South Thomson Bay Barge Development

Coastal Hazard Risk Management and Adaptation Plan

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Coastal Hazard Risk Management and Adaptation Plan

Prepared for:

Rottnest Island Authority (RIA)
1 Mews Rd
Fremantle
WA 6160

Prepared by:

Baird Australia Pty Ltd as Trustee for the Baird Australia Unit Trust
ACN 161 683 889 | ABN 92 798 128 010

For further information, please contact
Jim Churchill at +61 8 6255 5080
jchurchill@baird.com
www.baird.com

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Executive Summary

The Rottnest Island Authority (RIA) is preparing to convert the former Army Jetty (Army Groyne) site in South Thomson Bay into a barge landing, freight handling and associated storage facility. To support the approvals process, Baird Australia (Baird) prepared a Coastal Processes Assessment report for the site (Baird 2025a) and a Dredge Plume Modelling Study (Baird 2025b).

A site-specific Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) has been prepared to provide an overview of coastal hazard at the location, identify key risks and to present the RIA with management strategies for mitigating risks. In short, the risk from erosion and inundation hazard is low and mitigation strategies for mitigating future risk for minor assets (pathways, toilet, pavilion) adopt a general managed retreat approach. The structures of the barge development will provide protection from erosion for the shorelines in the footprint. The height of the road and laydown area is at risk of inundation in extreme events (500yr ARI) and the RIA may need to consider preventing access to the road on top of the breakwaters in large storm events due to risk of wave overtopping to people.

There are projected impacts to the coastal processes at the location that will occur with the construction of the breakwater structures, notably for the eastern side of the development and the shoreline in the lee. There is a risk of sedimentation and of seagrass wrack build up along the eastern shoreline that is expected to require some form of management by RIA.

The desktop analysis in this report presents estimates of sediment and wrack volume that will build up on the eastern side of the development, forecasting approximately 800m^3 of sediment and up to 1,600m^3 of wrack that will be required to be managed on an annual basis. The removal of sediment and wrack should target the early autumn (May / June) as this is the period where natural coastal processes currently maintain the beach equilibrium through storms. This natural process of wave action on the beach to the east of the existing Army Goyne will be inhibited through the construction of the offshore breakwater.

The management and removal of the sediment is expected to be achievable through use of excavator from the shoreline. For the wrack a combination of excavator on the shore and longreach excavator from the road on top of the breakwater structure will address wrack from the landside. Over time, wrack will likely enter the deeper dredged area offshore and may cause navigation issues. As a guide based on other similar facilities in Perth with wrack issues, dredging to remove wrack buildup could be required approximately every 5 years. Following extreme storm events this could also be required.

A dedicated monitoring program to confirm the coastal processes at the site, particularly on the shoreline east of the development will be required to properly support the management of wrack and sediment. It is proposed this should start immediately (pre-construction) and be continued through the construction process and after.

The annual monitoring program will be key to informing the maintenance activities discussed in this CHRMAP for management and removal of seagrass wrack and sediment from the project area. The volumes of seagrass wrack and sediment are estimated in the CHRMAP from desktop methods and these processes will need to be carefully monitored post-construction to confirm the volumes that need to be managed annually, the timing (ie season) of management actions and method of removal as recommended in this report.

The CHRMAP presents an overview of the recommended shoreline monitoring tasks and identifies potential funding options that could be applied to support future coastal monitoring and management efforts.

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1. Introduction

1.1 Background

The Rottnest Island Authority (RIA) is preparing to convert the former Army Jetty (Army Groyne) site in South Thomson Bay into a barge landing, freight handling and associated storage facility. To support the approvals process, Baird Australia (Baird) prepared a Coastal Processes Assessment report for the site (Baird 2025a) and a Dredge Plume Modelling Study (Baird 2025b).

Following review of the referral documents for the project, the Department of Transport (DoT) recommended that a site-specific Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) be prepared for the South Thomson location. The purpose of the CHRMAP is to provide an overview of coastal hazard at the location, identify key risks and to present the RIA with management strategies for mitigating risks which include impacts from sedimentation and seagrass wrack associated with the barge development. The CHRMAP presents recommendations for shoreline monitoring post-development and identifies potential funding options for future coastal monitoring and management efforts.

