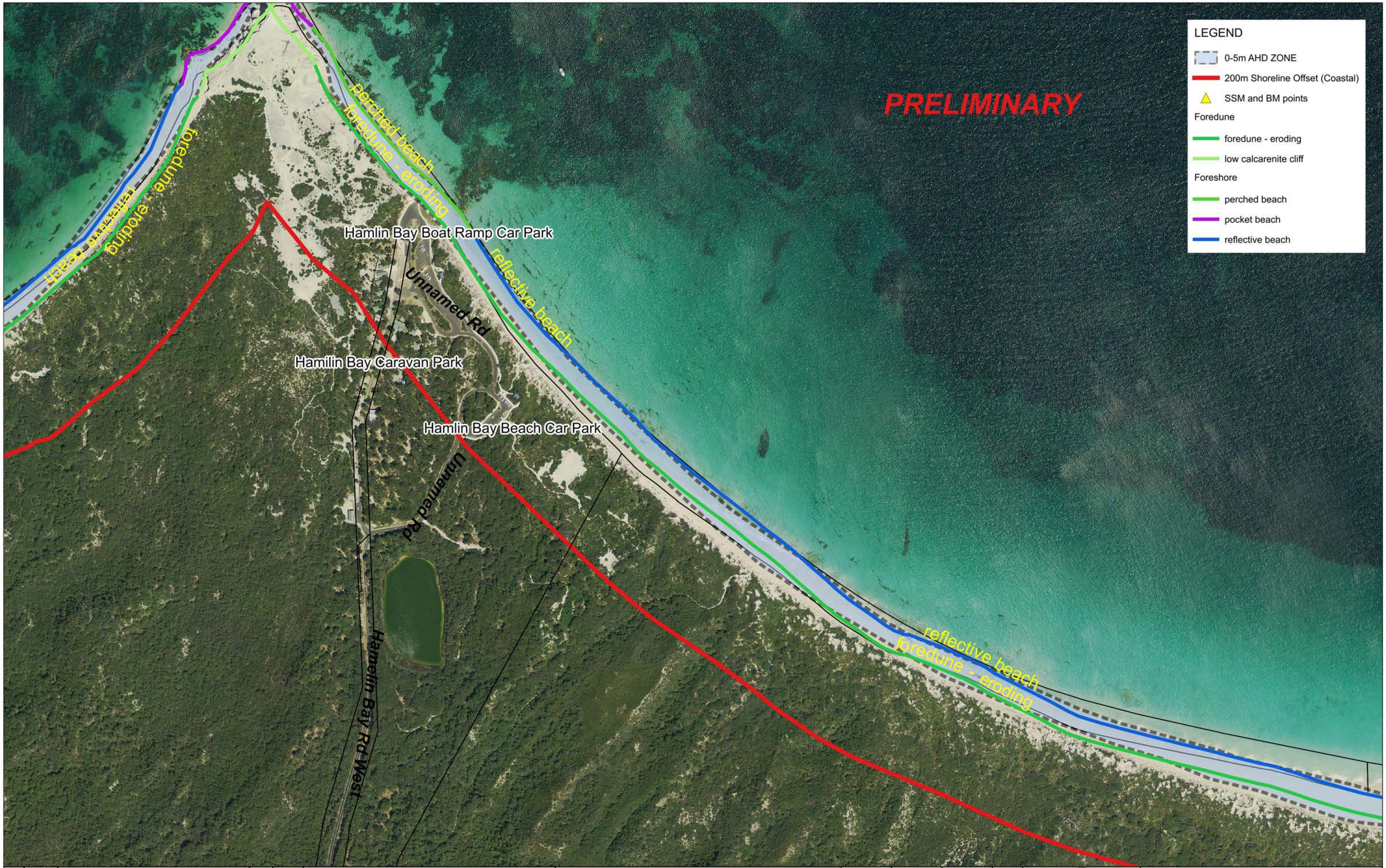
N

DATUM
VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)
HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

ACTION	NAME	SIGNATURE	DATE
ENGINEER	OS		13/02/15
DRAWN	SB		13/02/15
ENGINEERING CHECK			
DRAFTING CHECK			
APPROVED PROJECT MANAGER	SB		13/02/15

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
GNARABUP
SITE OVERVIEW

DRAWING NUMBER SC1411-3-1 REVN A



A	13/02/15	PRELIMINARY	OS	SB
REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL

ORIG SIZE A3 | ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS | PROJECT No 1411

NOTES:

1. 200m SHORELINE OFFSET BASED ON CADASTRE COASTLINE
2. FOREDUNE AND FORESHORE CLASSIFICATION BASED ON SMARTLINE DATABASE
3. COASTAL ASSETS BASED ON COASTAL & FORESHORE FACILITIES ASSET MANAGEMENT PLAN
4. AERIAL IMAGE AUGUST 2012
5. 0-5m AHD ZONE BASED ON 2007 5m CONTOURS FROM LANDGATE

SCALE 1:5,000

50 0 50 100 150 200

DATUM

VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)

HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

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GDA

ACTION	NAME	SIGNATURE	DATE
ENGINEER	OS		13/02/15
DRAWN	SB		13/02/15
ENGINEERING CHECK			
DRAFTING CHECK			
APPROVED PROJECT MANAGER	SB		13/02/15

SHIRE OF AUGUSTA MARGARET RIVER

SHORE COASTAL

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
HAMELIN BAY
SITE OVERVIEW

DRAWING NUMBER SC1411-4-1 REVN A

A	13/02/15	PRELIMINARY	OS	SB
REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL

ORIG SIZE A3 | ARCHIVE afp://shoreccoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS | PROJECT No 1411

NOTES:
1. 200m SHORELINE OFFSET BASED ON CADASTRE COASTLINE
2. FOREDUNE AND FORESHORE CLASSIFICATION BASED ON SMARTLINE DATABASE
3. COASTAL ASSETS BASED ON COASTAL & FORESHORE FACILITIES ASSET MANAGEMENT PLAN
4. AERIAL IMAGE AUGUST 2012
5. 0-5m AHD ZONE BASED ON 2007 5m CONTOURS FROM LANDGATE

SCALE 1:7,500
75 0 75 150 225 300

DATUM
VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)
HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

N

GDA

ACTION	NAME	SIGNATURE	DATE
ENGINEER	OS		13/02/15
DRAWN	SB		13/02/15
ENGINEERING CHECK			
DRAFTING CHECK			
APPROVED PROJECT MANAGER	SB		13/02/15

SHIRE OF AUGUSTA MARGARET RIVER

SHORE COASTAL

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
MOLLOY ISLAND
SITE OVERVIEW

DRAWING NUMBER SC1411-5-1 REVN A

B	13/02/15	PRELIMINARY (REFINMENT OF 0-5m AHD CONTOUR)	OS	SB
A	10/02/15	PRELIMINARY/FOR INFORMATION	OS	SB
REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL

ORIG SIZE A3 | ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS | PROJECT No 1411

NOTES:
1. 200m SHORELINE OFFSET BASED ON CADASTRE COASTLINE
2. FOREDUNE AND FORESHORE CLASSIFICATION BASED ON SMARTLINE DATABASE
3. COASTAL ASSETS BASED ON COASTAL & FORESHORE FACILITIES ASSET MANAGEMENT PLAN
4. AERIAL IMAGE AUGUST 2012
5. 0-5m AHD ZONE BASED ON 2009 1m CONTOURS FROM LANDGATE

SCALE 1:7,500
75 0 75 150 225 300

DATUM
VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)
HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

N

ACTION	NAME	SIGNATURE	DATE
ENGINEER	SB		13/02/15
DRAWN	OS		13/02/15
ENGINEERING CHECK			
DRAFTING CHECK			
APPROVED PROJECT MANAGER	SB		13/02/15

SHORE COASTAL

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
AUGUSTA NORTH
SITE OVERVIEW

DRAWING NUMBER SC1411-6-1 REVN B

REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL
B	13/02/2015	PRELIMINARY (REFINEMENT OF 0-5m AHD CONTOUR)	OS	SB
A	10/02/2015	PRELIMINARY/FOR INFORMATION	OS	SB

ORIG SIZE A3 | ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS | PROJECT No 1411

NOTES:

1. 200m SHORELINE OFFSET BASED ON CADASTRE COASTLINE
2. FOREDUNE AND FORESHORE CLASSIFICATION BASED ON SMARTLINE DATABASE
3. COASTAL ASSETS BASED ON COASTAL & FORESHORE FACILITIES ASSET MANAGEMENT PLAN
4. AERIAL IMAGE AUGUST 2012
5. 0-5m AHD ZONE BASED ON 2009 1m CONTOURS FROM LANDGATE

SCALE 1:7,500

75 0 75 150 225 300

Z

DATUM

VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)

HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

GDA

ACTION	NAME	SIGNATURE	DATE
ENGINEER	SB		10/02/15
DRAWN	OS		10/02/15
ENGINEERING CHECK			??/??/????
DRAFTING CHECK			??/??/????
APPROVED PROJECT MANAGER	SB		10/02/15

SHORE COASTAL

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
AUGUSTA SOUTH
SITE OVERVIEW

DRAWING NUMBER SC1411-7-1 REVN B

10. Attachment 2 Risk Analysis Tables

A Risk analysis has been undertaken to consider the potential impact of coastal processes on the coastal settlements in further detail using the procedures outlined in the State Coastal Planning Policy. This required consideration of storm erosion of beaches, longer-term coastal recession and the influence of sea level rise on the coast.

Planning timeframes of 10, 20 and 100 years were adopted to align coastal adaptation and planning with the Shire's broader strategic planning, asset management and financial management timeframes.

These risk analysis tables are an application of Schedule 1 of the State Coastal Planning Policy to the nominated project sites in the Shire of Augusta Margaret River. These tables provide the allowances for coastal processes mapped in Attachment 3.

Gracetown 1411 AMRSC Coastal Study Areas Assessment 150930.xlsx

	Coastal node	Cowaramup Bay Boat Ramp	Cowaramup Bay Swimming Beach	Melaleuca Beach	South Point Car Park	South Point
	Coastal Type	Rocky Coast	Sandy Coast	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast
Storm erosion	S1	0	11	11	20	20
Long-term Trend	S2	0	0	2	0	0
Erosion due to SLR	S3	0	4	4	4	4
Factor of Safety	FoS	0	2	2	2	2
Inundation	S4	5m AHD contour				
	Subtotal (m)	0	17	19	26	26
	10yr Coastal Processes Allowance Including Rounding (m)	0	15	20	25	25

Notes

	Coastal node	Cowaramup Bay Boat Ramp	Cowaramup Bay Swimming Beach	Melaleuca Beach	South Point Car Park	South Point
	Coastal Type	Rocky Coast	Sandy Coast	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast
Storm erosion	S1	Assumed no erosion	Sandy coast erosion based on average recession from SBEACH modelling of the 23/09/2013 erosion event	Sandy coast erosion based on average recession from SBEACH modelling of the 23/09/2013 erosion event	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high
Long-term Trend	S2	Assumed no erosion	2000 to 2013 aerial imagery shows slight accretion trend	2000 to 2013 aerial imagery shows erosion of 2.5m (0.2m/year)	Assumed no long term erosion	Assumed no long term erosion
Erosion due to SLR	S3	Assumed no erosion	Assumed default value as per SPP2.6 (100 x SLR (0.04))	Assumed default value as per SPP2.6 (100 x SLR (0.04))	Assumed default value as per SPP2.6 (100 x SLR (0.04))	Assumed default value as per SPP2.6 (100 x SLR (0.04))
Factor of Safety	FoS	Assumed no erosion	0.2m/year	0.2m/year	0.2m/year	0.2m/year
Inundation	S4	5m AHD contour				

	Coastal node	Cowaramup Bay Boat Ramp	Cowaramup Bay Swimming Beach	Melaleuca Beach	South Point Car Park	South Point
	Coastal Type	Rocky Coast	Sandy Coast	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast
Storm erosion	S1	0	16	16	20	20
Long-term Trend	S2	0	0	4	0	0
Erosion due to SLR	S3	0	10	10	10	10
Factor of Safety	FoS	0	4	4	4	4
Inundation	S4	5m AHD contour				
	Subtotal (m)	0	30	34	34	34
	20yr Coastal Processes Allowance Including Rounding (m)	0	30	35	35	35

Notes

	Coastal node	Cowaramup Bay Boat Ramp	Cowaramup Bay Swimming Beach	Melaleuca Beach	South Point Car Park	South Point
	Coastal Type	Rocky Coast	Sandy Coast	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast
Storm erosion	S1	Assumed no erosion	Sandy coast erosion based on average recession from SBEACH modelling of the 23/09/2013 erosion event	Sandy coast erosion based on average recession from SBEACH modelling of the 23/09/2013 erosion event	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high
Long-term Trend	S2	Assumed no erosion	2000 to 2013 aerial imagery shows slight accretion trend	2000 to 2013 aerial imagery shows erosion of 2.5m (0.2m/year)	Assumed no long term erosion	Assumed no long term erosion
Erosion due to SLR	S3	Assumed no erosion	Assumed default value as per SPP2.6 (100 x SLR (0.1))	Assumed default value as per SPP2.6 (100 x SLR (0.1))	Assumed default value as per SPP2.6 (100 x SLR (0.1))	Assumed default value as per SPP2.6 (100 x SLR (0.1))
Factor of Safety	FoS	Assumed no erosion	0.2m/year	0.2m/year	0.2m/year	0.2m/year
Inundation	S4	5m AHD contour				

	Coastal node	Cowaramup Bay Boat Ramp	Cowaramup Bay Swimming Beach	Melaleuca Beach	South Point Car Park	South Point
	Coastal Type	Rocky Coast[1]	Sandy Coast	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast
Storm erosion		0	18	18	20	20
Long-term Trend		0	0	20	0	0
Erosion due to SLR		0	90	90	90	90
Factor of Safety		0	20	20	20	20
Inundation	S4	5m AHD contour				
	Subtotal (m)	0	128	148	130	130
	100yr Coastal Processes Allowance Including Rounding (m)	0	130	150	130	130

Notes

	Coastal node	Cowaramup Bay Boat Ramp	Cowaramup Bay Swimming Beach	Melaleuca Beach	South Point Car Park	South Point
	Coastal Type	Rocky Coast	Sandy Coast	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast
Storm erosion	S1	Assumed no erosion	Sandy coast erosion based on average recession from SBEACH modelling of 3 consecutive 100yr erosion events	Sandy coast erosion based on average recession from SBEACH modelling of 3 consecutive 100yr erosion events	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high
Long-term Trend	S2	Assumed no erosion	2000 to 2013 aerial imagery shows slight accretion trend	2000 to 2013 aerial imagery shows erosion of 2.5m (0.2m/year)	Assumed no long term erosion	Assumed no long term erosion
Erosion due to SLR	S3	Assumed no erosion	Assumed default value as per SPP2.6 (100 x SLR (0.9))	Assumed default value as per SPP2.6 (100 x SLR (0.9))	Assumed default value as per SPP2.6 (100 x SLR (0.9))	Assumed default value as per SPP2.6 (100 x SLR (0.9))
Factor of Safety	FoS	Assumed no erosion	0.2m/year	0.2m/year	0.2m/year	0.2m/year
Inundation	S4	5m AHD contour				

Prevelly 1411 AMRSC Coastal Study Areas Assessment 150930.xlsx

	Coastal node	Rivermouth Beach	Rivermouth Road	Surfers Point	Riflebutts Beach	Prevelly Beach
	Coastal Type	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast	Sandy Coast
Storm erosion	S1	6	20	20	20	6
Long-term Trend	S2	6.3	0	0	0	2.5
Erosion due to SLR	S3	4	4	4	4	4
Factor of Safety	FoS	2	2	2	2	2
Inundation	S4	5m AHD contour				
	Subtotal (m)	18.3	26	26	26	14.5
	10yr Coastal Processes Allowance Including Rounding (m)	20	30	25	25	15

Notes

	Coastal node	Rivermouth Beach	Rivermouth Road	Surfers Point	Riflebutts Beach	Prevelly Beach
	Coastal Type	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast	Sandy Coast
Storm erosion	S1	Sandy coast erosion based on average recession from SBEACH modelling of the 23/09/2013 erosion event	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high	Sandy coast erosion based on average recession from SBEACH modelling of the 23/09/2013 erosion event
Long-term Trend	S2	2000 to 2013 aerial imagery shows 8.2m of erosion (0.63m/year)	Assumed no long term erosion	Assumed no long term erosion	Assumed no long term erosion	2000 to 2013 aerial imagery shows erosion of 3m to 4m (0.25m/year)
Erosion due to SLR	S3	Assumed default value as per SPP2.6 (100 x SLR (0.04))	Assumed default value as per SPP2.6 (100 x SLR (0.04))	Assumed default value as per SPP2.6 (100 x SLR (0.04))	Assumed default value as per SPP2.6 (100 x SLR (0.04))	Assumed default value as per SPP2.6 (100 x SLR (0.04))
Factor of Safety	FoS	0.2m/year	0.2m/year	0.2m/year	0.2m/year	0.2m/year
Inundation	S4	5m AHD contour				

	Coastal node	Rivermouth Beach	Rivermouth Road	Surfers Point	Riflebutts Beach	Prevelly Beach
	Coastal Type	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast	Sandy Coast
Storm erosion	S1	9	20	20	20	9
Long-term Trend	S2	12.6	0	0	0	5
Erosion due to SLR	S3	10	10	10	10	10
Factor of Safety	FoS	4	4	4	4	4
Inundation	S4	5m AHD contour				
	Subtotal (m)	35.6	34	34	34	28
	20yr Coastal Processes Allowance Including Rounding (m)	35	35	35	35	30

Notes

	Coastal node	Rivermouth Beach	Rivermouth Road	Surfers Point	Riflebutts Beach	Prevelly Beach
	Coastal Type	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast	Sandy Coast
Storm erosion	S1	Sandy coast erosion based on average recession from SBEACH modelling of the 100yr erosion event	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high	Sandy coast erosion based on average recession from SBEACH modelling of the 100yr erosion event
Long-term Trend	S2	2000 to 2013 aerial imagery shows 8.2m of erosion (0.63m/year)	Assumed no long term erosion	Assumed no long term erosion	Assumed no long term erosion	2000 to 2013 aerial imagery shows erosion of 3m to 4m (0.25m/year)
Erosion due to SLR	S3	Assumed default value as per SPP2.6 (100 x SLR (0.1))	Assumed default value as per SPP2.6 (100 x SLR (0.1))	Assumed default value as per SPP2.6 (100 x SLR (0.1))	Assumed default value as per SPP2.6 (100 x SLR (0.1))	Assumed default value as per SPP2.6 (100 x SLR (0.1))
Factor of Safety	FoS	0.2m/year	0.2m/year	0.2m/year	0.2m/year	0.2m/year
Inundation	S4	5m AHD contour				

	Coastal node	Rivermouth Beach	Rivermouth Road	Surfers Point	Riflebutts Beach	Prevelly Beach
	Coastal Type	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast	Sandy Coast
Storm erosion	S1	13	20	20	20	13
Long-term Trend	S2	63	0	0	0	25
Erosion due to SLR	S3	90	90	90	90	90
Factor of Safety	FoS	20	20	20	20	20
Inundation	S4	5m AHD contour				
	Subtotal (m)	186	130	130	130	148
	100yr Coastal Processes Allowance Including Rounding (m)	185	130	130	130	150