1.2 Study Location

Wadjemup (Rottnest Island) is located approximately 20 kilometres west of the port of Fremantle and is an A-class nature reserve of ecological, cultural, and social significance. It is a popular tourist attraction with over 780,000 visitors to the Island annually enjoying short stay accommodation and a range of recreational activities.

Thomson Bay is located on the northeast side of the island, spanning a distance of approximately 2.5 km and sheltered from the prevailing south westerly swell conditions (Figure 1.1). The shoreline of Thomson Bay consists mainly of sandy perched beaches, with much of the beach sitting on top of rock platforms or pavements (Seashore Engineering 2019) and interspersed with rocky outcrops and limestone cliffs (Short 2005). The dunes to the east of the Army Groyne are well vegetated and sit between approx 5m and 10m high (Figure 1.2) with the dunes to the west at a similar height immediately landward of the Army Groyne (Figure 1.3) and decreasing in height along the beach towards the Main Jetty (Figure 1.4).

A coastal hazard assessment was completed for the Thomson Bay area with the inclusion of the breakwater structures for the barge development as reported in Baird (2025a). The coastal hazard assessment has been used to inform coastal processes for this CHRMAP.

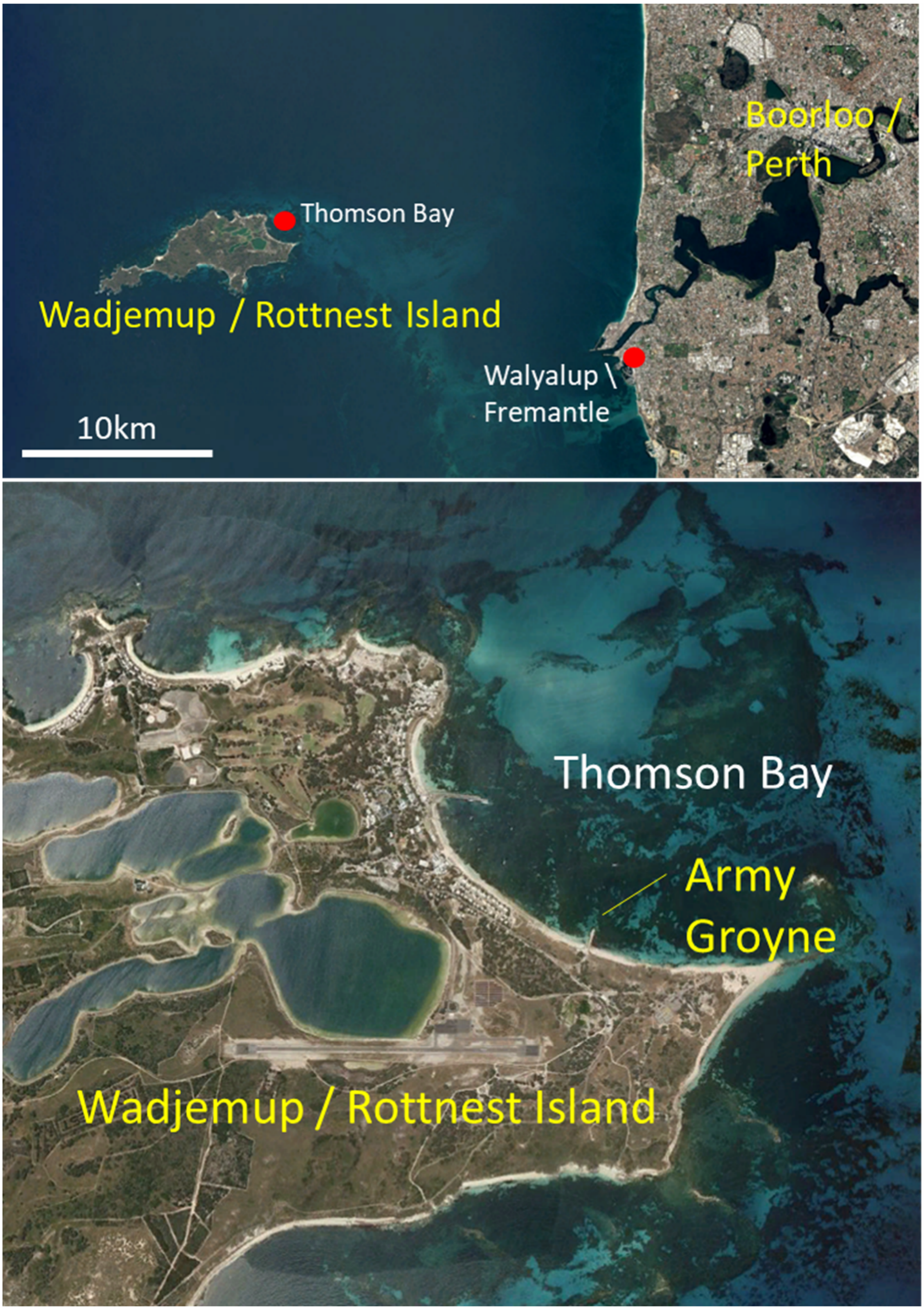


Figure 1.1: Study Area for the South Thomson Bay Barge Ramp Development project

Figure 1.2: View of the dunes backing the beach east of the Army Groyne structure.

Figure 1.3: View towards the Army Groyne structure, showing dune height east and west of the structure

Figure 1.4: View of Thomson Bay to the west of the Army Groyne structure

1.3 Barge Development Concept

The current design to convert the Army Groyne site in South Thomson Bay into a barge landing, freight handling and associated storage area has been developed by AECOM. The concept developed by AECOM in their Value Engineering of Concept Design reporting (AECOM 2020) is shown in Figure 1.5 and has been used as the basis for the Coastal Processes Report (Baird 2025a) and this CHRMAP.

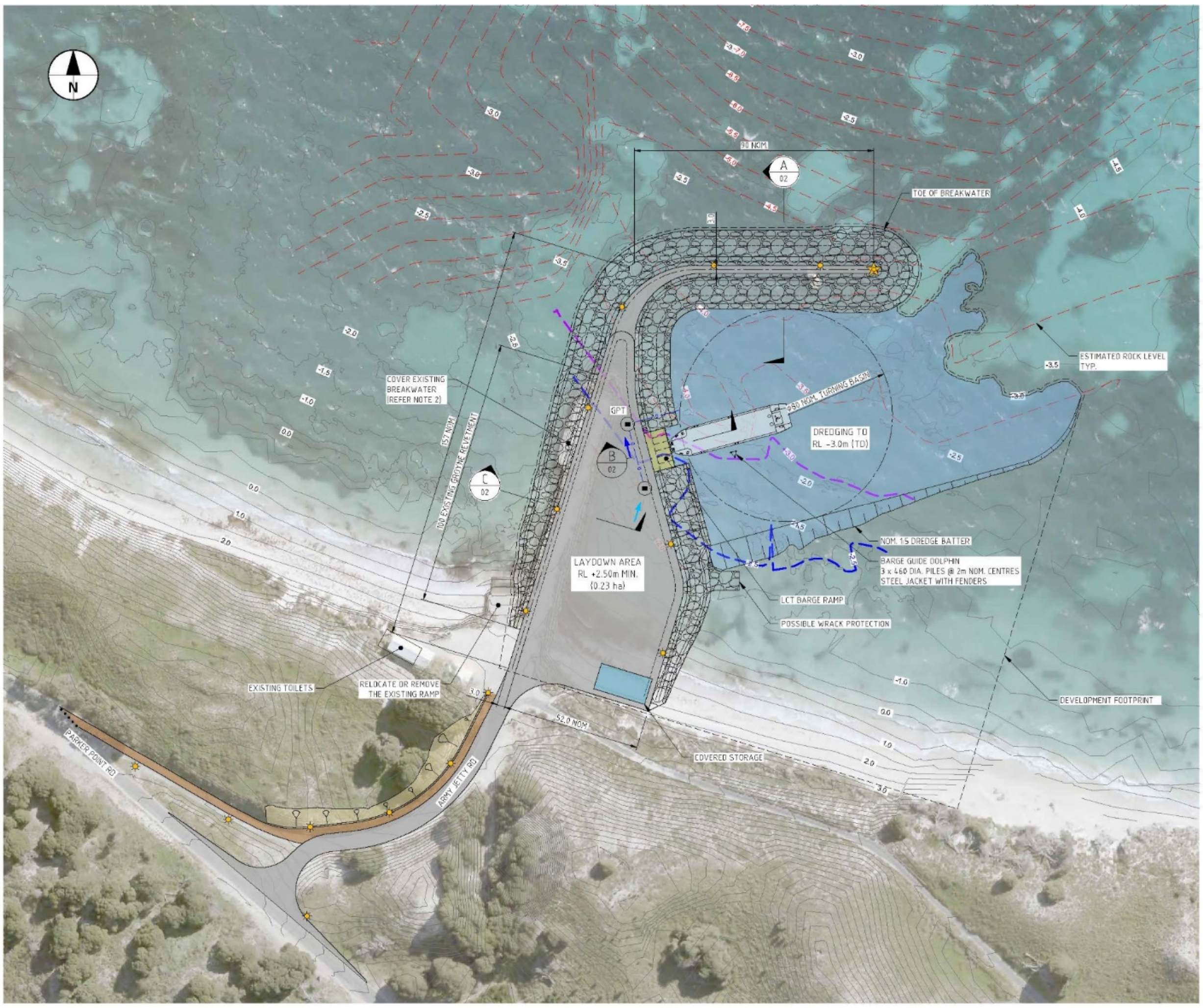


Figure 1.5: Value Engineering Concept 1 General Arrangement (AECOM 2020, RIA-2520-19180-MAR-01 RevE)

2. Coastal Hazard

2.1 Study Area

This Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) has been prepared for the Barge development site in South Thomson Bay and the shoreline areas immediately adjacent. The study area extents are shown in Figure 2.1, with the development concept overlaid.

In accordance with Western Australia's State Planning Policy 2.6 – State Coastal Planning Policy (SPP2.6), coastal areas identified as being at risk of coastal hazard require a coastal hazard risk management and adaptation plan (CHRMAP). The CHRMAP process is a risk-based approach to ensure that the coastal hazard is factored into decision-making for future planning requirements and has been established in Western Australia for the past decade, with guidelines published by the Department of Planning, Lands and Heritage (DPLH, WAPC 2019).

Figure 2.1: Study area for site specific CHRMAP of the Barge Development site. Design drawing of barge development overlaid on Aerial Image.

2.2 Previous CHRMAP Study and Coastal Hazard Summary

A CHRMAP was prepared that covers all of Rottnest Island as presented in Cardno (2023). The current site specific CHRMAP report for the Barge Development site incorporates the information from Cardno (2023) at the Army Groyne location, with updates to the coastal processes understanding based on Baird (2025a) with the incorporation of the Barge Development.

The advice from Cardno (2023) regarding calculated coastal erosion and inundation hazard for the south Thomson Bay area of this site specific CHRMAP is incorporated for consistency. Baird have considered how the breakwater structures that are planned as part of the Barge Development site will modify the coastal hazard risk (eg inundation and erosion) for the shorelines in the lee, based on analysis presented in Baird (2025a).

The key coastal hazard information is as follows:

- The beach type for the section of South Thomson Bay at the Army Groyne location as 'sandy shoreline'. A shoreline area backed by limestone to the east of the Army groyne location is treated as 'rocky shoreline'.
- The planning timeframes are adopted as present day, 2030, 2050, 2080, 2122.

The coastal erosion allowance for the shoreline is calculated from the sum of four components in accordance with SPP2.6:

- S1: The loss of beach width resulting from the impact of a storm with a 1 in 100 chance of occurring (in any given year);
- S2: The historical rate of change along the shore (i.e., accreting or eroding coast);
- S3: Response to sea level rise allowance; and
- Additional allowance for uncertainty (+ 0.2 m annually)

The coastal processes allowances (erosion setback) are summarised in Table 2.1 for the shoreline west of the groyne.