Notes

	Coastal node	Rivermouth Beach	Rivermouth Road	Surfers Point	Riflebutts Beach	Prevelly Beach
	Coastal Type	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast	Weakly Lithified Sedimentary Rock Coast	Sandy Coast
Storm erosion	S1	Sandy coast erosion based on average recession from SBEACH modelling of 3 consecutive 100yr erosion events	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high	Sandy coast erosion based on average recession from SBEACH modelling of 3 consecutive 100yr erosion events
Long-term Trend	S2	2000 to 2013 aerial imagery shows 8.2m of erosion (0.63m/year)	Assumed no long term erosion	Assumed no long term erosion	Assumed no long term erosion	2000 to 2013 aerial imagery shows erosion of 3m to 4m (0.25m/year)
Erosion due to SLR	S3	Assumed default value as per SPP2.6 (100 x SLR (0.9))	Assumed default value as per SPP2.6 (100 x SLR (0.9))	Assumed default value as per SPP2.6 (100 x SLR (0.9))	Assumed default value as per SPP2.6 (100 x SLR (0.9))	Assumed default value as per SPP2.6 (100 x SLR (0.9))
Factor of Safety	FoS	0.2m/year	0.2m/year	0.2m/year	0.2m/year	0.2m/year
Inundation	S4	5m AHD contour				

	Coastal Nodes	Gnarabup Beach	Gnarabup Headland.	Back Beach (Reef Drive	Back Beach (Seagrass	Grunters Headland	Sewers Beach
	Coastal Type	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Sandy Coast	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Sandy/Hard Rock
Storm erosion	S1	6	20	6	6	6	0
Long-term Trend	S2	5.2	0	1.5	4.2	0	0
Erosion due to SLR	S3	4	4	4	4	4	0
Factor of Safety	FoS	2	2	2	2	2	0
Inundation	S4	5m AHD contour					
	Subtotal (m)	17.2	26	13.5	16.2	12	0
	10yr Coastal Processes Allowance Including Rounding (m)	0	25	15	15	10	0

	Coastal Nodes	Gnarabup Beach	Gnarabup Headland.	Back Beach (Reef Drive	Back Beach (Seagrass Place (Dog Beach))	Grunters Headland	Sewers Beach
	Coastal Type	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Sandy Coast	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Sandy/Hard Rock
Storm erosion	S1	Sandy coast erosion based on average recession from SBEACH modelling of the 23/09/2013 erosion event	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high	Sandy coast erosion based on average recession from SBEACH modelling of the 23/09/2013 erosion event	Sandy coast erosion based on average recession from SBEACH modelling of the 23/09/2013 erosion event	Sandy coast erosion based on average recession from SBEACH modelling of the 23/09/2013 erosion event	Assumes no erosion
Long-term Trend	S2	2001 to 2013 aerial imagery shows erosion of 6.8m (0.52m/year)	Assumed no long term erosion	2000 to 2013 aerial imagery shows erosion of 2m (0.15m/year)	2000 to 2013 aerial imagery shows erosion of 5.5m (0.42m/year)	2000 to 2013 aerial imagery shows no long term trends	Assumes no erosion
Erosion due to SLR	S3	Assumed default value as per SPP2.6 (100 x SLR (0.04))	Assumed default value as per SPP2.6 (100 x SLR (0.04))	Assumed default value as per SPP2.6 (100 x SLR (0.04))	Assumed default value as per SPP2.6 (100 x SLR (0.04))	Assumed default value as per SPP2.6 (100 x SLR (0.04))	Assumes no erosion
Factor of Safety	FoS	0.2m/year	0.2m/year	0.2m/year	0.2m/year	0.2m/year	Assumes no erosion
Inundation	S4	5m AHD contour					

	Coastal Nodes	Gnarabup Beach	Gnarabup Headland.	Back Beach (Reef Drive	Back Beach (Seagrass Place (Dog Beach))	Grunters Headland	Sewers Beach
	Coastal Type	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Sandy Coast	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Sandy/Hard Rock
Storm erosion	S1	9	20	9	9	9	0
Long-term Trend	S2	10.4	0	3	8.4	0	0
Erosion due to SLR	S3	10	10	10	10	10	0
Factor of Safety	FoS	4	4	4	4	4	0
Inundation	S4	5m AHD contour					
	Subtotal (m)	33.4	34	26	31.4	23	0
	20yr Coastal Processes Allowance Including Rounding (m)	35	35	25	30	25	0

	Coastal Nodes	Gnarabup Beach	Gnarabup Headland.	Back Beach (Reef Drive	Back Beach (Seagrass Place (Dog Beach))	Grunters Headland	Sewers Beach
	Coastal Type	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Sandy Coast	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Sandy/Hard Rock
Storm erosion	S1	Sandy coast erosion based on average recession from SBEACH modelling of the 100yr erosion event	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high	Sandy coast erosion based on average recession from SBEACH modelling of the 100yr erosion event	Sandy coast erosion based on average recession from SBEACH modelling of the 100yr erosion event	Sandy coast erosion based on average recession from SBEACH modelling of the 100yr erosion event	Assumes no erosion
Long-term Trend	S2	2001 to 2013 aerial imagery shows erosion of 6.8m (0.52m/year)	Assumed no long term erosion	2000 to 2013 aerial imagery shows erosion of 2m (0.15m/year)	2000 to 2013 aerial imagery shows erosion of 5.5m (0.42m/year)	2000 to 2013 aerial imagery shows no long term trends	Assumes no erosion
Erosion due to SLR	S3	Assumed default value as per SPP2.6 (100 x SLR (0.1))	Assumed default value as per SPP2.6 (100 x SLR (0.1))	Assumed default value as per SPP2.6 (100 x SLR (0.1))	Assumed default value as per SPP2.6 (100 x SLR (0.1))	Assumed default value as per SPP2.6 (100 x SLR (0.1))	Assumes no erosion
Factor of Safety	FoS	0.2m/year	0.2m/year	0.2m/year	0.2m/year	0.2m/year	Assumes no erosion
Inundation	S4	5m AHD contour					

	Coastal Nodes	Gnarabup Beach	Gnarabup Headland.	Back Beach (Reef Drive	Back Beach (Seagrass Place (Dog Beach))	Grunters Headland	Sewers Beach
	Coastal Type	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Sandy Coast	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Sandy/Hard Rock
Storm erosion	S1	13	20	13	13	13	13
Long-term Trend	S2	52	0	15	42	0	0
Erosion due to SLR	S3	90	90	90	90	90	90
Factor of Safety	FoS	20	20	20	20	20	20
Inundation	S4	5m AHD contour					
	Subtotal (m)	175	130	138	165	123	123
	100yr Coastal Processes Allowance Including Rounding (m)	175	130	140	165	125	

	Coastal Nodes	Gnarabup Beach	Gnarabup Headland.	Back Beach (Reef Drive	Back Beach (Seagrass Place (Dog Beach))	Grunters Headland	Sewers Beach
	Coastal Type	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Sandy Coast	Sandy Coast	Weakly Lithified Sedimentary Rock Coast	Sandy/Hard Rock
Storm erosion	S1	Sandy coast erosion based on average recession from SBEACH modelling of 3 consecutive 100yr erosion events	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high	Sandy coast erosion based on average recession from SBEACH modelling of 3 consecutive 100yr erosion events	Sandy coast erosion based on average recession from SBEACH modelling of 3 consecutive 100yr erosion events	Sandy coast erosion based on average recession from SBEACH modelling of 3 consecutive 100yr erosion events	Sandy coast erosion based on average recession from SBEACH modelling of 3 consecutive 100yr erosion events
Long-term Trend	S2	2001 to 2013 aerial imagery shows erosion of 6.8m (0.52m/year)	Assumed no long term erosion	2000 to 2013 aerial imagery shows erosion of 2m (0.15m/year)	2000 to 2013 aerial imagery shows erosion of 5.5m (0.42m/year)	2000 to 2013 aerial imagery shows no long term trends	Assumes no erosion
Erosion due to SLR	S3	Assumed default value as per SPP2.6 (100 x SLR (0.9))	Assumed default value as per SPP2.6 (100 x SLR (0.9))	Assumed default value as per SPP2.6 (100 x SLR (0.9))	Assumed default value as per SPP2.6 (100 x SLR (0.9))	Assumed default value as per SPP2.6 (100 x SLR (0.9))	Assumes SLR will result in submergence of low lying hard rock and erosion in line with Sand Coast Grunters
Factor of Safety	FoS	0.2m/year	0.2m/year	0.2m/year	0.2m/year	0.2m/year	Assumes no erosion
Inundation	S4	5m AHD contour					

Hamelin 1411 AMRSC Coastal Study Areas Assessment 150930.xlsx

	Coastal node	Hamelin Bay Caravan Park	Hamelin Bay Headland
	Coastal Type	**Sandy Coast**	**Weakly Lithified Sedimentary Rock Coast**
Storm erosion	S1	2	20
Long-term Trend	S2	0	0
Erosion due to SLR	S3	4	4
Factor of Safety	FoS	2	2
Inundation	S4	5m AHD contour	
	Subtotal (m)	8	26
	10yr Coastal Processes Allowance Including Rounding (m)	10	25

Notes

	Coastal node	Hamelin Bay Caravan Park	Hamelin Bay Headland
	Coastal Type	**Sandy Coast**	**Weakly Lithified Sedimentary Rock Coast**
Storm erosion	S1	Sandy coast erosion based on average recession from SBEACH modelling of the 23/09/2013 erosion event	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high
Long-term Trend	S2	2000 to 2013 aerial imagery shows no trend	Assumed no long term erosion
Erosion due to SLR	S3	Assumed default value as per SPP2.6 (100 x SLR (0.04))	Assumed default value as per SPP2.6 (100 x SLR (0.04))
Factor of Safety	FoS	0.2m/year	0.2m/year
Inundation	S4	5m AHD contour	

	Coastal node	Hamelin Bay Caravan Park	Hamelin Bay Headland
	Coastal Type	**Sandy Coast**	**Weakly Lithified Sedimentary Rock Coast**
Storm erosion	S1	8	20
Long-term Trend	S2	0	0
Erosion due to SLR	S3	10	10
Factor of Safety	FoS	4	4
Inundation	S4	5m AHD contour	
	Subtotal (m)	22	34
	20yr Coastal Processes Allowance Including Rounding (m)	20	35

Notes

	Coastal node	Hamelin Bay Caravan Park	Hamelin Bay Headland
	Coastal Type	**Sandy Coast**	**Weakly Lithified Sedimentary Rock Coast**
Storm erosion	S1	Sandy coast erosion based on average recession from SBEACH modelling of the 100yr erosion event	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high
Long-term Trend	S2	2000 to 2013 aerial imagery shows no trend	Assumed no long term erosion
Erosion due to SLR	S3	Assumed default value as per SPP2.6 (100 x SLR (0.1))	Assumed default value as per SPP2.6 (100 x SLR (0.1))
Factor of Safety	FoS	0.2m/year	0.2m/year
Inundation	S4	5m AHD contour	

	Coastal node	Hamelin Bay Caravan Park	Hamelin Bay Headland
	Coastal Type	**Sandy Coast**	**Weakly Lithified Sedimentary Rock Coast**
Storm erosion	S1	9	20
Long-term Trend	S2	0	0
Erosion due to SLR	S3	90	90
Factor of Safety	FoS	20	20
Inundation	S4	5m AHD contour	
	Subtotal (m)	119	130
	100yr Coastal Processes Allowance Including Rounding (m)	120	130

Notes

	Coastal node	Hamelin Bay Caravan Park	Hamelin Bay Headland
	Coastal Type	**Sandy Coast**	**Weakly Lithified Sedimentary Rock Coast**
Storm erosion	S1	Sandy coast erosion based on average recession from SBEACH modelling of 3 consecutive 100yr erosion events	Assumes erosion event causes cliff to slump to 1:2 and cliff is 10m high
Long-term Trend	S2	2000 to 2013 aerial imagery shows no trend	Assumed no long term erosion
Erosion due to SLR	S3	Assumed default value as per SPP2.6 (100 x SLR (0.9))	Assumed default value as per SPP2.6 (100 x SLR (0.9))
Factor of Safety	FoS	0.2m/year	0.2m/year
Inundation	S4	5m AHD contour	

	Coastal node	Albany Terrace – Blackwood River Cut	Albany Terrace – Rocky Coast	Albany Terrace – Sandy Coast	Flinders Bay Caravan park	Flinders Bay
	Coastal Type	**Sandy Coast**	**Hard Rock (low)**	**Sandy Coast**	**Sandy Coast**	**Sandy Coast/Rocky Coast**
Storm erosion	S1	1	0	1	1	1
Long-term Trend	S2	0	0	0	0	0
Erosion due to SLR	S3	4	0	4	4	4
Factor of Safety	FoS	2	0	2	2	2
Inundation	S4	5m AHD contour				
	Subtotal (m)	7	0	7	7	7
	10yr Coastal Processes Allowance Including Rounding (m)	10	0	10	10	10

Notes

	Coastal node	Albany Terrace – Blackwood River Cut	Albany Terrace – Rocky Coast	Albany Terrace – Sandy Coast	Flinders Bay Caravan park	Flinders Bay
	Coastal Type	**Sandy Coast**	**Hard Rock (low)**	**Sandy Coast**	**Sandy Coast**	**Sandy Coast/Rocky Coast**
Storm erosion	S1	Sandy coast erosion based on average recession from SBEACH modelling of the 23/09/2013 erosion event	Assumes no erosion	Sandy coast erosion based on average recession from SBEACH modelling of the 23/09/2013 erosion event	Sandy coast erosion based on average recession from SBEACH modelling of the 23/09/2013 erosion event	Sandy coast erosion based on average recession from SBEACH modelling of the 23/09/2013 erosion event
Long-term Trend	S2	2000 to 2013 aerial imagery shows no long term trends	Assumes no erosion	2000 to 2013 aerial imagery shows no long term trends	2001 to 2013 aerial imagery shows no long term trends	2002 to 2013 aerial imagery shows no long term trends
Erosion due to SLR	S3	Assumed default value as per SPP2.6 (100 x SLR (0.04))	Assumes no erosion	Assumed default value as per SPP2.6 (100 x SLR (0.04))	Assumed default value as per SPP2.6 (100 x SLR (0.04))	Assumed default value as per SPP2.6 (100 x SLR (0.04))
Factor of Safety	FoS	0.2m/year	Assumes no erosion	0.2m/year	0.2m/year	0.2m/year
Inundation	S4	5m AHD contour				

	Coastal node	Albany Terrace – Blackwood River Cut	Albany Terrace – Rocky Coast	Albany Terrace – Sandy Coast	Flinders Bay Caravan park	Flinders Bay
	Coastal Type	**Sandy Coast**	**Hard Rock (low)**	**Sandy Coast**	**Sandy Coast**	**Sandy Coast/Rocky Coast**
Storm erosion	S1	6	0	6	6	6
Long-term Trend	S2	0	0	0	0	0
Erosion due to SLR	S3	10	#REF!	10	10	10
Factor of Safety	FoS	4	#REF!	4	4	4
Inundation	S4	5m AHD contour				
	Subtotal (m)	20	#REF!	20	20	20
	20yr Coastal Processes Allowance Including Rounding (m)	20	#REF!	20	20	20

Notes

	Coastal node	Albany Terrace – Blackwood River Cut	Albany Terrace – Rocky Coast	Albany Terrace – Sandy Coast	Flinders Bay Caravan park	Flinders Bay
	Coastal Type	**Sandy Coast**	**Hard Rock (low)**	**Sandy Coast**	**Sandy Coast**	**Sandy Coast/Rocky Coast**
Storm erosion	S1	Sandy coast erosion based on average recession from SBEACH modelling of the 100yr erosion event	Assumes no erosion	Sandy coast erosion based on average recession from SBEACH modelling of the 100yr erosion event	Sandy coast erosion based on average recession from SBEACH modelling of the 100yr erosion event	Sandy coast erosion based on average recession from SBEACH modelling of the 100yr erosion event
Long-term Trend	S2	2000 to 2013 aerial imagery shows no long term trends	Assumes no erosion	2000 to 2013 aerial imagery shows no long term trends	2001 to 2013 aerial imagery shows no long term trends	2002 to 2013 aerial imagery shows no long term trends
Erosion due to SLR	S3	Assumed default value as per SPP2.6 (100 x SLR (0.1))	Assumes no erosion	Assumed default value as per SPP2.6 (100 x SLR (0.1))	Assumed default value as per SPP2.6 (100 x SLR (0.1))	Assumed default value as per SPP2.6 (100 x SLR (0.1))
Factor of Safety	FoS	0.2m/year	Assumes no erosion	0.2m/year	0.2m/year	0.2m/year
Inundation	S4	5m AHD contour				

	Coastal node	Albany Terrace – Blackwood River Cut	Albany Terrace – Rocky Coast	Albany Terrace – Sandy Coast	Flinders Bay Caravan park	Flinders Bay
	Coastal Type	**Sandy Coast**	**Hard Rock (low)**	**Sandy Coast**	**Sandy Coast**	**Sandy Coast/Rocky Coast**
Storm erosion	S1	10	10	10	10	10
Long-term Trend	S2	0	0	0	0	0
Erosion due to SLR	S3	90	90	90	90	90
Factor of Safety	FoS	20	20	20	20	20
Inundation	S4	5m AHD contour				
	Subtotal (m)	120	120	120	120	120
	100yr Coastal Processes Allowance Including Rounding (m)	120	120	120	120	120

Notes

	Coastal node	Albany Terrace – Blackwood River Cut	Albany Terrace – Rocky Coast	Albany Terrace – Sandy Coast	Flinders Bay Caravan park	Flinders Bay
	Coastal Type	**Sandy Coast**	**Hard Rock (low)**	**Sandy Coast**	**Sandy Coast**	**Sandy Coast/Rocky Coast**
Storm erosion	S1	Sandy coast erosion based on average recession from SBEACH modelling of 3 consecutive 100yr erosion events	Assumes that 100yr setback rises above the hard rock and that above the level of the hard rock are dunes/weakly lithefied cliffs	Sandy coast erosion based on average recession from SBEACH modelling of 3 consecutive 100yr erosion events	Sandy coast erosion based on average recession from SBEACH modelling of 3 consecutive 100yr erosion events	Sandy coast erosion based on average recession from SBEACH modelling of 3 consecutive 100yr erosion events
Long-term Trend	S2	2000 to 2013 aerial imagery shows no long term trends	Assumes no erosion	2000 to 2013 aerial imagery shows no long term trends	2001 to 2013 aerial imagery shows no long term trends	2002 to 2013 aerial imagery shows no long term trends
Erosion due to SLR	S3	Assumed default value as per SPP2.6 (100 x SLR (0.9))	Assumes that 100yr setback rises above the hard rock and that above the level of the hard rock are dunes/weakly lithefied cliffs	Assumed default value as per SPP2.6 (100 x SLR (0.9))	Assumed default value as per SPP2.6 (100 x SLR (0.9))	Assumed default value as per SPP2.6 (100 x SLR (0.9))
Factor of Safety	FoS	0.2m/year	0.2m/year	0.2m/year	0.2m/year	0.2m/year
Inundation	S4	5m AHD contour				

Notes

1. Nominal erosion in the Rivermouth due to high variability of new river entrance.
2. Survey information is not available on the elevation of hard rock coast. It is assumed it is relatively low lying and behaves as per the sandy coast for the 100yr planning period.

11. Attachment 3 Risk Analysis Drawings

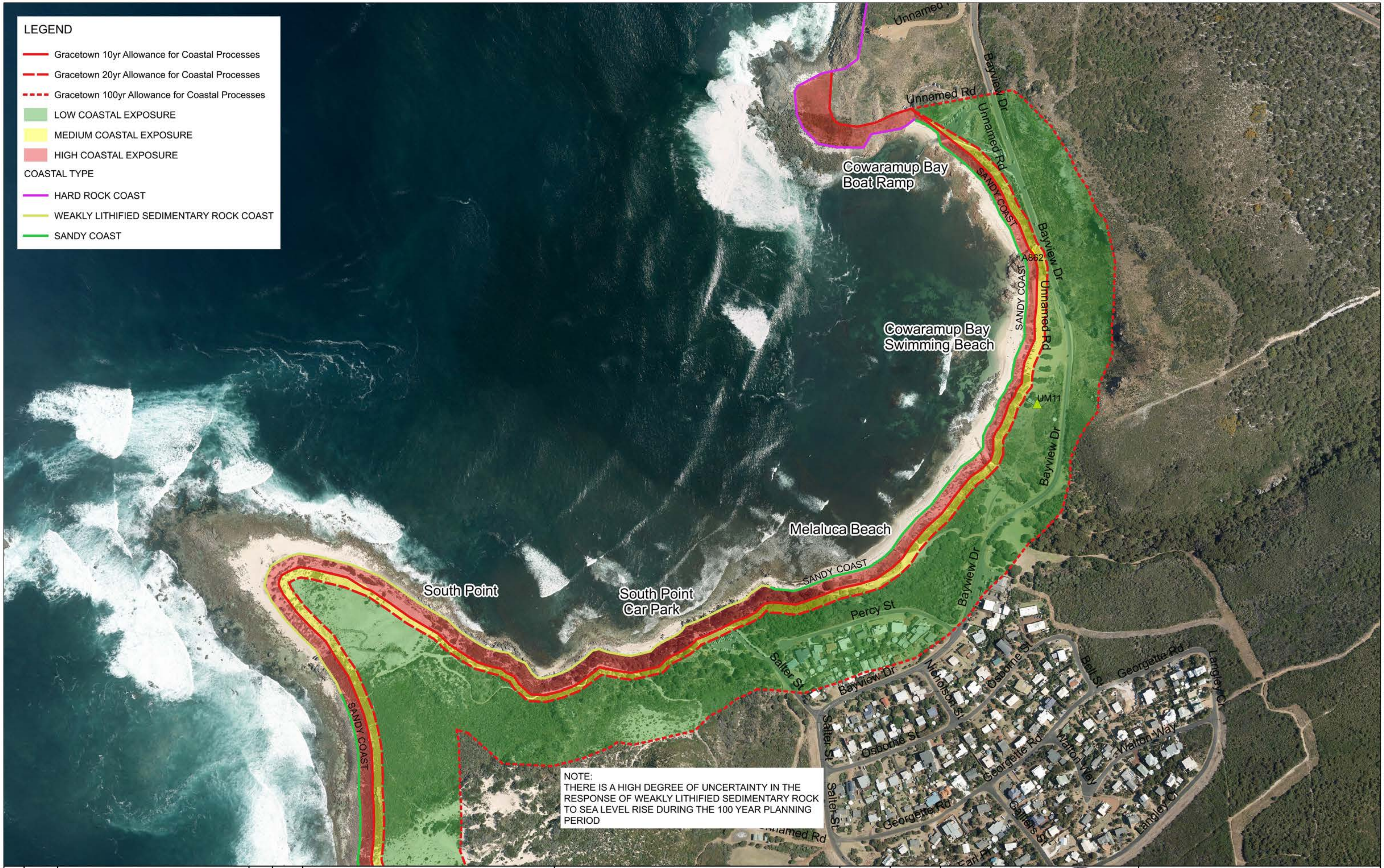
A Risk analysis has been undertaken to consider the potential impact of coastal processes on the coastal settlements in further detail using the procedures outlined in the State Coastal Planning Policy. This required consideration of storm erosion of beaches, longer-term coastal recession and the influence of sea level rise on the coast (Attachment 2 Risk Analysis Tables).

Planning timeframes of 10, 20 and 100 years were adopted to align coastal adaptation and planning with the Shire's broader strategic planning, asset management and financial management timeframes.

Drawings have been developed identifying planning allowances for coastal processes for the coastal settlements within a 10-year, a 20- year and a 100-year timeframe. Whilst the drawings are not predictions of future shoreline position, they do identify areas where exposure to coastal processes requires consideration in the relevant planning period.

The following is noted in regard to these drawings:

- These plans provide an interpretation of areas exposed to coastal processes using the procedures of the state coastal planning policy. These plans do not have the precision required to define the erosion risk to individual properties.
- Allowances are not a prediction of the future shoreline position.
- Coastal hazards in the vicinity of limestone cliffs require further assessment by a geotechnical engineer.
- Allowances for coastal processes have been determined using methods outlined in Schedule 1 of SPP2.6. Allowances are based on available data at the time of study.
- Allowances have been rounded to the nearest 5 meters and have been offset from the vegetation line.
- There is a high degree of uncertainty in the response of weakly lithified sedimentary rock to sea level rise during the 100 year planning period.
- The 100yr ARI floodway and flood fringe line is from the DoW.
- There is insufficient data available to evaluate the extent of medium and low coastal vulnerability areas for Augusta North/Molloy Island. This would require river modelling at variable ocean water levels.



REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL
C	30/09/15	ISSUED WITH DRAFT REPORT	OS	SB
B	19/06/15	CHANGE DISPLAY OF EROSION STUDY AREAS	OS	SB
A	30/03/15	PRELIMINARY	OS	SB

ORIG SIZE A3 | ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS | PROJECT No 1411

NOTES:

1. COASTAL ASSET NODES BASED ON COASTAL & FORESHORE FACILITIES ASSET MANAGEMENT PLAN
2. AERIAL IMAGE DECEMBER 2013
3. ALLOWANCES FOR COASTAL PROCESSES HAVE BEEN DETERMINED USING METHODS OUTLINED IN SCHEDULE 1 OF SPP2.6.
4. ALLOWANCES ARE BASED ON AVAILABLE DATA AT THE TIME OF STUDY.
5. ALLOWANCES ARE NOT A PREDICTION OF THE SHORELINE POSITION AT THE END OF THE RESPECTIVE PLANNING PERIODS.
6. THESE PLANS PROVIDE AN INTERPRETATION OF AREAS EXPOSED TO COASTAL PROCESSES USING THE PROCEDURES OF THE STATE COASTAL PLANNING POLICY. THESE PLANS DO NOT HAVE THE PRECISION REQUIRED TO DEFINE THE EROSION RISK TO INDIVIDUAL PROPERTIES.
7. STUDY AREA BOUNDARIES HAVE BEEN ROUNDED TO THE NEAREST 5 METERS AND HAVE BEEN OFFSET FROM THE VEGETATION LINE.
8. COASTAL HAZARDS IN THE VICINITY OF LIMESTONE CLIFFS REQUIRE FURTHER ASSESSMENT BY A GEOTECHNICAL ENGINEER.

SCALE 1:5,000

50 0 50 100 150 200

N

DATUM

VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)

HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

GDA

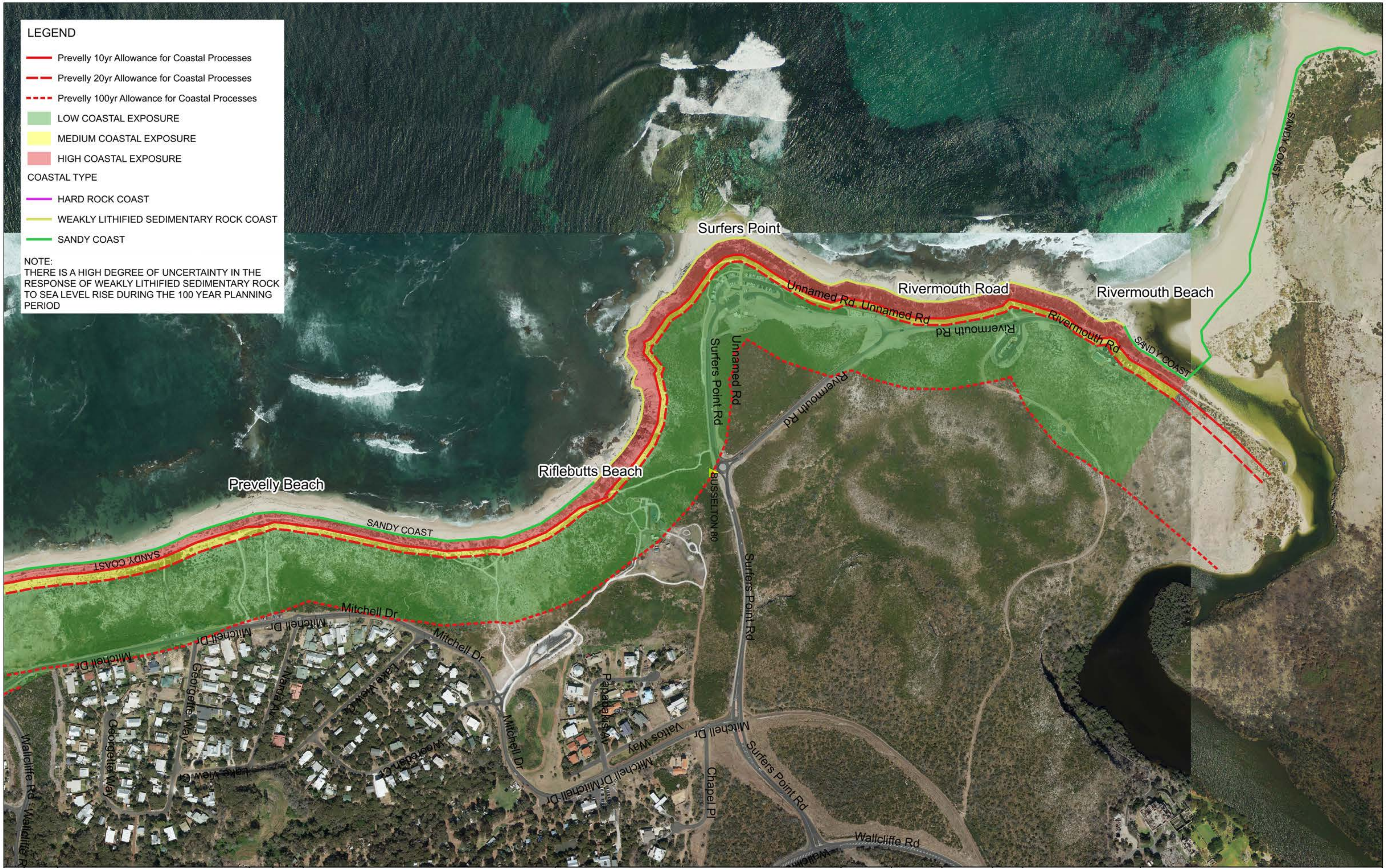
ACTION	NAME	SIGNATURE	DATE
ENGINEER	SB		09/03/15
DRAWN	OS		09/03/15
ENGINEERING CHECK			
DRAFTING CHECK			
APPROVED PROJECT MANAGER	SB		30/09/15

SHIRE OF AUGUSTA MARGARET RIVER

SHORE COASTAL

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
GRACETOWN
AREAS EXPOSED TO COASTAL PROCESSES

DRAWING NUMBER SC1411-1-2 REVN C



REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL
C	30/09/15	ISSUED WITH DRAFT REPORT	OS	SB
B	19/06/15	CHANGE DISPLAY OF EROSION STUDY AREAS	OS	SB
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ORIG SIZE A3 | ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS | PROJECT No 1411

NOTES:

1. COASTAL ASSET NODES BASED ON COASTAL & FORESHORE FACILITIES ASSET MANAGEMENT PLAN
2. AERIAL IMAGE DECEMBER 2013
3. ALLOWANCES FOR COASTAL PROCESSES HAVE BEEN DETERMINED USING METHODS OUTLINED IN SCHEDULE 1 OF SPP2.6.
4. ALLOWANCES ARE BASED ON AVAILABLE DATA AT THE TIME OF STUDY.
5. ALLOWANCES ARE NOT A PREDICTION OF THE SHORELINE POSITION AT THE END OF THE RESPECTIVE PLANNING PERIODS.
6. THESE PLANS PROVIDE AN INTERPRETATION OF AREAS EXPOSED TO COASTAL PROCESSES USING THE PROCEDURES OF THE STATE COASTAL PLANNING POLICY. THESE PLANS DO NOT HAVE THE PRECISION REQUIRED TO DEFINE THE EROSION RISK TO INDIVIDUAL PROPERTIES.
7. STUDY AREA BOUNDARIES HAVE BEEN ROUNDED TO THE NEAREST 5 METERS AND HAVE BEEN OFFSET FROM THE VEGETATION LINE.
8. COASTAL HAZARDS IN THE VICINITY OF LIMESTONE CLIFFS REQUIRE FURTHER ASSESSMENT BY A GEOTECHNICAL ENGINEER

SCALE 1:5,000
50 0 50 100 150 200

DATUM
VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)
HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

ACTION	NAME	SIGNATURE	DATE
ENGINEER	SB		09/03/15
DRAWN	OS		09/03/15
ENGINEERING CHECK			
DRAFTING CHECK			
APPROVED PROJECT MANAGER	SB		30/09/15

SHORE COASTAL

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
PREVELLY
AREAS EXPOSED TO COASTAL PROCESSES

DRAWING NUMBER SC1411-2-2 REVN C

C	30/09/15	ISSUED WITH DRAFT REPORT	OS	SB
B	19/06/15	CHANGE DISPLAY OF EROSION STUDY AREAS	OS	SB
A	30/03/15	PRELIMINARY	OS	SB
REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL

ORIG SIZE A3 | ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS | PROJECT No 1411

NOTES:

1. COASTAL ASSET NODES BASED ON COASTAL & FORESHORE FACILITIES ASSET MANAGEMENT PLAN
2. AERIAL IMAGE DECEMBER 2013
3. ALLOWANCES FOR COASTAL PROCESSES HAVE BEEN DETERMINED USING METHODS OUTLINED IN SCHEDULE 1 OF SPP2.6.
4. ALLOWANCES ARE BASED ON AVAILABLE DATA AT THE TIME OF STUDY.
5. ALLOWANCES ARE NOT A PREDICTION OF THE SHORELINE POSITION AT THE END OF THE RESPECTIVE PLANNING PERIODS.
6. THESE PLANS PROVIDE AN INTERPRETATION OF AREAS EXPOSED TO COASTAL PROCESSES USING THE PROCEDURES OF THE STATE COASTAL PLANNING POLICY. THESE PLANS DO NOT HAVE THE PRECISION REQUIRED TO DEFINE THE EROSION RISK TO INDIVIDUAL PROPERTIES.
7. STUDY AREA BOUNDARIES HAVE BEEN ROUNDED TO THE NEAREST 5 METERS AND HAVE BEEN OFFSET FROM THE VEGETATION LINE.
8. COASTAL HAZARDS IN THE VICINITY OF LIMESTONE CLIFFS REQUIRE FURTHER ASSESSMENT BY A GEOTECHNICAL ENGINEER

SCALE 1:5,000

50 0 50 100 150 200

Z

DATUM

VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)

HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

GDA

ACTION	NAME	SIGNATURE	DATE
ENGINEER	SB		09/03/15
DRAWN	OS		09/03/15
ENGINEERING CHECK			
DRAFTING CHECK			
APPROVED PROJECT MANAGER	SB		30/09/15

SHIRE OF AUGUSTA MARGARET RIVER

SHORE COASTAL

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
GNARABUP
AREAS EXPOSED TO COASTAL PROCESSES

DRAWING NUMBER SC1411-3-2 REVN C

C	30/09/15	ISSUED WITH DRAFT REPORT	OS	SB
B	19/06/15	CHANGE DISPLAY OF EROSION STUDY AREAS	OS	SB
A	30/03/15	PRELIMINARY	OS	SB
REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL

ORIG SIZE A3 | ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS | PROJECT No 1411

NOTES:

1. COASTAL ASSET NODES BASED ON COASTAL & FORESHORE FACILITIES ASSET MANAGEMENT PLAN
2. AERIAL IMAGE DECEMBER 2013
3. ALLOWANCES FOR COASTAL PROCESSES HAVE BEEN DETERMINED USING METHODS OUTLINED IN SCHEDULE 1 OF SPP2.6.
4. ALLOWANCES ARE BASED ON AVAILABLE DATA AT THE TIME OF STUDY.
5. ALLOWANCES ARE NOT A PREDICTION OF THE SHORELINE POSITION AT THE END OF THE RESPECTIVE PLANNING PERIODS.
6. THESE PLANS PROVIDE AN INTERPRETATION OF AREAS EXPOSED TO COASTAL PROCESSES USING THE PROCEDURES OF THE STATE COASTAL PLANNING POLICY. THESE PLANS DO NOT HAVE THE PRECISION REQUIRED TO DEFINE THE EROSION RISK TO INDIVIDUAL PROPERTIES.
7. STUDY AREA BOUNDARIES HAVE BEEN ROUNDED TO THE NEAREST 5 METERS AND HAVE BEEN OFFSET FROM THE VEGETATION LINE.
8. COASTAL HAZARDS IN THE VICINITY OF LIMESTONE CLIFFS REQUIRE FURTHER ASSESSMENT BY A GEOTECHNICAL ENGINEER

SCALE 1:5,000

50 0 50 100 150 200

DATUM

VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)

HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

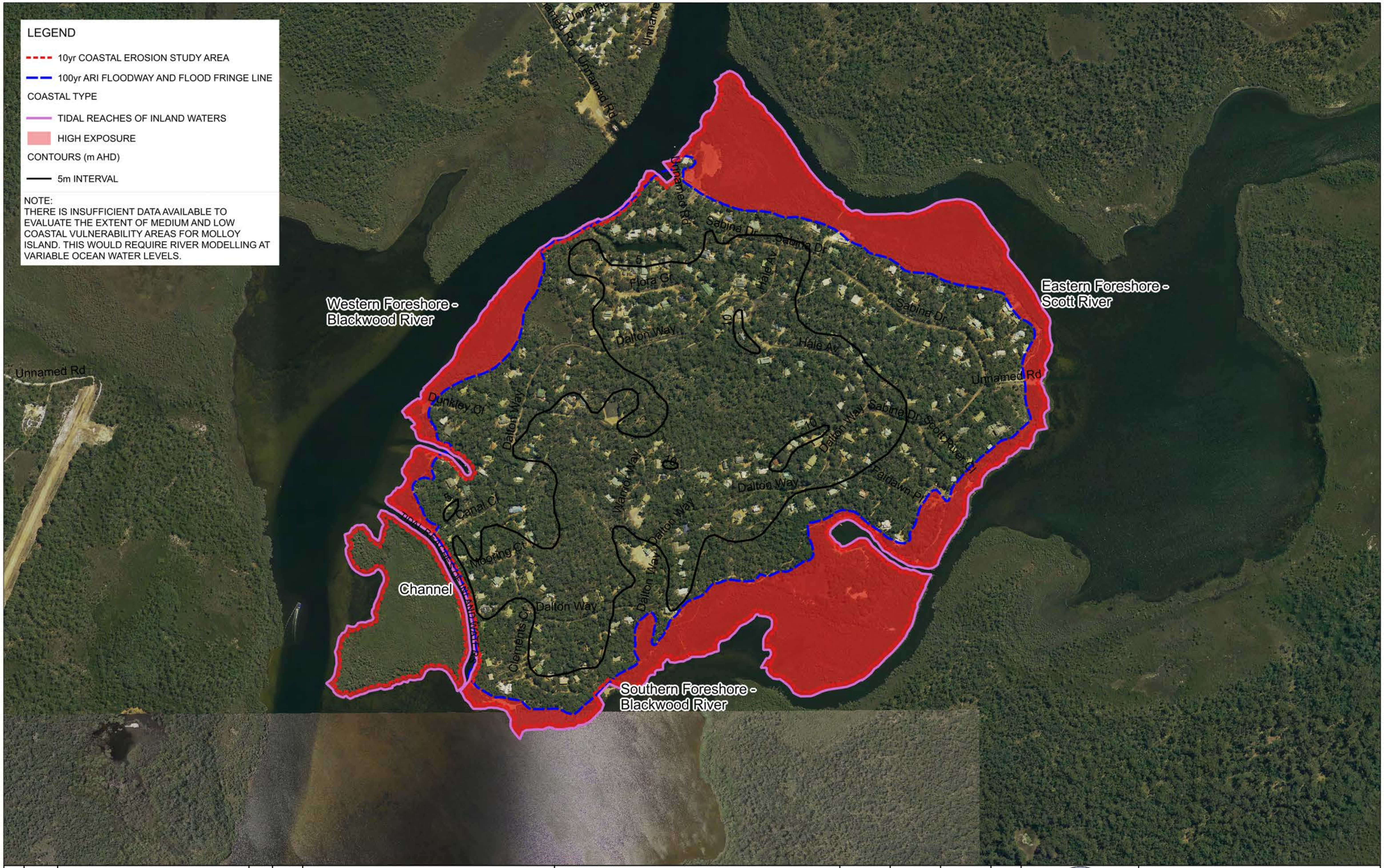
ACTION	NAME	SIGNATURE	DATE
ENGINEER	SB		09/03/15
DRAWN	OS		09/03/15
ENGINEERING CHECK			
DRAFTING CHECK			
APPROVED PROJECT MANAGER	SB		30/09/15

SHIRE OF AUGUSTA MARGARET RIVER

SHORE COASTAL

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
HAMELIN BAY
AREAS EXPOSED TO COASTAL PROCESSES

DRAWING NUMBER SC1411-4-2 REVN C



REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL
C	30/09/15	ISSUED WITH DRAFT REPORT	OS	SB
B	19/06/15	CHANGE DISPLAY OF EROSION STUDY AREAS	OS	SB
A	30/03/15	PRELIMINARY	OS	SB

ORIG SIZE A3 | ARCHIVE alp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS | PROJECT No 1411

NOTES:
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2. AERIAL IMAGE DECEMBER 2013
3. ALLOWANCES FOR COASTAL PROCESSES HAVE BEEN DETERMINED USING METHODS OUTLINED IN SCHEDULE 1 OF SPP2.6.
4. ALLOWANCES ARE BASED ON AVAILABLE DATA AT THE TIME OF STUDY.
5. ALLOWANCES ARE NOT A PREDICTION OF THE SHORELINE POSITION AT THE END OF THE RESPECTIVE PLANNING PERIODS.
6. THESE PLANS PROVIDE AN INTERPRETATION OF AREAS EXPOSED TO COASTAL PROCESSES USING THE PROCEDURES OF THE STATE COASTAL PLANNING POLICY. THESE PLANS DO NOT HAVE THE PRECISION REQUIRED TO DEFINE THE EROSION RISK TO INDIVIDUAL PROPERTIES.
7. STUDY AREA BOUNDARIES HAVE BEEN ROUNDED TO THE NEAREST 5 METERS AND HAVE BEEN OFFSET FROM THE VEGETATION LINE.
8. THE 100yr ARI FLOODWAY AND FLOOD FRINGE LINE IS FROM THE DEPARTMENT OF WATER.