Table 2.1: Coastal Erosion Allowance (Cardno 2023, Transect 25)

Erosion	Planning Timeframe			
Component	**2030**	**2050**	**2080**	**2122**
S1	5m	5m	5m	5m
S2	1m	2m	5m	8m
S3	5m	18m	48m	94m
Uncertainty	2m	6m	12m	20m
Total	**13m**	**31m**	**70m**	**128m**

- There is a limestone outcrop along the shore approximately 170m east of the Army Groyne. This section of rocky shoreline adopts annual erosion rate of 0.05m / yr in the present day to 2080 period. The limestone does not create a barrier against erosion after 2080 timeframe due to sea level rise, resulting in significant erosion in the 2080 to 2122 timeframe consistent with a 'sandy coast' (46m).
- The total still water levels for the 500-yr storm surge inundation (S4) are adopted as discussed in Section 2.4.2.
- Coastal Assets identified in the vicinity of the Army Groyne are described in Cardno (2023) from management unit 1 (MU1) east of the Army Groyne and MU6 west of the groyne are carried into the present study. Assets identified are the South Thomson Bay Beach, South Thomson Bay Beach and Dunes, Boat Ramp, Public Toilet, Beach Pavillion with further discussion in Section 3.3.

2.3 Changes to Coastal Processes - Post Construction

2.3.1 Sediment Transport

The Thomson Bay shoreline west of the Army Groyne are not expected to experience significant changes to the coastal processes following construction of the breakwater structures (Baird 2025a). The coastal processes allowances stated in Table 2.1 remain as guidance for this section of the shoreline.

For the barge development location, the footprint of the hardstand and laydown area provides a hard barrier against erosion. The area landward is protected throughout the future planning periods and is not susceptible to erosion, providing the breakwater structures are maintained.

The presence of the breakwater structures results in modification of the shoreline processes in the lee of the structures, the shoreline connection point and the Thomson Bay shoreline on the eastern side.

In the lee of the structures, for the shoreline on the eastern side, there is expected to be changes to the existing coastal processes. This shoreline is presently supplied with sediment in the summer months with notable volume of sediment building up on the east side of the groyne through the November to March period due to wind driven longshore transport. During the autumn to winter period (April through July) storms direct wave conditions through Thomson Bay with waves from the North and North-Northeast, which serve to naturally clear the sediment buildup on the east side of the groyne and move it offshore and back along the beaches to the east. This mechanism will be inhibited once the groyne structures are in place, with wave shadowing presented in Baird (2025a) clearly indicating the reduction in wave energy for northern storms with the extended breakwater in place (Figure 2.2).