SCALE 1:7,500

75 0 75 150 225 300

DATUM

VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)

HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

N

GDA

ACTION	NAME	SIGNATURE	DATE
ENGINEER	SB		09/03/15
DRAWN	OS		09/03/15
ENGINEERING CHECK			
DRAFTING CHECK			
APPROVED PROJECT MANAGER	SB		30/09/15

SHORE COASTAL

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
MOLLOY ISLAND
AREAS EXPOSED TO COASTAL PROCESSES

DRAWING NUMBER SC1411-5-2 REVN C

C	30/09/15	ISSUED WITH DRAFT REPORT	OS	SB
B	19/06/15	CHANGE DISPLAY OF EROSION STUDY AREAS	OS	SB
A	30/03/15	PRELIMINARY	OS	SB
REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL

ORIG SIZE A3 | ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS | PROJECT No 1411

NOTES:

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3. ALLOWANCES FOR COASTAL PROCESSES HAVE BEEN DETERMINED USING METHODS OUTLINED IN SCHEDULE 1 OF SPP2.6.
4. ALLOWANCES ARE BASED ON AVAILABLE DATA AT THE TIME OF STUDY.
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7. STUDY AREA BOUNDARIES HAVE BEEN ROUNDED TO THE NEAREST 5 METERS AND HAVE BEEN OFFSET FROM THE VEGETATION LINE.
8. THE 100yr ARI FLOODWAY AND FLOOD FRINGE LINE IS FROM THE DEPARTMENT OF WATER.

SCALE 1:7,500

75 0 75 150 225 300

DATUM

VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)

HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

N

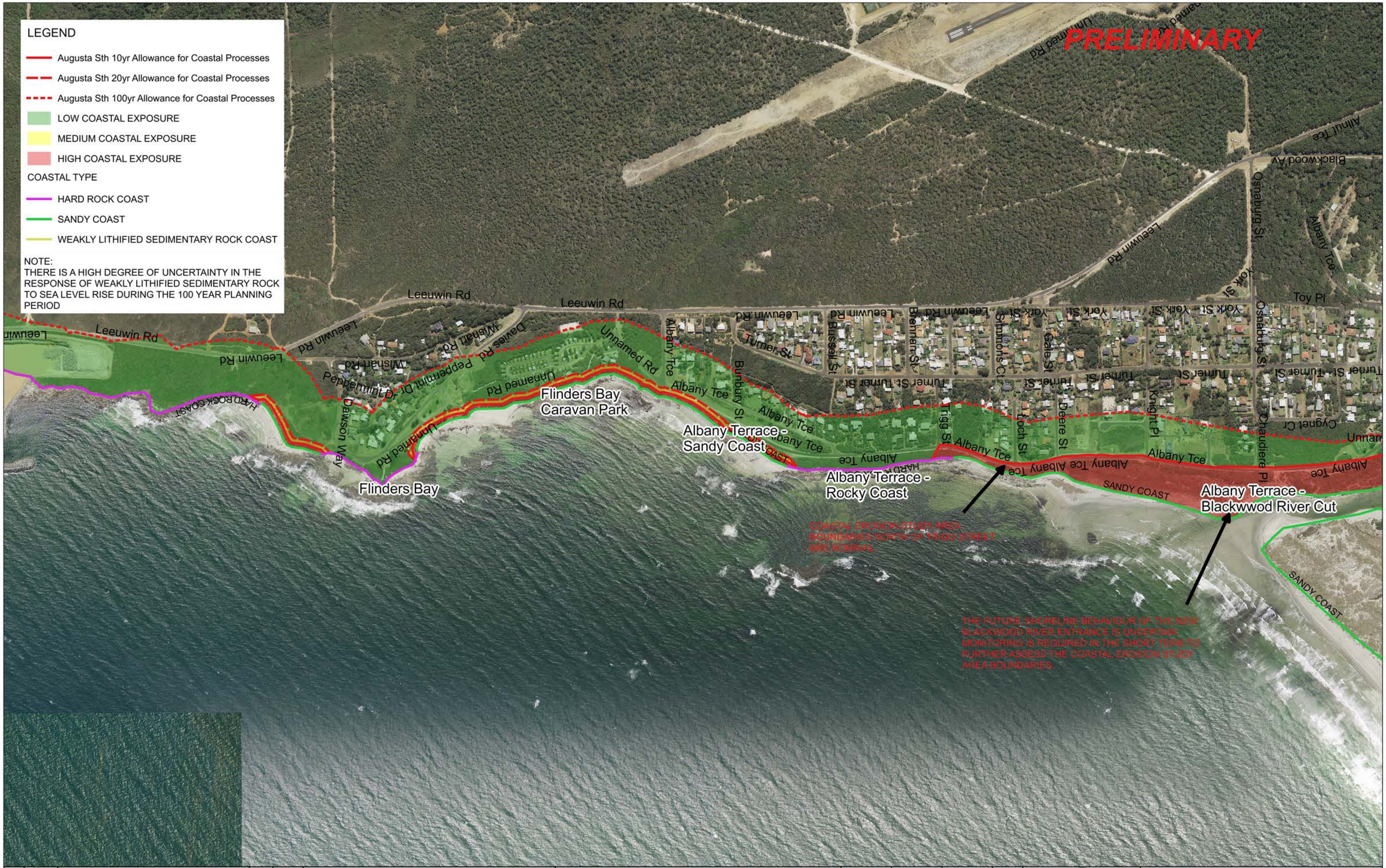
ACTION	NAME	SIGNATURE	DATE
ENGINEER	SB		09/03/15
DRAWN	OS		09/03/15
ENGINEERING CHECK			
DRAFTING CHECK			
APPROVED PROJECT MANAGER	SB		30/09/15

SHIRE OF AUGUSTA MARGARET RIVER

SHORE COASTAL

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
AUGUSTA NORTH
AREAS EXPOSED TO COASTAL PROCESSES

DRAWING NUMBER SC1411-6-2 REVN C



REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL
C	30/09/15	ISSUED WITH DRAFT REPORT	OS	SB
B	19/06/15	CHANGE DISPLAY OF EROSION STUDY AREAS	OS	SB
A	30/03/2015	PRELIMINARY	OS	SB

ORIG SIZE A3 | ARCHIVE afp://shorecoastal.local/ShoreCoastal/2 Shore Coastal Projects/1411 AMRSC Coastal Hazards/2 References/Drawings/WIP/GIS | PROJECT No 1411

NOTES:
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4. ALLOWANCES ARE BASED ON AVAILABLE DATA AT THE TIME OF STUDY.
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7. STUDY AREA BOUNDARIES HAVE BEEN ROUNDED TO THE NEAREST 5 METERS AND HAVE BEEN OFFSET FROM THE VEGETATION LINE.
8. COASTAL HAZARDS IN THE VICINITY OF LIMESTONE CLIFFS REQUIRE FURTHER ASSESSMENT BY A GEOTECHNICAL ENGINEER

SCALE 1:7,500
75 0 75 150 225 300

DATUM
VERTICAL AUSTRALIAN HEIGHT DATUM (AHD)
HORIZONTAL MAP GRID OF AUSTRALIA, BASED ON GDA94

N

GDA

ACTION	NAME	SIGNATURE	DATE
ENGINEER	SB		09/03/15
DRAWN	OS		09/03/15
ENGINEERING CHECK			
DRAFTING CHECK			
APPROVED PROJECT MANAGER	SB		30/09/15

SHIRE OF AUGUSTA MARGARET RIVER

SHORE COASTAL

AUGUSTA MARGARET RIVER SHIRE
COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN
AUGUSTA SOUTH
AREAS EXPOSED TO COASTAL PROCESSES

DRAWING NUMBER SC1411-7-2 REVN C

12. Attachment 4 Risk Evaluation Tables

The Risk Evaluation phase incorporates the information from the risk analysis to identify the exposure of coastal assets to coastal processes. High (<10-year), medium (10-20 year) and low (20-100yr) coastal exposure areas were identified. Coastal assets considered included coastal stairs and platforms, carparks, buildings, roads and adjacent paths, coastal walkways and access paths, marine structures, private residences, landscaping, playgrounds and shelters and caravan parks.

An estimate has been made of the cost of each of these assets. The asset cost (the consequence of losing this asset to coastal erosion) and asset exposure (likelihood) was input into a coastal risk evaluation matrix to identify coastal assets at low, medium, high and very high risk. In general high cost assets located close to the coast in areas exposed to coastal processes are identified as high risk.

The following is noted in regard to these tables:

- Asset costs are based on values provided by the Shire and/or based on assumed rates and quantities for typical assets.
- Asset cost represents an estimate of present day replacement costs with no allowance for depreciation or maintenance.
- Asset exposure to coastal processes has been assessed based on the Risk Analysis Drawings (Attachment 3).
- Valuations have been undertaken for coastal planning purposes. They may not be sufficient for other purposes.

SHORE COASTAL

Gracetown - Asset Cost

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m²)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters	Subtotal
GT_1	Sandy Coast	**Cowaramup Bay Boat Ramp**	275	15	4125	Cowaramup Bay Boat Ramp including associated ramp, jetty, parking trailer parking and rigging facilities.		$ 402,240		$ 187,200			$ 414,000			$ 1,003,440
GT_2	Sandy Coast	**Cowaramup Bay Swimming Beach**	300	20	6000	Gravel car park with associated footpaths, shade shelters and toilet block		$ 57,160	$ 140,000	$ 619,800	$ 56,325		$ 30,000		$ 15,000	$ 918,285
GT_3	Sand Coast	**Melaluca Beach**	400	10	4000	Gravel beach car park with wooden step beach access points and associated fencing and bollards, steps up to Percy St	$ 32,000	$ 15,015		$ 453,513	$ 7,500	$ 170,000		$ 25,335,000	$ 5,000	$ 26,018,028
GT_4	Weakly Lithified Sediminary Rock Coast	**South Point Car Park**	275	5	1375	36 Bay car park, associated fencing, paths, lookout platform and toilet block	$ 284,000	$ 105,324	$ 109,000	$ 111,000					$ 5,000	$ 614,324
GT_5	Weakly Lithified Sediminary Rock Coast	**South Point**	550	2	1100	Wooden walkway, memorial and access stairs and lookout platforms providing access to South Point	$ 150,000				$ 12,500					$ 162,500
			1800		16600											$ 28,716,577

High Asset Cost (>$500,000)
Medium Asset Cost
Low Asset Cost (<$100,000)

Gracetown - Asset Exposure to Coastal Processes

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m²)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters
GT_1	Sandy Coast	Cowaramup Bay Boat Ramp	275	15	4125	Cowaramup Bay Boat Ramp including associated ramp, jetty, parking trailer parking and rigging facilities.		M		M			H		
GT_2	Sandy Coast	Cowaramup Bay Swimming Beach	300	20	6000	Gravel car park with associated footpaths, shade shelters and toilet block		H	L	L	L		L		H
GT_3	Sand Coast	Melaluca Beach	400	10	4000	Gravel beach car park with wooden step beach access points and associated fencing and bollards, steps up to Percy St	H	H		L	L	L		L	M
GT_4	Weakly Lithified Sediminary Rock Coast	South Point Car Park	275	5	1375	36 Bay car park, associated fencing, paths, lookout platform and toilet block	H	H	L	L					M
GT_5	Weakly Lithified Sediminary Rock Coast	South Point	550	2	1100	Wooden walkway, memorial and access stairs and lookout platforms providing access to South Point	H				H				

High Coastal Exposure (within 10 year area)
Medium Coastal Exposure (10-20 year area)
Low Coastal Exposure (20-100 year area)

Gracetown - Asset Risk

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m²)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters
GT_1	Sandy Coast	Cowaramup Bay Boat Ramp	275	15	4125	Cowaramup Bay Boat Ramp including associated ramp, jetty, parking trailer parking and rigging facilities.		M		M			H		
GT_2	Sandy Coast	Cowaramup Bay Swimming Beach	300	20	6000	Gravel car park with associated footpaths, shade shelters and toilet block		M	L	M	L		L		M
GT_3	Sand Coast	Melaluca Beach	400	10	4000	Gravel beach car park with wooden step beach access points and associated fencing and bollards, steps up to Percy St	M	M		L	L	L		M	L
GT_4	Weakly Lithified Sediminary Rock Coast	South Point Car Park	275	5	1375	36 Bay car park, associated fencing, paths, lookout platform and toilet block	H	H	L	L					L
GT_5	Weakly Lithified Sediminary Rock Coast	South Point	550	2	1100	Wooden walkway, memorial and access stairs and lookout platforms providing access to South Point	H				M				

High Asset Risk
Medium Asset Risk
Low Asset Risk

Coastal Risk Evaluation Matrix

		Exposure to Coastal Processes (Likelihood)		
		High (within 10yr area)	Medium (10-20 year area)	Low (20-100yr area)
Asset Cost (Consequence)	High	Very High	High	Med
	Medium	High	Med	Low
	Low	Med	Low	Low

Notes:

1. Asset costs are based on values provided by the Shire and/or based on assume rates and quantities for typical assets.

2. Asset cost represents present day replacement costs with no allowance for depreciation or maintenance.

3. Asset exposure to coastal processes has been assesed based on SC1411-X-2 RevC Drawing series.

4. Valuation have been undertaken for coastal planning purposes. They may not be sufficient for other purposes.

Prevelly - Asset Cost

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m^2)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters	Subtotal
PV_1	Sandy Coast	**Rivermouth Beach**	660	40	26400	65 Bay car pak including access steps and walkways and toilet and showering facilities	$ 295,500	$ 786,590	$ 230,000	$ 50,000	$ 37,500	$ 15,000			$ 8,000	$ 1,422,590
PV_2	Weakly Lithified Sediminary Rock Coast	**Rivermouth Road**	350	15	5250	Access Road from Surfers Point Car Park to Rivermouth Carpark	$ 70,000	$ 318,655		$ 160,350	$ 41,250	$ 5,000				$ 595,255
PV_3	Weakly Lithified Sediminary Rock Coast	**Surfers Point**	700	20	14000	100+ bay car park with associated infrastructure including walkways, beach access stairs and toilet and shower facilities	$ 452,000	$ 1,342,925	$ 582,000	$ 216,815	$ 75,000	$ 30,000			$ 202,800	$ 2,901,540
PV_4	Weakly Lithified Sediminary Rock Coast	**Rifflebutts Beach**	100	20	2000	Recreational area and toilets.			$ 150,000			$ 65,000			$ 373,000	$ 588,000
PV_5	Sandy Coast	**Prevelly Beach**	900	20	18000	Coastal Path, Mitchell Dve, Carparks & access		$ 120,000	$ 165,000	$ 468,000	$ 135,000	$ 40,000				$ 928,000
					65650											$ 6,435,385

High Asset Cost (>$500,000)
Medium Asset Cost
Low Asset Cost (<$100,000)

Prevelly - Asset Exposure to Coastal Processes

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m^2)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters
PV_1	Sandy Coast	Rivermouth Beach	660	40	26400	65 Bay car pak including access steps and walkways and toilet and showering facilities	H	H	L	H	H	L			H
PV_2	Weakly Lithified Sediminary Rock Coast	Rivermouth Road	350	15	5250	Access Road from Surfers Point Car Park to Rivermouth Carpark	H	L		M	M	L			
PV_3	Weakly Lithified Sediminary Rock Coast	Surfers Point	700	20	14000	100+ bay car park with associated infrastructure including walkways, beach access stairs and toilet and shower facilities	H	L	L	L	M	L			M
PV_4	Weakly Lithified Sediminary Rock Coast	Rifflebutts Beach	100	20	2000	Recreational area and toilets.			L			L			L
PV_5	Sandy Coast	Prevelly Beach	900	20	18000	Coastal Path, Mitchell Dve, Carparks & access		L	L	L	H	L			
			2710												

High Coastal Exposure (within 10 year area)
Medium Coastal Exposure (10-20 year area)
Low Coastal Exposure (20-100 year area)

Prevelly - Asset Risk

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m^2)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters
PV_1	Sandy Coast	Rivermouth Beach	660	40	26400	65 Bay car pak including access steps and walkways and toilet and showering facilities	H	VH	L	M	M	L			M
PV_2	Weakly Lithified Sediminary Rock Coast	Rivermouth Road	350	15	5250	Access Road from Surfers Point Car Park to Rivermouth Carpark	M	L		M	L	L			
PV_3	Weakly Lithified Sediminary Rock Coast	Surfers Point	700	20	14000	100+ bay car park with associated infrastructure including walkways, beach access stairs and toilet and shower facilities	H	M	M	L	L	L			M
PV_4	Weakly Lithified Sediminary Rock Coast	Rifflebutts Beach	100	20	2000	Recreational area and toilets.			L			L			L
PV_5	Sandy Coast	Prevelly Beach	900	20	18000	Coastal Path, Mitchell Dve, Carparks & access		L	L	L	H	L			

High Asset Risk
Medium Asset Risk
Low Asset Risk

Coastal Risk Evaluation Matrix

		Exposure to Coastal Processes (Likelihood)		
		High (within 10yr area)	Medium (10-20 year area)	Low (20-100yr area)
Asset Cost (Consequence)	High	Very High	High	Med
	Medium	High	Med	Low
	Low	Med	Low	Low

Notes:

1. Asset costs are based on values provided by the Shire and/or based on assume rates and quantities for typical assets.

2. Asset cost represents present day replacement costs with no allowance for depreciation or maintenance.

3. Asset exposure to coastal processes has been assesed based on SC1411-X-2 RevC Drawing series.

4. Valuation have been undertaken for coastal planning purposes. They may not be sufficient for other purposes.

Gnarabup - Asset Cost

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m^2)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters	Subtotal
GN_1	Sandy Coast	**Gnarabup Beach**	480	15	7200	Coastal path, beach access stairs, beach carpark, Whilte Elephant Café and boat ramp.	$ 181,600	$ 600,000	$ 600,000	$ 475,000	$ 82,500	$ 381,420	$ 438,000			$ 2,758,520
GN_2	Weakly Lithified Sediminary Rock Coast	**Gnarabup Headland**	320	0	0	Coastal path, lookouts and access stairs.	$ 121,420									$ 121,420
GN_3	Sandy Coast	**Back Beach**	850	15	12750	Beach carparks, access paths and stairs.	$ 78,300	$ 155,000								$ 233,300
GN_4	Weakly Lithified Sediminary Rock Coast	**Grunters Beach**	150	20	3000	Beach carparks, access paths and stairs.	$ 106,000	$ 36,000				$ 28,000				$ 170,000
GN_5	Sandy Coast	**Gas Bay Beach**	400	25	10000	Beach carparks, access paths and stairs.	$ 41,000	$ 144,000								$ 185,000
					32950											$ 3,468,240

High Asset Cost (>$500,000)
Medium Asset Cost
Low Asset Cost (<$100,000)

Gnarabup - Asset Exposure to Coastal Processes

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m^2)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters
GN_1	Sandy Coast	Gnarabup Beach	480	15	7200	Coastal path, beach access stairs, beach carpark, Whilte Elephant Café and boat ramp.	H	H	H	L	H	L	H		
GN_2	Weakly Lithified Sediminary Rock Coast	Gnarabup Headland	320	0	0	Coastal path, lookouts and access stairs.	H								
GN_3	Sandy Coast	Back Beach	850	15	12750	Beach carparks, access paths and stairs.	H	L							
GN_4	Weakly Lithified Sediminary Rock Coast	Grunters Beach	150	20	3000	Beach carparks, access paths and stairs.	H	L				L			
GN_5	Sandy Coast	Gas Bay Beach	400	25	10000	Beach carparks, access paths and stairs.	H	L							

High Coastal Exposure (within 10 year area)
Medium Coastal Exposure (10-20 year area)
Low Coastal Exposure (20-100 year area)

Gnarabup - Asset Risk

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m^2)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters
GN_1	Sandy Coast	Gnarabup Beach	480	15	7200	Coastal path, beach access stairs, beach carpark, Whilte Elephant Café and boat ramp.	H	VH	VH	L	M	L	H		
GN_2	Weakly Lithified Sediminary Rock Coast	Gnarabup Headland	320	0	0	Coastal path, lookouts and access stairs.	H								
GN_3	Sandy Coast	Back Beach	850	15	12750	Beach carparks, access paths and stairs.	M	L							
GN_4	Weakly Lithified Sediminary Rock Coast	Grunters Beach	150	20	3000	Beach carparks, access paths and stairs.	H	L				L			
GN_5	Sandy Coast	Gas Bay Beach	400	25	10000	Beach carparks, access paths and stairs.	M	L							

High Asset Risk
Medium Asset Risk
Low Asset Risk

Coastal Risk Evaluation Matrix

		Exposure to Coastal Processes (Likelihood)		
		High (within 10yr area)	Medium (10-20 year area)	Low (20-100yr area)
Asset Cost (Consequence)	High	Very High	High	Med
	Medium	High	Med	Low
	Low	Med	Low	Low

Notes:

1. Asset costs are based on values provided by the Shire and/or based on assume rates and quantities for typical assets.

2. Asset cost represents present day replacement costs with no allowance for depreciation or maintenance.

3. Asset exposure to coastal processes has been assesed based on SC1411-X-2 RevC Drawing series.

4. Valuation have been undertaken for coastal planning purposes. They may not be sufficient for other purposes.

Hamelin Bay - Asset Cost

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m^2)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters	10. Private Jetties	11. Caravan Park	Subtotal
HB_1	Sandy Coast	Hamelin Bay Caravan Park	1800	15	27000	Caravan park, beach access stairs, beach carparks and boat ramp.	$ 250,000	$ 255,000	$ 300,000	$ 141,000			$ 350,000				$ 1,000,000	$ 2,296,000

$ 2,296,000

High Asset Cost (>$500,000)
Medium Asset Cost
Low Asset Cost (<$100,000)

Hamelin Bay - Asset Exposure to Coastal Processes

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m^2)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters	10. Private Jetties	11. Caravan Park
HB_1	Sandy Coast	**Hamelin Bay Caravan Park**	1800	15	27000	Caravan park, beach access stairs, beach carparks and boat ramp.	H	H	L	L			H				L

High Coastal Exposure (within 10 year area)
Medium Coastal Exposure (10-20 year area)
Low Coastal Exposure (20-100 year area)

Hamelin Bay - Asset Risk

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m^2)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters	10. Private Jetties	11. Caravan Park
HB_1	Sandy Coast	Hamelin Bay Caravan Park	1800	15	27000	Caravan park, beach access stairs, beach carparks and boat ramp.	H	H	L	L			H				M

High Asset Risk
Medium Asset Risk
Low Asset Risk

Coastal Risk Evaluation Matrix

		Exposure to Coastal Processes (Likelihood)		
		High (within 10yr area)	Medium (10-20 year area)	Low (20-100yr area)
Asset Cost (Consequence)	High	Very High	High	Med
	Medium	High	Med	Low
	Low	Med	Low	Low

Notes:

1. Asset costs are based on values provided by the Shire and/or based on assume rates and quantities for typical assets.

2. Asset cost represents present day replacement costs with no allowance for depreciation or maintenance.

3. Asset exposure to coastal processes has been assesed based on SC1411-X-2 RevC Drawing series.

4. Valuation have been undertaken for coastal planning purposes. They may not be sufficient for other purposes.

Molloy Island - Asset Cost

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m^2)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters	10. Private Jetties	Subtotal
MI_1	Tidal Reaches of Inland Waters	**Western Foreshore - Blackwood River**	1660	0	0	Foreshore reserve, Ferry landing, coastal path	$ 50,000		$ 1,000,000				$ 150,000	$ 800,000			$ 2,000,000
MI_2	Tidal Reaches of Inland Waters	**Channel**	500	0	0	Private jetties, santuary										$ 150,000	$ 150,000
MI_3	Tidal Reaches of Inland Waters	**Southern Foreshore - Blackwood River**	1030	0	750	Foreshore reserve, public boat ramp and jetty.											$ -
MI_4	Tidal Reaches of Inland Waters	**Eastern Foreshore - Scott River**	2760	0	0	Foreshore reserve, the Lagoon, the Basin, Teds Landing.							$ 93,500	$ 3,200,000			$ 3,293,500
			5950		750												$ 5,443,500

High Asset Cost (>$500,000)
Medium Asset Cost
Low Asset Cost (<$100,000)

Note: There is a Sandy Beach along the Southern Foreshore with a nominal area of 750m2

Molloy Island - Asset Exposure to Coastal Processes

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m^2)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters	10. Private Jetties
MI_1	Tidal Reaches of Inland Waters	Western Foreshore - Blackwood River	1660	0	0	Foreshore reserve, Ferry landing, coastal path	M		H				H	H		
MI_2	Tidal Reaches of Inland Waters	Channel	500	0	0	Private jetties, santuary										H
MI_3	Tidal Reaches of Inland Waters	Southern Foreshore - Blackwood River	1030	0	750	Foreshore reserve, public boat ramp and jetty.										
MI_4	Tidal Reaches of Inland Waters	Eastern Foreshore - Scott River	2760	0	0	Foreshore reserve, the Lagoon, the Basin, Teds Landing.							H	H		

High Coastal Exposure (within 10 year area)
Medium Coastal Exposure (10-20 year area)
Low Coastal Exposure (20-100 year area)

Molloy Island - Asset Risk

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m^2)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters	10. Private Jetties
MI_1	Tidal Reaches of Inland Waters	Western Foreshore - Blackwood River	1660	0	0	Foreshore reserve, Ferry landing, coastal path	L		VH				H	VH		
MI_2	Tidal Reaches of Inland Waters	Channel	500	0	0	Private jetties, santuary										H
MI_3	Tidal Reaches of Inland Waters	Southern Foreshore - Blackwood River	1030	0	750	Foreshore reserve, public boat ramp and jetty.										
MI_4	Tidal Reaches of Inland Waters	Eastern Foreshore - Scott River	2760	0	0	Foreshore reserve, the Lagoon, the Basin, Teds Landing.							M	VH		

High Asset Risk
Medium Asset Risk
Low Asset Risk

Coastal Risk Evaluation Matrix

		Exposure to Coastal Processes (Likelihood)		
		High (within 10yr area)	Medium (10-20 year area)	Low (20-100yr area)
Asset Cost (Consequence)	High	Very High	High	Med
	Medium	High	Med	Low
	Low	Med	Low	Low

Notes:

1. Asset costs are based on values provided by the Shire and/or based on assume rates and quantities for typical assets.

2. Asset cost represents present day replacement costs with no allowance for depreciation or maintenance.

3. Asset exposure to coastal processes has been assesed based on SC1411-X-2 RevC Drawing series.

4. Valuation have been undertaken for coastal planning purposes. They may not be sufficient for other purposes.

Augusta South - Asset Cost

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m^2)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters	10. Private Jetties	11. Caravan Park	Subtotal
AS_1	Sandy Coast	Albany Terrace - Blackwood River Cut	1100	10	11000	Foreshore from Blackwood River cut to Trigg St	$ 16,200			$ 1,004,400	$ 108,000			$ 48,000,000				$ 49,128,600
AS_2	Rocky Coast	Albany Terrace - Rocky Coast	320	2	640	Rocky coast west of Trigg St				$ 530,100	$ 32,000			$ 16,500,000				$ 17,062,100
AS_3	Sandy Coast	Albany Terrace - Sandy Coast	340	15	5100	Sandy Coast between Trigg St and Caravan Park				$ 334,800	$ 36,000			$ 12,750,000				$ 13,120,800
AS_4	Sandy Coast	Flinders Bay Caravan	460	10	4600	Beach carparks, access paths and stairs.											$ 1,656,137	$ 1,656,137
AS_5	Sandy Coast / Rocky Coast	Flinders Bay	650	10	6500	Beach carparks, access paths and stairs.	$ 115,700		$ 200,000	$ 502,200	$ 40,500		$ 246,000	$ 20,250,000	$ 49,800			$ 21,404,200
			2870		27840													$ 102,371,837

High Asset Cost (>$500,000)
Medium Asset Cost
Low Asset Cost (<$100,000)

Augusta South - Asset Exposure to Coastal Processes

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m^2)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters	10. Private Jetties	11. Caravan Park
AS_1	Sandy Coast	**Albany Terrace - Blackwood River Cut**	1100	10	11000	Foreshore from Blackwood River cut to Trigg St	H			H	H			L			
AS_2	Rocky Coast	**Albany Terrace - Rocky Coast**	320	2	640	Rocky coast west of Trigg St				L	L			L			
AS_3	Sandy Coast	**Albany Terrace - Sandy Coast**	340	15	5100	Sandy Coast between Trigg St and Caravan Park				H	H			L			
AS_4	Sandy Coast	**Flinders Bay Caravan**	460	10	4600	Beach carparks, access paths and stairs.											L
AS_5	Sandy Coast / Rocky Coast	**Flinders Bay**	650	10	6500	Beach carparks, access paths and stairs.	H		L	M	L		H	L	L		

High Coastal Exposure (within 10 year area)
Medium Coastal Exposure (10-20 year area)
Low Coastal Exposure (20-100 year area)

Augusta South - Asset Risk

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m^2)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters	10. Private Jetties	11. Caravan Park
AS_1	Sandy Coast	Albany Terrace - Blackwood River Cut	1100	10	11000	Foreshore from Blackwood River cut to Trigg St	M			VH	H			M			
AS_2	Rocky Coast	Albany Terrace - Rocky Coast	320	2	640	Rocky coast west of Trigg St				M	L			M			
AS_3	Sandy Coast	Albany Terrace - Sandy Coast	340	15	5100	Sandy Coast between Trigg St and Caravan Park				H	M			M			
AS_4	Sandy Coast	Flinders Bay Caravan	460	10	4600	Beach carparks, access paths and stairs.											M
AS_5	Sandy Coast / Rocky Coast	Flinders Bay	650	10	6500	Beach carparks, access paths and stairs.	H		L	H	L		H	M	L		

High Asset Risk
Medium Asset Risk
Low Asset Risk

Coastal Risk Evaluation Matrix

		Exposure to Coastal Processes (Likelihood)		
		High (within 10yr area)	Medium (10-20 year area)	Low (20-100yr area)
Asset Cost (Consequence)	High	Very High	High	Med
	Medium	High	Med	Low
	Low	Med	Low	Low

Notes:

1. Asset costs are based on values provided by the Shire and/or based on assume rates and quantities for typical assets.

2. Asset cost represents present day replacement costs with no allowance for depreciation or maintenance.

3. Asset exposure to coastal processes has been assesed based on SC1411-X-2 RevC Drawing series.

4. Valuation have been undertaken for coastal planning purposes. They may not be sufficient for other purposes.

Augusta North - Asset Cost

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m^2)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters	10. Private Jetties	11. Caravan Park	Subtotal
AN_1	Tidal Reaches of Inland Waters	**Colour Patch**	370	5	1850	Foreshore infront of Colour Path café		$ 72,000			$ 172,000		$ 497,000		$ 10,000			$ 751,000
AN_2	Tidal Reaches of Inland Waters	**Turner Caravan Park**	250	2	500	Foreshore infront of Caravan Park					$ 109,000		$ 111,000			$ 200,000		$ 420,000
AN_3	Tidal Reaches of Inland Waters	**Ellist St South**	950	5	4750	Northern boundary of Caravan Park to Ellis St					$ 90,000		$ 625,000	$ 4,800,000	$ 10,000	$ 200,000	$ 2,400,000	$ 8,125,000
AN_4	Tidal Reaches of Inland Waters	**Ellist St North**	1800	1	1800	Foreshore north of Ellist St, to Pelican Rise										$ 200,000		$ 200,000
			3370		8900													$ 9,496,000

(red)	High Asset Cost (>$500,000)
(yellow)	Medium Asset Cost
(green)	Low Asset Cost (<$100,000)

Augusta North - Asset Exposure to Coastal Processes

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m^2)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters	10. Private Jetties	11. Caravan Park
AN_1	Tidal Reaches of Inland Waters	Colour Patch	370	5	1850	Foreshore infront of Colour Path café		H			H		H		H		
AN_2	Tidal Reaches of Inland Waters	Turner Caravan Park	250	2	500	Foreshore infront of Caravan Park					H		H			H	
AN_3	Tidal Reaches of Inland Waters	Ellist St South	950	5	4750	Northern boundary of Caravan Park to Ellis St					H		H	H	M	H	M
AN_4	Tidal Reaches of Inland Waters	Ellist St North	1800	1	1800	Foreshore north of Ellist St, to Pelican Rise										H	

(red)	High Coastal Exposure (within 10 year area)
(yellow)	Medium Coastal Exposure (10-20 year area)
(green)	Low Coastal Exposure (20-100 year area)

Augusta North - Asset Risk

ID	Coastal Type	Coastal Node	Length of Coastal Node (m)	Average Sandy Beach Width (m)	Nominal Sandy Beach Area (m^2)	Description	1. Coastal Stairs and Platforms	2. Carparks	3. Buildings (large structures, toilets, changerooms etc)	4. Roads & Adjacent Paths	5. Coastal Walkways	6. Coastal Access Paths	7. Public Marine Structures (Boat Ramps / Jetties)	8 Private Residential Property	9. Landscaping and Playgrounds and Shelters	10. Private Jetties	11. Caravan Park
AN_1	Tidal Reaches of Inland Waters	Colour Patch	370	5	1850	Foreshore infront of Colour Path café		M			H		H		M		
AN_2	Tidal Reaches of Inland Waters	Turner Caravan Park	250	2	500	Foreshore infront of Caravan Park					H		H			H	
AN_3	Tidal Reaches of Inland Waters	Ellist St South	950	5	4750	Northern boundary of Caravan Park to Ellis St					M		VH	VH	L	H	H
AN_4	Tidal Reaches of Inland Waters	Ellist St North	1800	1	1800	Foreshore north of Ellist St, to Pelican Rise										H	

(red)	High Asset Risk
(yellow)	Medium Asset Risk
(green)	Low Asset Risk

Coastal Risk Evaluation Matrix

		Exposure to Coastal Processes (Likelihood)		
		High (within 10yr area)	Medium (10-20 year area)	Low (20-100yr area)
Asset Cost (Consequence)	High	Very High	High	Med
	Medium	High	Med	Low
	Low	Med	Low	Low

Notes:

1. Asset costs are based on values provided by the Shire and/or based on assume rates and quantities for typical assets.

2. Asset cost represents present day replacement costs with no allowance for depreciation or maintenance.

3. Asset exposure to coastal processes has been assesed based on SC1411-X-2 RevC Drawing series.

4. Valuation have been undertaken for coastal planning purposes. They may not be sufficient for other purposes.

13. Attachment 5 Socio Economic Evaluation

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Socio-economic Benefits of Beaches

The Margaret River region is renowned for its coastal amenity and the marine activities (swimming, surfing, diving, boating and beach walking) that it provides for both residents and visitors. The *Beach and Surf Tourism and Recreation in Australia: Vulnerability and Adaptation* study (Raybould et. al 2013) estimated that the non-market consumer surplus[1] of beach recreation is valued at $3.7 million p.a. for residents of the Shire. The Shire also receives more than 600,000 domestic, international and day-trip visitors annually, the vast majority of whom visit the beach during their stay. The proportion of their expenditure that can be attributed to these visits is in the order of $24.6 million p.a.

Hence the coastal areas of the Shire produce significant socio-economic benefits for both residents and visitors and any loss of access or beach amenity due to inundation, erosion and loss of infrastructure could impact on these values. In order to estimate the order of magnitude of the value of the benefits of each node within the seven case study sites, extant studies (Raybould et. al 2013; Jones et al 2010; AMRTA 2010, ACIL Tasman 2012), and methods (Attribution[2], Travel Cost[3] and Benefit Transfer[4]) were used to assign socio-economic values for each node.

Additionally, feedback from the Workshop held at the Shire on March 31st 2015 was used to inform the asset values associated with each node (see Appendix A). Asset replacement costs have been estimated for all identifiable assets (see Appendix B) within each node and will be compared with the value of economic benefits from beach use in each node in order to estimate the net economic benefits and benefit cost ratio of each node.

Previous Estimates of Beach Use Values

Previous studies have evaluated recreation and tourism values of beaches in Northern NSW (Carlsen, 1997), Sunshine Coast, Clarence Valley, Surf Coast and Augusta-Margaret River Shires (Raybould et. al. 2013) and Peron-Naturaliste Coastal Region (ACIL Tasman 2012). A range of approaches and methods were used to arrive at the estimates of economic value, and in all cases the values were based on a combination of tourism and recreation use by visitors and local residents. In the absence of a market price for beach use per user or per square metre, researchers had to use substitute, or surrogate market techniques such as Travel Cost and Consumer Surplus to estimate non-market values of beach use by residents. Additionally, the direct use values by visitors to the case study regions have been estimated based on the proportion of their daily expenditure attributable to their beach recreation and tourism activities (for a detailed description of the attribution method see

[1] Consumer surplus is the amount that consumers would be willing to pay if a market price for beach use existed. As beach use is free, there is no market and consumer surplus is referred to as a non-market estimate.
[2] Attribution is a method for assigning a proportion of tourism expenditure to a specific asset or place (see Carlsen and Wood, 2004)
[3] Travel Cost Method uses travel time and cost as an indicator of the value placed by visitors to a specific location (in this case, a beach)
[4] Benefit Transfer uses the results of valuation studies in comparable locations to estimate the value of a specific study site (see Raybould et al, 2013)

Carlsen and Wood, 2004). The sum of these values estimate the financial benefits that are derived directly from beach use by residents and visitors in coastal Shires but do not include the environmental and cultural values of beaches in the case study regions.

In the case of the Northern NSW beaches (including the very popular beaches in Tweed Heads, Byron Bay, Ballina, Coffs Harbour and Nambucca Heads) the gross market values of recreation and tourism was estimated at $200 million p.a. (Carlsen, 1997).

The Beach and surf tourism and recreation in Australia: Vulnerability and adaptation project (Raybould et. al 2013) has produced estimates of economic values for recreation and tourism related to beach and surf amenities across four case-study locations in Australia. Estimates of the non-market consumer surplus values of beach recreation indicate that beach recreation is worth around: $70 million per annum (p.a.) to residents of the Sunshine Coast (Qld), $32 million p.a. to residents of Clarence Valley (NSW), $6 million p.a. to residents of the Surf Coast (Vic) and $4 million p.a. for residents of Augusta-Margaret River (WA).

In addition to the non-market values, real market expenditures are incurred by tourists in order to visit and stay in coastal locations. The value of this tourism expenditure that is specifically related to beach and surf recreation is estimated to be in the order of $270 million annually for the Sunshine Coast (Qld), $32 million p.a. for Clarence Valley (NSW), $107 million for the Surf Coast (Vic) and $25 million for the Augusta-Margaret River (WA) region.

A study of Climate Change Adaptation options in the region between Point Peron and Cape Naturaliste in Western Australia (ACIL Tasman, 2012), included an assessment of the value of beaches along the 212 kilometres of coastline . This study also recognises that beaches are not bought and sold, and thus do not have a market value and instead makes use of benefit transfer to value beaches in the study area. Beaches in the asset register were classified as either urban, natural or remote beaches according to the Coastal Planning Policy (Western Australian Planning Commission, 2012). The study area comprised 105 kilometres of urban coast, 19 kilometres of natural coast and 88 kilometres of remote coast.

The study then established a value for urban beaches of $9 million per km^2 based on Blackwell (2007), who used the work of Carlsen (1997) to derive this value. Natural and remote beaches were valued at $3 million per km^2, based on the same study by Blackwell but using the work of Pitt (1992) who valued 'non-urban' beaches. The study valued the beaches within the area between Point Peron and Cape Naturaliste at $11.09 million.

Finally, as previously stated in the introduction to this section, a study by Raybould *et al*, 2013 valued the beach use by residents of the Shire of Augusta Margaret River at $3.72 million p.a. and the direct value of beaches for tourism use at $24.58 million. Thus, the beaches in the study region have been valued at $28.3 million.

It should be noted that there are many limitations to the estimates provided in these studies, and they represent an 'order of magnitude' comparable only with studies that use similar approaches to estimation, but not with any real world market situation. The estimations are largely dependent on the classification of beach type (urban beaches are three times more valuable than natural or remote beaches, due mainly to the higher number and frequency of users). The extent of coastal development in the form of residential and commercial land also has a large effect on beach values, with highly developed urban coastlines, such as the Sunshine Coast in Queensland and the Surf Coast in Victoria having substantially higher values than the Clarence Valley, Augusta-Margaret River or Peron-Naturaliste coastlines.

Bearing this in mind, it is reasonable to accept the valuation of beaches in the Augusta-Margaret River Shire at $30 million in 2015 (adjusted for inflation) for the purposes of estimating the value of benefits provided to residents and visitors from beach use annually. Using a similar approach to ACIL Tasman for estimating the value of a beach per square metre was also considered appropriate for this report, given that the nodes and assets under consideration all support beach use in one way or another. That is, any loss of coastal assets such as roads would compromise beach use values. Alternatively, any action to protect beaches would conserve those values, but would involve site specific evaluation of areas to be protected in the long-term.

To this end, the total area (147,421 M^2) of all beaches used by residents and visitors in the Raybould *et. al* study area was estimated. These swimming and surfing beaches (excluding Augusta North/South and Molloy Island) were evaluated in 2013 using resident and visitor surveys and a total value of $28.3 million was assigned to them, as explained above (Raybould et. al 2013).

Dividing the estimated value of these beaches in 2015, by the total area provides an estimate in the order of $200 per square metre. Whilst this is less than the $300 per square metre for natural and remote beaches in the Peron-Naturaliste study, it is consider to be a better estimate as it is based on actual primary data from the study area, not on values from previous studies in other locations. Also, the authors of the ACIL Tasman Report admit that their estimates of beach values may be overstated and should therefore be treated with caution, as follows:

> *In the case of beaches, there are also good reasons to treat the valuation with caution, particularly since many of the urban beaches in the studies which are used to derive values are in areas of much higher urban density than occurs in the South West; though not necessarily higher surrounding real estate values or personal wealth. Moreover, for non-urban beaches, except where these have specific value to particular groups of users that would be lost (a good surfing break, for example), one could argue whether the beach is indeed being lost by climate change, as opposed to simply being moved "inland" as the shoreline is eroded. For these reasons, there may be a case for considering our estimates of value as being too high.*

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Estimates of Beach Values in the Augusta Margaret River Shire

Using the valuation of $200 per square metre and the areas of beaches in the seven project sites that include swimming and surfing beaches, the annualised socio-economic values are shown in Table 1.

Table 1– Annualised Value of Beaches at Project Sites

Project Site	**Value (2015 $)**
Gracetown	3,320,000
Prevelly	13,130,000
Gnarabup	6,590,000
Hamelin Bay	5,400,000
Molloy Island	150,00
Augusta South	5,568,000
Augusta North	1,780,000

Valuing beaches in square metres provides a basis for estimating the economic benefits that would be lost if those beaches, or access to those beaches was lost due to coastal inundation. It is interesting to note that the beaches with the highest values also have significant assets located on site and are also considered relatively safe swimming beaches (Gracetown, River mouth, Prevelly, Gnarabup and Hamelin Bay. Surfer's Point and Gas Bay are primarily surfing beaches with lower value assets and a smaller beach area and therefore a lower economic value. This analysis assumes that the socio-economic value is lost if the beach completely erodes. It is, however, possible that along sandy coasts backed by dunes that the beaches may recede, or 'moved inland' due to sea-level rise but still be available to the public.

In the next section, the value of the economic benefit of beach use at the coastal project sites will be compared with the financial cost of replacement of the assets in each node as a basis for estimating the net economic benefit associated with each of them.

Socio-Economic Benefit – Cost Analysis

The socio-economic benefits of tourism and recreation on beaches in the Coastal Zone were evaluated based on estimated beach area and a nominal value of $200 per square metre, as estimated above.

The cost of coastal assets that support beach access and at the coastal project sites was estimated by Shore Coastal based on the replacement cost of assets including Coastal Stairs and Platforms, Carparks, Buildings (large structures, toilets, change rooms etc.), Roads & Concrete Paths, Coastal Walkways, Coastal Access Paths, Public Marine Structures (Boat Ramps / Jetties) and Services.

It was assumed that the loss of any of these assets (due to an extreme weather event, for example) would reduce the annualised value of recreation and tourism associated with beach use to zero. Benefit Cost Analysis was based on the ratio of the annualised benefit value of beach use compared to the replacement cost of the assets that facilitate that beach use.

Using this approach, five coastal nodes were found to have high Benefit-Cost (B-C) ratios (greater than 2.0), six were found to have medium B-C ratios (between 1.0 and 2.0) and ten were found to have low B-C ratios (less than or equal to 1.0). Six coastal nodes were not evaluated as they did not possess or were not adjacent to a swimming/surfing beach.

The coastal nodes with High B-C ratios are listed in Table 2.

Table 2 – High B-C Ratio Coastal Nodes

Study Site	Coastal Node	Beach Area (M^2)	Socio-economic Value (AUD)	Public Asset Cost (AUD)	Annualised Benefit-Cost Ratio
Gnarabup	Back Beach	12,750	2,550,000	233,300	10.9
Gnarabup	Gas Bay Beach	10,000	2,000,000	185,000	10.8
Prevelly	Prevelly Beach	18,000	3,600,000	928,000	3.9
Prevelly	Rivermouth Beach	26,400	5,280,000	1,479,590	3.6
Gnarabup	Grunters Beach	3,000	600,000	170,000	3.5

The coastal nodes with Medium B-C ratios are listed in Table 3.

Table 3 – Medium B-C Ratio Coastal Nodes

Study Site	Coastal Node	Beach Area (M^2)	Socio-economic Value (AUD)	Public Asset Cost (AUD)	Annualised Benefit-Cost Ratio
Augusta South	Albany Terrace - Blackwood River Cut	11,000	2,200,000	1,128,600	1.9
Prevelly	Rivermouth Road	5,250	1,050,000	595,255	1.8
Gracetown	Cowaramup Bay Swimming Beach	6,000	1,200,000	878,085	1.4
Gracetown	South Point	1,100	220,000	162,500	1.4
Gracetown	Melaleuca Beach	4,000	800,000	683,028	1.2
Augusta South	Flinders Bay	6,500	1,300,000	1,154,200	1.1

The coastal nodes with Low B-C ratios are listed in Table 4.

Table 4 – Low B-C Ratio Coastal Nodes

Study Site	Coastal Node	Beach Area (M^2)	Socio-economic Value (AUD)	Public Asset Cost (AUD)	Annualised Benefit-Cost Ratio
Prevelly	Surfers Point	14,000	2,800,000	2873540	1.0
Gracetown	Cowaramup Bay Boat Ramp	4,125	825,000	1,003,410	0.8
Gracetown	South Point Car Park	1,375	275,000	453,404	0.6
Prevelly	Riflebutts Beach	2,000	400,000	677791	0.6
Augusta South	Flinders Bay Caravan	4,600	920,000	1656137	0.6
Gnarabup	Gnarabup Beach	7,200	1,440,000	2758520	0.5
Augusta North	Colour Patch	1,850	370,000	751000	0.5
Augusta North	Turner Caravan Park	500	100,000	220000	0.5
Augusta North	Ellis St South	4,750	950,000	3125000	0.3
Augusta South	Albany Terrace - Rocky Coast	640	128,000	562100	0.2

Benefit-Cost Ratios and Risk

In order to inform prioritisation and decision-making regarding the timing of risk management and adaptation strategies in the future, categorised Benefit-Cost Ratios have been compared with Asset Risk Evaluation for each node. Analysis has focussed on 'High' and 'Medium' B-C Ratios and 'Very High' and 'High' Asset Risk (Table Z).

Based on this comparison, the Rivermouth Beach node has both a high B-C ratio (3.6) and 'Very High Risk' and could be considered a highest priority in hazard management planning. Prevelly Beach and Grunters Beach are also in the 'High Risk' category as well as having a 'High' B-C Ratio. These nodes should also be considered having the highest priority. Finally, it is significant that the two nodes with the highest B-C Ratios (Back Beach and Gas Bay Beach) are in the 'Medium Risk' category, indicating that these could be considered as having a high priority.

Nodes that have a 'Medium' B-C Ratio but are at 'Very High' or 'High' Risk are: Albany Terrace - Blackwood River Cut; South Point; Melaleuca Beach; Flinders Bay and Surfers Point. Of these Albany Terrace – Blackwood River Cut has a B-C ratio at the upper end of the 'Medium' category, as well as a 'Very High' Risk and should be considered as having a medium to high priority. The other nodes are in the medium priority range.

Of the remaining nodes that have been included in the B-C analysis, Gnarabup Beach and Ellis St. South have 'Low' B-C Ratios but are in the 'Very High' Risk category. It should be noted here that the B-C analysis only relates to *public* assets, and the commercial (i.e. cafes and caravan parks) and private asset (i.e. jetties) values associated with these nodes have not been taken into account. Should the Shire elect to include the commercial and private values of assets in these nodes, the prioritisation could change substantially. However, based purely on socio-economic B-C ratios public assets at risk, the South Point, Melaleuca Beach, Flinders Bay, Surfers Point, Cowaramup Bay Boat Ramp, South Point Carpark, Colour Patch and Turner Caravan Park have low priority (Table 5).

Table 5 – Benefit Cost and Asset Risk Categories

Project Site	Coastal Node	Annualised Benefit-Cost Ratio	Asset Risk Category
Gnarabup	Back Beach	10.9	Medium
Gnarabup	Gas Bay Beach	10.8	Medium
Prevelly	Prevelly Beach	3.9	High
Prevelly	Rivermouth Beach	3.6	Very High
Gnarabup	Grunters Beach	3.5	High
Augusta South	Albany Terrace - Blackwood River Cut	1.9	Very High
Gracetown	South Point	1.4	High
Gracetown	Melaleuca Beach	1.2	High
Augusta South	Flinders Bay	1.1	High
Prevelly	Surfers Point	1.0	High
Gracetown	Cowaramup Bay Boat Ramp	0.8	High
Gracetown	South Point Car Park	0.6	High
Gnarabup	Gnarabup Beach	0.5	Very High
Augusta North	Colour Patch	0.5	High
Augusta North	Turner Caravan Park	0.5	High
Augusta North	Ellis St South	0.3	Very High

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Summary

For the purposes of this study, the annualised benefit-cost ratios and risk categories associated with the coastal nodes within each site provides an indication and decision-support and prioritisation tool for planning and management of coastal assets within the Shire in the future.

On this basis, coastal nodes that have both high B-C ratios and also have assets in the high risk category should be prioritised in terms of risk management and adaptation options. Rivermouth, Prevelly and Grunters beaches have the highest priority under these criteria. Back and Gas Bay beaches also have high B-C ratios, but are categorised as 'medium risk', indicating that these should be next in terms of adaptation consideration.

In this way, the socio-economic values are cross-referenced with physical risk and adaptation options identified elsewhere in this report to inform future planning and management of the coastal zone within the Augusta Margaret River Shire.

The socio-economic evaluation of coastal nodes in the seven study sites was based on extant estimates of the benefit value of coastal tourism and recreation and the associated cost of the public assets that facilitate access to those sites. It should be noted that some use values associated with some sites (such as surfing and boating) could not be estimated as no data is available. Future studies of coastal tourism and recreation benefits and costs should include estimates of the value of these, as well as other cultural and environmental values identified in the stakeholder workshop (Appendices A and B).

Recommendations

Following workshops and feedback from community groups and Shire staff (see Appendices A and B) a number of recommendations regarding evaluation of coastal assets and amenity in the future:

1. There is several types of values that have not been estimated due to a lack of primary survey data and monitoring, including cultural, indigenous, environmental, heritage and aesthetic values. Whilst the techniques exist in environmental economics to estimate these non-market values, data collection would require an extensive survey of residents and visitors in order to estimate these. Should these values be deemed important to community groups, a discrete project aimed at capturing these values should be planned and implemented by the Shire.
2. There is several types of uses that have not been evaluated due to lack of data, such as the value of recreation boating and fishing and the value of recreational surfing. Both of these use types are supported by extensive coastal assets (boat ramps, carparks and beach access stairs) so it would be logical to evaluate the volume and value of these activities for future benefit-cost studies. Again, measurement and monitoring of surfer numbers and boat users at specified nodes would be an important component of any future study of socio-economic values.
3. Valuation of beach use does not take into account actual patronage, as beach user numbers are not systematically collected across the study sites. In order to provide an estimate of the value per user specific to each site, good estimates of average beach user numbers over a twelve month period would need to be provided. Again, techniques for collecting this data,

including aerial surveys and non-participant observation could be employed to identify high, medium and low beach use intensity. This would provide another parameter for informing resource allocation and adaptation strategies for coastal hazard management in the future.

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APPENDIX A

Workshop 1 – Risk analysis and risk identification

Community input towards preparation of the Shire's Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) is an essential component of the study. The workshop was held at Shire offices on Tuesday 31 March, 4.30 – 6.30pm. The following key stakeholders attended the meeting:

- Shire officers
- Shore Coastal
- Shire Councillors
- Transition Margaret River
- Sustainability Advisory Committee
- Tangaroa Blue
- Margaret River Coastal Residents Association
- Coastal engineering consultants
- Environmental experts
- Margaret River Environment Centre
- Cape to Cape Catchments Group

The following aspects of the CHRAMP have been prepared to date.

- Risk identification - identification of key assets along the coastline which may be subject to impacts from climate change and associated sea level rise.
- Risk analysis – this involves consideration of the likelihood and consequence of the risks identified in the risk identification stage.

In particular the risk identification and risk analysis stages identified key assets for several locations in the Shire including Augusta, Hamelin Bay, Molloy Island, Gnarabup, Prevelly and Gracetown. The coastal characteristics were then identified for each site i.e. sandy coast, mixed rocky/sandy coastline etc. An assessment of the impacts caused from sea level rise, erosion, storm events, was then undertaken and erosion setback lines identified for each of the sites.

Key stakeholders were requested to provide input on two important issues:

- The importance of key coastal assets; and
- What it would mean to the community should key assets be impacted upon from potential erosion, sea level rise etc. (taking into consideration environmental, social and economic impacts.

The following bullet points for each location were recorded from the workshop. A second workshop was scheduled for June 2015 to address Risk Evaluation and Risk Adaptation phases of the CHRMAP.

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Gracetown (key assets)

1. Cowaramup Bay boat ramp
   - Serves as important function for boating and surfing
   - Important safety boat launching facility

2. Cowaramup bay swimming beach
   - Unique protected beach safe for swimming and diving

3. Melaleuca beach car park
   - The only dog exercise area in Gracetown
   - Swimming, diving and fishing recreation
   - Proximity to shops is important

4. South Point car park
   - Provides access to walking tracks and the beach
   - High social values for both visitors and local community
   - Unique viewing platform

5. South Point stairs and walkway
   - Recognised indigenous site
   - Access to surfing breaks and beach is highly valuable

6. Residential areas and local roads
   - Represents significant economic and social values. Replacement costs would be significant

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Prevelly (Key assets)

1. River mouth car park
   - Important heritage and indigenous values
   - Economic and tourism opportunities
   - Potential environmental values, loss of habitat and river banks
   - Unpredictable coastal movement over time

2. River mouth Road
   - Highly important for traffic movement to key tourism spots
   - Economic linkage for small eco-businesses
   - One of the most important/valuable tourist routes in the Shire.

3. Surfers Point car park
   - Valuable surfing breaks and swimming area for both visitors and locals
   - Extremely valuable economic driver to the community
   - Recognised for its high social value

4. Surfers Point drive
   - Same responses as above

5. Riflebutts oval
   - Potential short term low lying risk
   - Increasing social value and pressure from additional usage and recreational development in the area
   - Local significance to community

6. Mitchell Drive
   - Essential access path/dog exercise areas

7. Coastal path
   - Extremely high social value
   - Realignment required in the short term due to increasing erosion impacts on the coast

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Gnarabup (key assets)

1. White Elephant Café
   - Environmental values are extremely important to the beach
   - Potential need to relocate built assets i.e. buildings, pathways, stairs etc.
   - High social and economic values
   - Important for swimming, fishing, surfing and other recreational activities
   - High tourism values, key visitor asset

2. Boat ramp and car park
   - Jetty has impacts on environmental and social values of the site's amenity
   - Difficult to relocate as it is connected to the car park and large in size
   - Important boat launching facility for safety authorities

3. Wallcliffe Road to Seagrass Place
   - Important for fishing, swimming, surfing activities
   - Significant impacts from erosion beginning to occur to dunes along Long Reef area
   - Future development proposed in the area may impact upon on coastal areas
   - Site is important as a means of coastal access to nearby beaches

4. Grunters Beach car park
   - Important habitat for Hooded Plover birds. Beach recession may impact on this specie
   - Relocation of important recreational assets may be necessary
   - Cliff north of car park is important to be protected, some destabilisation beginning to occur

5. Waste water facility
   - Acts as an important infrastructure function for the Gnarabup settlement
   - Potential environmental disaster should this be impacted upon through coastal erosion

6. Gas Bay car park
   - Important access point for locals and visitors

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Molloy Island (key assets)

1. Public Jetties
   - Important means of transport for local residents
   - Required for safety mooring of the barge

2. Private jetties
   - Important recreational values to homeowners
   - Economic value due to significant cost of replacement

3. Barge
   - Important social value as it is the only mode of transport to the Island. Impacts on both local residents and the Molloy Island Homeowners Association.

4. Foreshore
   - Significant river foreshore environmental values
   - Social aesthetics

5. Residential housing
   - Important social value as an established community
   - Economic value, cost of replacement and relocation issues

Hamelin Bay (key assets)

1. Hamelin Bay car park
   - Important boat launching facility for both commercial and recreational fishing
   - Recreational importance and connection to the beach through pathways, stairs, lookouts
   - Parking requirements for tourists/ day trips

2. Hamelin Bay caravan park
   - Socially important site as it provides unique and affordable holiday accommodation close to the coast.
   - Economic driver for a number of other local businesses.
   - Source of employment

3. Hamelin boat ramp
   - Important for safety
   - Historic importance
   - Recreational boating facility

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Augusta (key assets)

1. Ellis St. jetties
   - Serves as passive recreation
   - provides for East Augusta access
   - close proximity to the town centre
   - Tourism (passive)
   - Economic infrastructure required for local tour operators
   - Consists of mature fringing vegetation

2. Turner caravan park
   - Unique location close to the river
   - Major tourism drawcard
   - Source of employment

3. Seine Bay to Loche Street
   - Important track for recreational walking groups and recreational boating
   - Important tourism and residential site

4. Flinders Caravan Park
   - Similar values to Turner Caravan Park
   - Mature dune system acts as primary erosion buffer

5. Flinders boat ramp
   - Passive recreation area
   - Unique sandy beach area
   - Area is used for swimming lessons
   - Road and adjacent residential areas are important economic assets

6. Flinders lookout and swimming area
   - Same response to above
   - Cape to Cape track highly valuable asset

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APPENDIX B

Workshop 2 – CHRMAP Stage 3 & 4

Date: Tuesday 18 August 2015

Time: 4.30pm

Venue: Shire of Augusta-Margaret River – Mainbreak Meeting Room

Attendees:

- Lyn Serventy (Councilor – Deputy President)
- Jared Drummond (Sustainability Planning Officer)
- Bruce McCauley and
- Pam Townshend – AMRTA
- Joan Hamersley – MIHO
- Karen Majer – Transition
- John McKinney – Shire
- Ann Matei – Augusta Community Environmental Group
- David Novy & Peter Toy
- Genny Broadhurst, Janet Dufall and Adrian Wilson – M/R Coastal Res Assoc.

Actions

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Risk evaluation presentation

- **COM -** When was 0.9m over 100 year rule applied?
  SC - SPP2.6 guidance guides this, could be higher or lower depending upon sea level response. Lines are not only sea level rise, also allow for historical change taking into account storms, erosion etc…case by case scenario
- **COM -** As figures are adjusted, can maps be adjusted to reflect new standards?
  SC - Mapping can be changed to reflect new government legislation, providing long term view is considered.
- **COM -** How do you account for setback distances based on topography, depending on whether assets are one metre or 30m above natural ground level?
  SC - Still governed by 90 metre setback regardless of topography as sand is subject to erosion etc. Reports needs to clarify this response.
- **COM -** Albany Terrace seawall, is that the answer to minimize coastal hazards?
  SC - Defend, Avoid, Accommodate, Retreat options – monitor high risk areas at the outset.
- **COM -** Where is the starting point for 100 yr study?
  Now
- **COM -** Ellis Street Jetty identified as high risk – what is the timeframe?
  SC - Consider development in high risk areas, needs to address different design features to address potential future impacts

Dr. Jack Carlsen – socio economic analysis of coastal Shire assets

- **COM -** Are the dollar values taking into account the usage of the sites?
  JACK - Made up partly by usage, travel costs, allows focus on priorities required for engineering
- **COM -** What does low cost ratio vs. high asset category mean?
  JACK - Shire to make judgment call based on what is most important depending upon location/benefits to the community, social value emphasis

SC - There is a need to protect assets behind the beach, but also tangible values of the beach itself. Data on visitor numbers would assist with this methodology. **COM -** Small areas that service a large area need to be taken into account i.e. such as Gracetown, more economic social value of such areas needs to be considered. Study should also take into account usable areas and provide higher value i.e. north facing beaches – study possibly needs to be refined and consider these responses?

Risk management/adaptation presentation

- **COM -** Augusta river cut – consequence is that the sand has drifted and caused navigational issues/ build up in certain areas/not in others. Flinders Beach is being eroded by the river, rehabilitation action is in place, guard already installed to protect them.
- **COM -** How will the report prioritise limited budget to implement action? Social ranking needs refining….Tourism values, biological values, aboriginal heritage factors….what stage will they be taken into account? **SHIRE -** Second stage of community consultation with preliminary findings will seek community feedback. Report will be taken to Council for community feedback, clarify findings before advertising…5 yr program, influenced by socio – economic analysis…set up systematic beach monitoring as a starting point – discuss social/heritage values further….initial monitoring as a default priority action….
- **COM -** What about access to the river with public/private jetties, will usage be taken into account when making decisions to implement engineering recommended actions?
  SC - Monitoring is key, can use aesthetic values from surveys to value, highly modified beach – back beach vs. pristine beach – Gracetown….dollar value study, loss of beach means pressure on back beach
- **COM -** What planning is in place to make current decisions on protecting coastal assets?
  SHIRE - Reactive and ad hoc decision making to date
- **COM -** Community education/consultation – In the future, community will need to understand a lot more about what this study means to the general public. Potential for negative response unless the Shire manages broadscale community consultation correctly. People will need to understand investment requirements to action engineering recommendations etc.

14. Attachment 6 Risk Management Tables

Following assessment of the risk to the coastal assets, risk management and adaptation options have been identified for each coastal node. Adaptation measures have been considered for High or Very High risk assets identified through the Risk Evaluation phase.

The general *sensitivity* of coastal assets to coastal erosion or coastal inundation has been assessed. Assets with high sensitivity to coastal erosion, based on the visual inspections (e.g. stairs already being undermined) are identified.

Potential impacts of erosion or inundation under rising sea levels and variable climatic conditions are outlined. The adaptive capacity has then been assessed in terms of the risk management and adaptation hierarchy (avoid, managed retreat, accommodation, coastal protection).

The following is noted in regard to these tables:

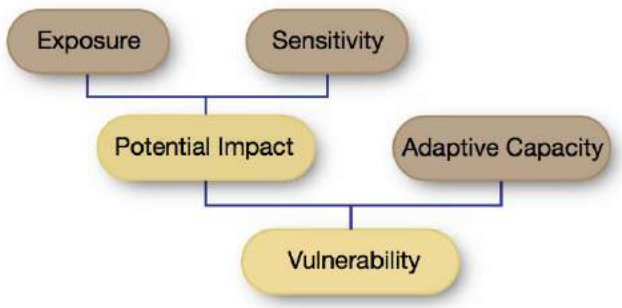
- Asset exposure based on Risk Analysis (Phase 2). High exposure means assets within 10yr coastal processes zone.
- ✖ means coastal asset is sensitive to coastal erosion or inundation.
- ✖✖ means visual inspection indicated high sensitivity to coastal erosion or inundation.
- Adaptive capacity identifies most feasible options. Other options may be considered.
- Asset risk based on Risk Evaluation (Phase 3) and is based on asset cost (consequence) and asset exposure (likelihood).
- There is not sufficient beach survey and design information to quantitatively assess the sensitivity of individual assets to coastal erosion or inundation. For example, the sensitivity of beach access stairs to erosion requires regular beach survey and design details including the depth of vertical supports
- The vulnerability of individual assets, as defined, cannot presently be assessed with confidence due to limited information on their sensitivity to erosion/inundation. This could however be assessed at a project scale where beach survey and design information is collected or collated.

Prevelly - Risk Management and Adaptation

ID	Coastal Type	Coastal Node	Asset □ype	Description	Exposure	Sensitivity: Coastal Erosion	Sensitivity: Coastal Inundation	Potential Impact	Adaptive Capacity: Avoid	Adaptive Capacity: Managed Retreat	Adaptive Capacity: Accommodate	Adaptive Capacity: Protect	Asset Risk	Risk Management and Adaptation Options
PV□1	Sandy Coast	Rivermouth Beach	Coastal stairs and platforms	Coastal stairs and platforms at River Mouth Beach constructed as part of recent Surfers Point upgrade.	High	✖	✖	1) Increased erosion adjacent to lower stair. 2) Exposure of footings for timber supports of stairs and platforms and reduced support for structure. 3) Potential collapse/failure of stairs.			☑	☑	High	A) Ongoing monitoring and management of fall distance from lower stair to beach. B) Adaptation of stairs to reduce frequency of large fall distances (i.e. stair extensions). C) Ongoing structural inspections of stairs, platforms, and supports including evaluation of durability of composite materials and response to erosion events.
PV□1	Sandy Coast	Rivermouth Beach	Carparks	Rivermouth Beach coastal carpark.	High	✖		1) Slope instability associated with toe erosion of dune due to increase in MSL and variable climatic conditions. 2) Exposure of seaward edge of carpark paths and retaining wall to slope instability.		☑	☑	☑	Very High	A) Ongoing monitoring and management of dune and retailing wall in front of carpark B) Consideration of rivermouth entrance opening regime C) Longer term planning for either relocating seaward edge of carpark to within medium vulnerability areas or maintaining and upgrading retaining wall to increase protective capacity D) Longer term planning for greater capacity for overflow parking in medium to low vulnerable areas.
PV□3	Weakly Lithified Sedimentary Rock Coast	Surfers Point	Coastal stairs and platforms	Coastal stairs and platforms at Surfers Point, constructed a part of recent Surfers Point upgrade.	High	✖✖		1) Slope instability associated with toe erosion of weakly lithified limestone coast due to increase in MSL and variable climatic conditions. 2) Exposure of footings for timber supports of stairs and platforms and reduced support for structure 3) Potential collapse/failure of stairs. 4) Erosion of perched beaches associated with increased wave exposure.			☑	☑	High	A) Geotechnical inspection of limestone cliff stability in area of access stairs and lookout (Immediate Priority). B) Ongoing structural inspections of stairs. C) Design of long term solutions to ensuring integrity of stairs and lookouts at this location can accommodate future instability.
PV□5	Sandy Coast	Prevelly Beach	Coastal walkways	Limestone coastal walkway along Prevelly beach (Mitchel Drive to Rifflebuts)	High	✖✖	✖	1) Slope instability or path erosion associated with erosion of dune due to increase in MSL 2) Increased difficulty in providing public coastal access.		☑			High	A) Detailed survey of Prevelly / Gnarabup beach and dunes B) Ongoing monitoring of beach behaviour (photo monitoring / beach profiles). C) Monitoring and inspections of vulnerable areas of path D) Longer term planning for progressive managed retreat of coastal walkway, higher on dunes and further setback from coast. E) Management of beach access.

Notes:
1. Asset exposure based on Risk Analysis (Phase 2). High exposure means assets within 10yr coastal processes zone.
2. ✖ means coastal asset in sensitive to coastal erosion or inundation
3. ✖✖ means visual inspection indicated high sensitivity to coastal erosion or inundation.
4. Adaptive capacity identifies most feasible options. Other options may be considered.
5. Asset risk based on Risk Evaluation (Phase 3) and is based on asset cost (consequence) and asset exposure (likelihood).
6. There is not sufficient beach survey and design information to quantitatively assess the sensitivity of individual assets to coastal erosion or inundation. For example, the sensitivity of beach access stairs to erosion requires regular beach survey and design details including the depth of vertical supports.
7. The vulnerability of individual assets, as defined, cannot presently be assessed with confidence due to limited information on their sensitivity to erosion/inundation. This could however be assessed at a project scale where beach survey and design information is collected or collated.

Risk Management and Adaptation Hierarchy (CHRMAP Guidelines)

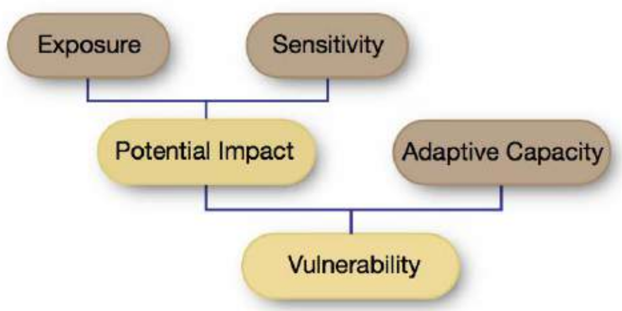


Vulnerability Assessment Flowchart (CHRMAP Guidelines)

Gracetown - Risk Management and Adaptation

ID	Coastal Type	Coastal Node	Asset □ype	Description	Exposure	Sensitivity		Potential Impact	Adaptive Capacity				Asset Risk	Risk Management and Adaptation Options
						Coastal Erosion	Coastal Inundation		Avoid	Managed Retreat	Accommodate	Protect		
GT□1	Sandy Coast	Cowaramup Bay Boat Ramp	Public Marine Structures	Concrete boat ramp and associated finger jetty	High		✖	1) Jetty inundated during higher tides due to increase in MSL. 2) Jetty and ramp damage due to increase exposure to waves. 3) Reduction in frequency of safe launching conditions.			☑		High	A) Inspect and maintain public marine structures to required standards. B) Design jetty deck level to accommodate future sea level rise at time of replacement or major maintenance. C) Monitor wave exposure in terms of safe launching.
GT□4	Weakly Lithified Sedimentary Rock Coast	South Point Car Park	Coastal Stairs and Platforms	Huzzas Beach Access Stairs (timber)	High	✖✖		1) Slope instability associated with toe erosion of weakly lithified limestone coast due to increase in MSL and variable climatic conditions. 2) Exposure of footings for timber supports of stairs and platforms and reduced support for structure 3) Potential collapse/failure of stairs. 4) Erosion of perched beaches associated with increased wave exposure.			☑	☑	High	**A) Geotechnical inspection of limestone cliff stability in area of access stairs and lookout, in particular overhang forming beneath lookout (Immediate Priority).** B) Ongoing structural inspections of temporary supports to stairs. C) Design of long term solutions to ensuring integrity of stairs and lookouts at this location can accommodate present and future slope instability. D) Detailed survey of cliff face.
GT□4	Weakly Lithified Sedimentary Rock Coast	South Point Car Park	Car Park	Southpoint coastal carpark.	High	✖		1) Slope instability associated with toe erosion of weakly lithified limestone coast due to increase in MSL and variable climatic conditions. 2) Exposure of seaward edge of carpark and paths to slope instability.		☑	☑	☑	High	A) Geotechnical inspection of limestone cliff stability adjacent to carpark. B) Planning to consider feasibility of relocating seaward edge of carpark to within medium vulnerability areas, and providing greater capacity for overflow parking on the southern side. C) Detailed survey of cliff face.
GT□5	Weakly Lithified Sedimentary Rock Coast	South Point	Coastal Stairs and Platforms	South Point Beach Access Stairs (timber)	High	✖		1) Slope instability associated with toe erosion of weakly lithified limestone coast with increase in MSL and variable climatic conditions. 2) Erosion of timber supports for stairs and platforms 3) Potential collapse/failure of stairs.			☑	☑	High	**A) Geotechnical inspection of limestone cliff stability in area of access stairs and lookout (Immediate Priority).** B) Ongoing structural inspections of stairs. C) Design of long term solutions to ensuring integrity of stairs and lookouts at this location can accommodate future instability. D) Detailed survey of cliff face. E) Coordination with Shire and DEC re: ongoing inspections and survey.

Notes:
1. Asset exposure based on Risk Analysis (Phase 2). High exposure means assets within 10yr coastal processes zone.
2. ✖ means coastal asset in sensitive to coastal erosion or inundation
3. ✖✖ means visual inspection indicated high sensitivity to coastal erosion or inundation.
4. Adaptive capacity identifies most feasible options. Other options may be considered.
5. Asset risk based on Risk Evaluation (Phase 3) and is based on asset cost (consequence) and asset exposure (likelihood).
6. There is not sufficient beach survey and design information to quantitatively assess the sensitivity of individual assets to coastal erosion or inundation.
For example, the sensitivity of beach access stairs to erosion requires regular beach survey and design details including the depth of vertical supports.
7. The vulnerability of individual assets, as defined, cannot presently be assessed with confidence due to limited information on their sensitivity to erosion/inundation.
This could however be assessed at a project scale where beach survey and design information is collected or collated.



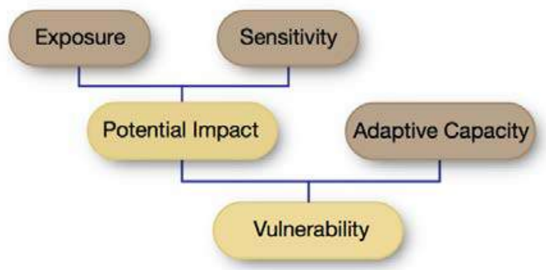
Vulnerability Assessment Flowchart (CHRMAP Guidelines)

Risk Management and Adaptation Hierarchy (CHRMAP Guidelines)

Gnarabup - Risk Management and Adaptation

ID	Coastal Type	Coastal Node	Asset □ype	Description	Exposure	Sensitivity: Coastal Erosion	Sensitivity: Coastal Inundation	Potential Impact	Adaptive Capacity: Avoid	Adaptive Capacity: Managed Retreat	Adaptive Capacity: Accommodate	Adaptive Capacity: Protect	Asset Risk	Risk Management and Adaptation Options
GN□1	Sandy Coast	Gnarabup Beach	Coastal stairs and platforms	Coastal stairs (timber) and platforms for beach access.	High	✖✖		1) Increased erosion adjacent to lower stair. 2) Exposure of footings for timber supports of stairs and platforms and reduced support for structure 3) Erosion behind approach to stairs. 4) Potential collapse/failure of stairs.	☑	☑	☑		High	A) Ongoing monitoring and management of fall distance from lower stair to beach. B) Adaptation of stairs to reduce frequency of large fall distances (i.e. stair extensions). C) Ongoing structural inspections of stairs, platforms and supports. D) Longer term planning to consider relocation and consolidation of beach access points in this location, and range of available beach access systems.
GN□1	Sandy Coast	Gnarabup Beach	Carparks	Coastal carpark (general parking and boat ramp parking and access)	High	✖		1) Slope instability associated with toe erosion of dune due to increase in MSL and variable climatic conditions. 2) Exposure of seaward edge of carpark and paths to slope instability.		☑		☑	Very High	A) Detailed survey of Prevelly / Gnarabup beach and dunes B) Ongoing monitoring of beach behaviour (photo monitoring / beach profiles) C) Planning to consider feasibility of relocating seaward edge of carpark to within medium vulnerability areas, and providing greater capacity for overflow parking on Ocean View road.
GN□1	Sandy Coast	Gnarabup Beach	Buildings	White Elephant café and associated public change rooms	High	✖		1) Slope instability associated with toe erosion of dune due to increase in MSL and variable climatic conditions. 2) Exposure of seaward edge of buildings to slope instability. 3) Exposure of footings for timber supports of decking and reduced support for structure		☑	☑	☑	Very High	A) Survey and monitoring (as above). B) Design of long term adaptation solutions for building (refer coastal engineering report)
GN□1	Sandy Coast	Gnarabup Beach	Public Marine Structures	Piled concrete boat ramp and associated finger jetty.	High	✖	✖	1) Jetty inundated during higher tides due to increase in MSL. 2) Jetty and ramp damage due to increase exposure to waves. 3) Exposure of jetty piles and reduced support for structure 4) Reduction in frequency of safe launching conditions.		☑			High	A) Inspect and maintain public marine structures to required standards. B) Design jetty deck level to accommodate future sea level rise at time of replacement or major maintenance. C) Monitor wave exposure in terms of safe launching conditions.
GN□2	Weakly Lithified Sedimentary Rock Coast	Gnarabup Headland	Coastal stairs and platforms	Coastal stairs (timber) and platforms for beach access.	High	✖		1) Slope instability associated with toe erosion of weakly lithified limestone coast due to increase in MSL and variable climatic conditions. 2) Exposure of footings for timber supports of stairs and platforms and reduced support for structure 3) Potential collapse/failure of stairs.			☑		High	A) Geotechnical inspection of limestone cliff stability in area of access stairs and lookout (Immediate Priority). B) Ongoing structural inspections of stairs and lookouts
GN□4	Weakly Lithified Sedimentary Rock Coast	Grunters Beach	Coastal stairs and platforms	Coastal stairs (composite) and platforms for beach access.	High	✖		1) Increased erosion adjacent to lower stair. 2) Exposure of footings for timber supports of stairs and platforms and reduced support for structure. 3) Potential collapse/failure of stairs.			☑		High	A) Ongoing monitoring and management of fall distance from lower stair to beach. B) Adaptation of stairs to reduce frequency of large fall distances (i.e. stair extensions). C) Ongoing structural inspections of stairs, platforms and supports and durability of composite materials

Notes:
1. Asset exposure based on Risk Analysis (Phase 2). High exposure means assets within 10yr coastal processes zone.
2. ✖ means coastal asset in sensitive to coastal erosion or inundation
3. ✖✖ means visual inspection indicated high sensitivity to coastal erosion or inundation.
4. Adaptive capacity identifies most feasible options. Other options may be considered.
5. Asset risk based on Risk Evaluation (Phase 3) and is based on asset cost (consequence) and asset exposure (likelihood).
6. There is not sufficient beach survey and design information to quantitatively assess the sensitivity of individual assets to coastal erosion or inundation.
For example, the sensitivity of beach access stairs to erosion requires regular beach survey and design details including the depth of vertical supports.
7. The vulnerability of individual assets, as defined, cannot presently be assessed with confidence due to limited information on their sensitivity to erosion/inundation.
This could however be assessed at a project scale where beach survey and design information is collected or collated.



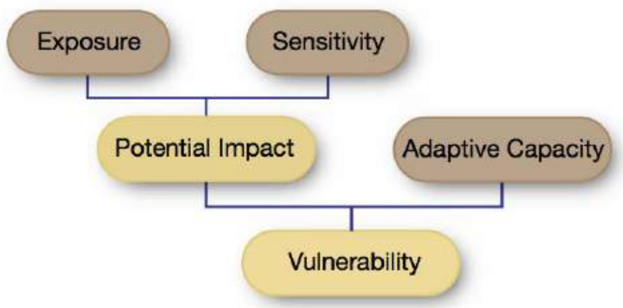
Vulnerability Assessment Flowchart (CHRMAP Guidelines)

Risk Management and Adaptation Hierarchy (CHRMAP Guidelines)

Hamelin Bay - Risk Management and Adaptation

ID	Coastal Type	Coastal Node	Asset □ype	Description	Exposure	Sensitivity: Coastal Erosion	Sensitivity: Coastal Inundation	Potential Impact	Adaptive Capacity: Avoid	Adaptive Capacity: Managed Retreat	Adaptive Capacity: Accommodate	Adaptive Capacity: Protect	Asset Risk	Risk Management and Adaptation Options
HB□1	Sandy Coast	Hamelin Bay Caravan Park	Coastal stairs and platforms	Coastal stairs (timber) and platforms for beach access.	High	✖		1) Increased erosion adjacent to lower stair. 2) Exposure of footings for timber supports of stairs and platforms and reduced support for structure. 3) Potential collapse / failure of stairs.	☑	☑	☑		High	A) Ongoing monitoring and management of fall distance from lower stair to beach. B) Ongoing structural inspections of stairs, platforms and supports.
HB□1	Sandy Coast	Hamelin Bay Caravan Park	Carparks	Coastal carpark (general parking and boat ramp parking and access)	High	✖	✖	1) Slope instability associated with toe erosion of dune due to increase in MSL and variable climatic conditions. 2) Exposure of seaward edge of carpark and paths to slope instability.		☑		☑	High	A) Monitoring and inspection of buried limestone rock seawall that provides erosion protection to carpark
HB□1	Sandy Coast	Hamelin Bay Caravan Park	Public Marine Structures	Piled concrete boat ramp.	High	✖	✖	1) Jetty inundated during higher tides due to increase in MSL. 2) Jetty and ramp damage due to increase exposure to waves. 3) Reduction in frequency of safe launching conditions.		☑	☑	☑	High	A) Inspect and maintain public marine structures to required standards. B) Design jetty deck level to accommodate future sea level rise at time of replacement or major maintenance. C) Monitor wave exposure in terms of safe launching conditions.

Notes:
1. Asset exposure based on Risk Analysis (Phase 2). High exposure means assets within 10yr coastal processes zone.
2. ✖ means coastal asset in sensitive to coastal erosion or inundation
3. ✖✖ means visual inspection indicated high sensitivity to coastal erosion or inundation.
4. Adaptive capacity identifies most feasible options. Other options may be considered.
5. Asset risk based on Risk Evaluation (Phase 3) and is based on asset cost (consequence) and asset exposure (likelihood).
6. There is not sufficient beach survey and design information to quantitatively assess the sensitivity of individual assets to coastal erosion or inundation.
For example, the sensitivity of beach access stairs to erosion requires regular beach survey and design details including the depth of vertical supports.
7. The vulnerability of individual assets, as defined, cannot presently be assessed with confidence due to limited information on their sensitivity to erosion/inundation.
This could however be assessed at a project scale where beach survey and design information is collected or collated.



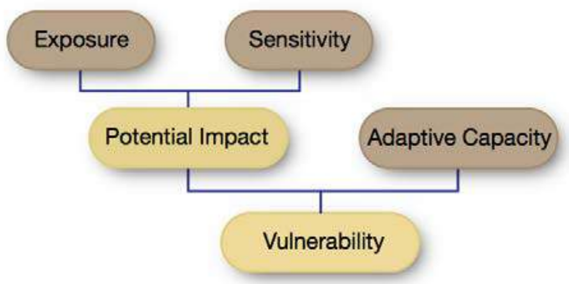
Vulnerability Assessment Flowchart (CHRMAP Guidelines)

Risk Management and Adaptation Hierarchy (CHRMAP Guidelines)

Molloy Island - Risk Management and Adaptation

ID	Coastal Type	Coastal Node	Asset □ype	Description	Exposure	Sensitivity: Coastal Erosion	Sensitivity: Coastal Inundation	Potential Impact	Adaptive Capacity: Avoid	Adaptive Capacity: Managed Retreat	Adaptive Capacity: Accommodate	Adaptive Capacity: Protect	Asset Risk	Risk Management and Adaptation Options
MI□1	Tidal Reaches of Inland Waters	Western Foreshore - Blackwood River	Buildings	Molloy Island ferry and associated infrastructure	High		✖	1) Increased frequency and depth of inundation of ferry infrastructure.		☑	☑	☑	Very High	A) Gradual relocation of main ferry infrastructure higher on the approach ramps (as presently occurs seasonally), or increasing resilience to inundation. B) Design ferry infrastructure to accommodate future sea level rise at time of replacement or major maintenance.
MI□1	Tidal Reaches of Inland Waters	Western Foreshore - Blackwood River	Public Marine Structures	Concrete boat ramp and associated timber jetty.	High	✖	✖	1) Jetty inundated during higher tides due to increase in MSL. 2) Damage to jetty.			☑		High	A) Inspect and maintain public marine structures to required standards. B) Design jetty deck level to accommodate future sea level rise at time of replacement or major maintenance. C) Monitor wave exposure in terms of safe launching.
MI□1	Tidal Reaches of Inland Waters	Western Foreshore - Blackwood River	Private Residential Property	Residential property with buildings footprint within DoW 100yr Floodway and Fringe Line	High		✖	1) Increased frequency and depth of inundation of residential buildings due to increased MSL		☑	☑	☑	Very High	A) Detail survey and confirmation of inundation risk with DoW. B) Inform residents of flooding risk. C) Consider adaptation options at time of redevelopment (e.g. minimum floor levels). D) Consider Blackwood River flood modelling under SLR scenarios.
MI□2	Tidal Reaches of Inland Waters	Channel	Private Jetties	Small private timber jetties.	High	✖	✖	1) Jetty inundated during higher tides due to increase in MSL.2) Damage to jetty.			☑		High	A) Jetty licensees to maintain private marine structures to required standards. B) Design jetty deck level to accommodate future sea level rise at time of replacement or major maintenance.
MI□4	Tidal Reaches of Inland Waters	Eastern Foreshore - Scott River	Private Residential Property	Residential property with buildings footprint within DoW 100yr Floodway and Fringe Line	High		✖	1) Increased frequency and depth of inundation of residential buildings due to increased MSL		☑	☑	☑	Very High	A) Detail survey and confirmation of inundation risk with DoW. B) Inform residents of flooding risk. C) Consider adaptation options at time of redevelopment (e.g. minimum floor levels). D) Consider Blackwood River flood modelling under SLR scenarios.

Notes:
1. Asset exposure based on Risk Analysis (Phase 2). High exposure means assets within 10yr coastal processes zone.
2. ✖ means coastal asset in sensitive to coastal erosion or inundation
3. ✖✖ means visual inspection indicated high sensitivity to coastal erosion or inundation.
4. Adaptive capacity identifies most feasible options. Other options may be considered.
5. Asset risk based on Risk Evaluation (Phase 3) and is based on asset cost (consequence) and asset exposure (likelihood).
6. There is not sufficient beach survey and design information to quantitatively assess the sensitivity of individual assets to coastal erosion or inundation.
For example, the sensitivity of beach access stairs to erosion requires regular beach survey and design details including the depth of vertical supports.
7. The vulnerability of individual assets, as defined, cannot presently be assessed with confidence due to limited information on their sensitivity to erosion/inundation.
This could however be assessed at a project scale where beach survey and design information is collected or collated.



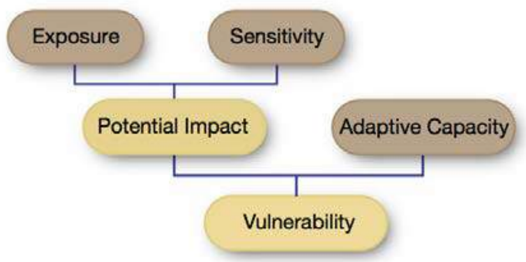
Vulnerability Assessment Flowchart (CHRMAP Guidelines)

Risk Management and Adaptation Hierarchy (CHRMAP Guidelines)

Augusta North - Risk Management and Adaptation

ID	Coastal Type	Coastal Node	Asset Type	Description	Exposure	Sensitivity: Coastal Erosion	Sensitivity: Coastal Inundation	Potential Impact	Adaptive Capacity: Avoid	Adaptive Capacity: Managed Retreat	Adaptive Capacity: Accommodate	Adaptive Capacity: Protect	Asset Risk	Risk Management and Adaptation Options
AN-1	Tidal Reaches of Inland Waters	Colour Patch	Coastal Walkways	Coastal walkways along Blackwood River foreshore.	High	✖	✖	1) Increased frequency and depth of inundation of coastal walkways 2) Exposure of seaward edge of coastal walkway to slope instability due to foreshore erosion.		☑	☑	☑	High	A) Inspect and monitor coastal walkways. B) Design coastal walkway to accommodate future sea level rise at time of replacement or major maintenance.
AN-1	Tidal Reaches of Inland Waters	Colour Patch	Public Marine Structures	Public timber jetty	High		✖				☑		High	A) Inspect and maintain public marine structures to required standards. B) Design jetty deck level to accommodate future sea level rise at time of replacement or major maintenance.
AN-2	Tidal Reaches of Inland Waters	Turner Caravan Park	Coastal Walkways	Coastal walkways along Blackwood River foreshore.	High	✖	✖	1) Increased frequency and depth of inundation of coastal walkways 2) Exposure of seaward edge of coastal walkway to slope instability due to foreshore erosion.		☑	☑	☑	High	A) Inspect and monitor coastal walkways. B) Design coastal walkway to accommodate future sea level rise at time of replacement or major maintenance.
AN-2	Tidal Reaches of Inland Waters	Turner Caravan Park	Public Marine Structures	Public timber jetty	High		✖	1) Jetty inundated during higher tides due to increase in MSL .2) Damage to jetty.			☑		High	A) Inspect and maintain public marine structures to required standards. B) Design jetty deck level to accommodate future sea level rise at time of replacement or major maintenance.
AN-2	Tidal Reaches of Inland Waters	Turner Caravan Park	Private Jetties	Small private timber jetties.	High		✖	1) Jetty inundated during higher tides due to increase in MSL. 2) Damage to jetty.			☑		High	A) Jetty licensees to maintain private marine structures to required standards. B) Design jetty deck level to accommodate future sea level rise at time of replacement or major maintenance.
AN-2	Tidal Reaches of Inland Waters	Turner Caravan Park	Caravan Park	Turner Street Caravan Park	Med		✖	1) Increased frequency and depth of inundation of campsites and buildings due to increased MSL		☑	☑	☑	High	A) Detail survey and confirmation of inundation risk with DoW. B) Inform park lessees of flooding risk. C) Consider adaptation options at time of redevelopment (e.g. minimum floor levels or location of buildings). D) Consider Blackwood River flood modelling under SLR scenarios.
AN-3	Tidal Reaches of Inland Waters	Ellis St St South	Public Marine Structures	Ellis St Street boat ramp, jetties and general marine facilities.	High	✖	✖	1) Jetty inundated during higher tides due to increase in MSL. 2) Exposure of land based facilities to slope instability due to foreshore erosion. 3) Damage to jetties.			☑	☑	Very High	A) Inspect and maintain public marine structures to required standards. B) Design jetty deck level and new marine structures to accommodate future sea level rise at time of replacement or major maintenance.
AN-3	Tidal Reaches of Inland Waters	Ellis St St South	Private Residential Property	Residential property with buildings footprint within DoW 100yr Floodway and Fringe Line	High		✖	1) Increased frequency and depth of inundation of residential buildings due to increased MSL		☑	☑	☑	Very High	A) Detail survey and confirmation of inundation risk with DoW. B) Inform residents of flooding risk. C) Consider adaptation options at time of redevelopment (e.g. minimum floor levels). D) Consider Blackwood River flood modelling under SLR scenarios.
AN-3	Tidal Reaches of Inland Waters	Ellis St St South	Private Jetties	Small private timber jetties.	High		✖	1) Jetty inundated during higher tides due to increase in MSL.2) Damage to jetty.			☑		High	A) Jetty licensees to maintain private marine structures to required standards. B) Design jetty deck level to accommodate future sea level rise at time of replacement or major maintenance.
AN-4	Tidal Reaches of Inland Waters	St North	Private Jetties	Small private timber jetties.	High		✖	1) Jetty inundated during higher tides due to increase in MSL.2) Damage to jetty.			☑		High	A) Jetty licensees to maintain private marine structures to required standards. B) Design jetty deck level to accommodate future sea level rise at time of replacement or major maintenance.

Notes:
1. Asset exposure based on Risk Analysis (Phase 2). High exposure means assets within 10yr coastal processes zone.
2. ✖ means coastal asset in sensitive to coastal erosion or inundation
3. ✖✖ means visual inspection indicated high sensitivity to coastal erosion or inundation.
4. Adaptive capacity identifies most feasible options. Other options may be considered.
5. Asset risk based on Risk Evaluation (Phase 3) and is based on asset cost (consequence) and asset exposure (likelihood).
6. There is not sufficient beach survey and design information to quantitatively assess the sensitivity of individual assets to coastal erosion or inundation.
For example, the sensitivity of beach access stairs to erosion requires regular beach survey and design details including the depth of vertical supports.
7. The vulnerability of individual assets, as defined, cannot presently be assessed with confidence due to limited information on their sensitivity to erosion/inundation.
This could however be assessed at a project scale where beach survey and design information is collected or collated.



Vulnerability Assessment Flowchart (CHRMAP Guidelines)

Risk Management and Adaptation Hierarchy (CHRMAP Guidelines)

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Augusta South - Risk Management and Adaptation

ID	Coastal Type	Coastal Node	Asset □ype	Description	Exposure	Sensitivity: Coastal Erosion	Sensitivity: Coastal Inundation	Potential Impact	Adaptive Capacity: Avoid	Adaptive Capacity: Managed Retreat	Adaptive Capacity: Accommodate	Adaptive Capacity: Protect	Asset Risk	Risk Management and Adaptation Options
AS□1	Sandy Coast	Albany Terrace - Blackwood River Cut	Roads and Adjacent Paths	Albany Terrace between the Cut and Trigg St	High	✖✖	✖	1) Slope instability associated with toe erosion of dune due to increase in MSL and variable climatic conditions. 2) Exposure of seaward edge of road to slope instability.		☑		☑	Very High	A) Detailed survey of Flinders Bay beach and dunes B) Ongoing monitoring of beach behaviour (photo monitoring / beach profiles), in particular Blackwood River cut migration C) Planning to consider feasibility of relocating road to within medium vulnerability areas.
AS□1	Sandy Coast	Albany Terrace - Blackwood River Cut	Coastal Walkways	Concrete foreshore path along Albany Terrace to Trigg St	High	✖		1) Slope instability associated with toe erosion of dune due to increase in MSL and variable climatic conditions. 2) Exposure of seaward edge of paths to slope instability.		☑		☑	High	A) Survey and monitoring (as above).
AS□3	Sandy Coast	Albany Terrace - Sandy Coast	Roads and Adjacent Paths	Albany Terrace between rocky coast and caravan park.	High	✖✖	✖	1) Slope instability associated with toe erosion of dune due to increase in MSL and variable climatic conditions. 2) Exposure of seaward edge of road to slope instability.		☑		☑	High	A) Survey and monitoring (as above). B) Planning to consider feasibility of relocating road to within medium vulnerability areas.
AS□5	Sandy Coast / Rocky Coast	Flinders Bay	Coastal stairs and platforms	Coastal access stairs and viewing platforms.	High	✖		1) Exposure of footings for timber supports of stairs and platforms and reduced support for structure 2) Erosion behind approach to stairs. 3) Potential collapse/failure of stairs.		☑	☑	☑	High	A) Ongoing monitoring and management of fall distance from lower stair to beach. B) Ongoing structural inspections of stairs, platforms and supports.
AS□5	Sandy Coast / Rocky Coast	Flinders Bay	Roads and Adjacent Paths	Beach access roads off Davies Road at Flinders swimming beach,	Med	✖		1) Slope instability associated with toe erosion of dune due to increase in MSL and variable climatic conditions. 2) Exposure of seaward edge of road and adjacent paths to slope instability.		☑		☑	High	A) Survey and monitoring (as above). B) Planning to consider layout of roads and car parking following decommissioning of the boat ramp.
AS□5	Sandy Coast / Rocky Coast	Flinders Bay	Public Marine Structures	Decommissioned concrete boat ramp and associated timber jetties.	High	✖	✖	1) Jetties inundated during higher tides due to increase in MSL. 2) Jetty damage due to increase exposure to waves.			☑		High	A) Inspect and maintain public marine structures to required standards. B) Consider coastal response to removing concrete boat ramp.

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4. Adaptive capacity identifies most feasible options. Other options may be considered.
5. Asset risk based on Risk Evaluation (Phase 3) and is based on asset cost (consequence) and asset exposure (likelihood).
6. There is not sufficient beach survey and design information to quantitatively assess the sensitivity of individual assets to coastal erosion or inundation.
For example, the sensitivity of beach access stairs to erosion requires regular beach survey and design details including the depth of vertical supports.
7. The vulnerability of individual assets, as defined, cannot presently be assessed with confidence due to limited information on their sensitivity to erosion/inundation.
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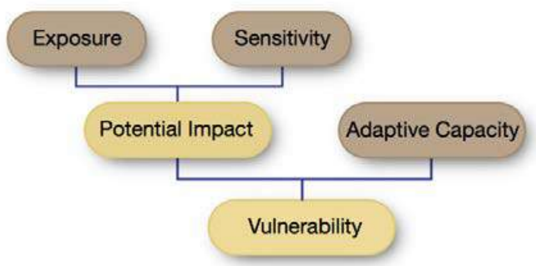

Vulnerability Assessment Flowchart (CHRMAP Guidelines)

Risk Management and Adaptation Hierarchy (CHRMAP Guidelines)