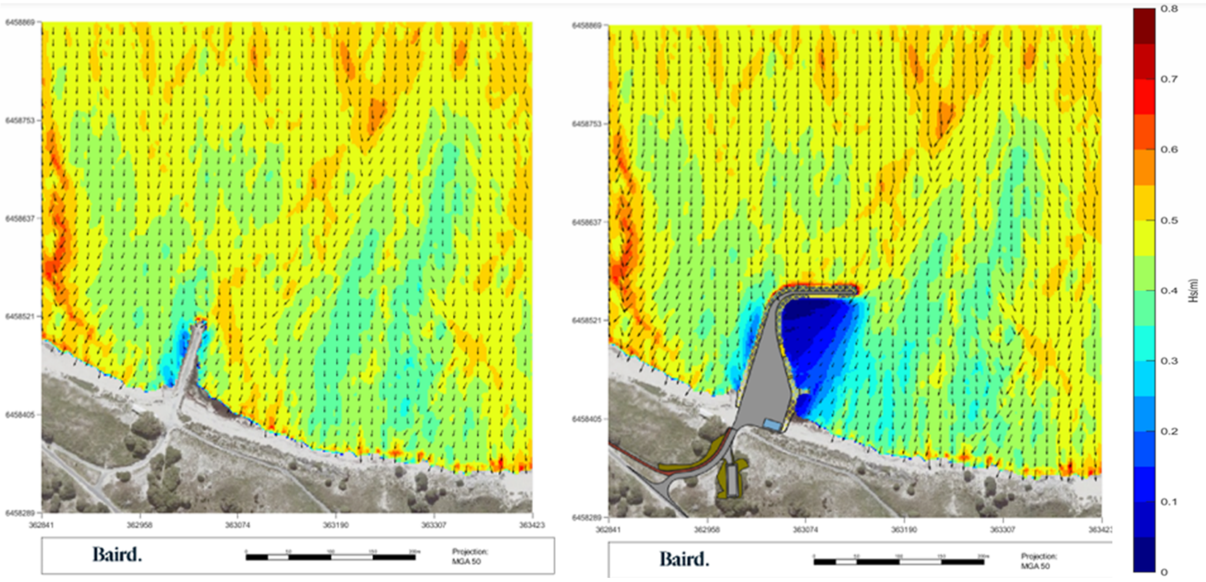
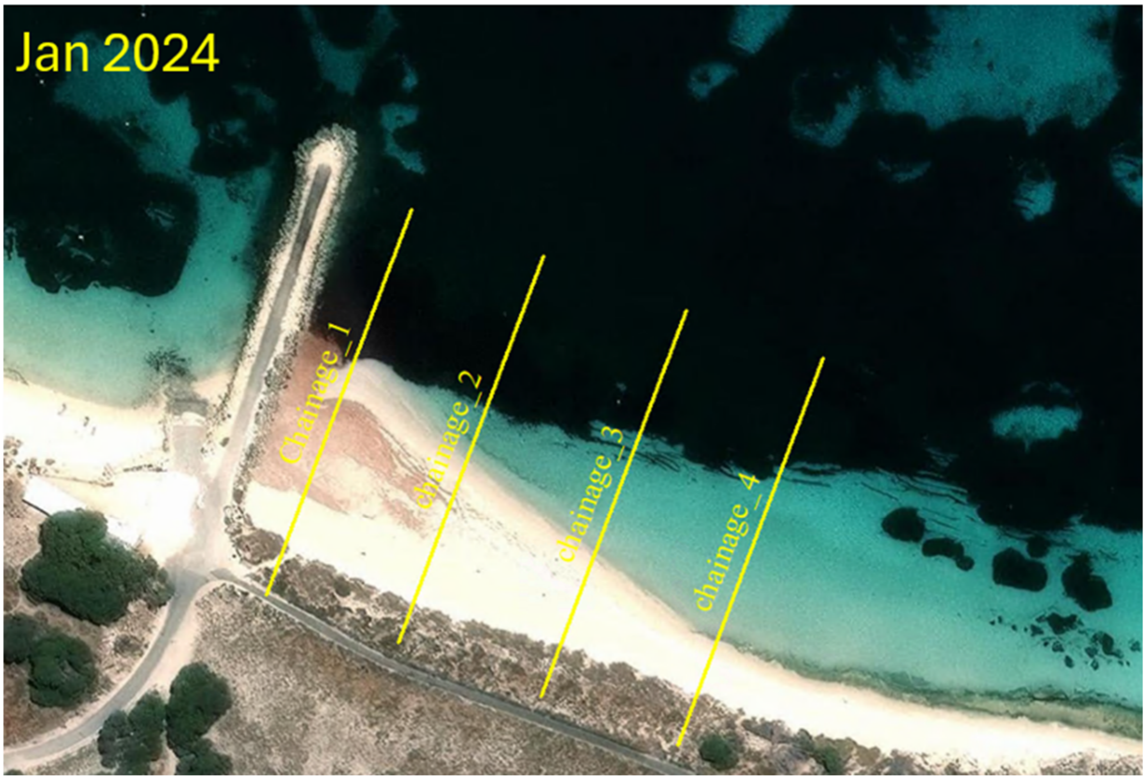


Figure 2.2: Northern swell event - wave conditions for the existing Army Groyne (left) and with the barge development breakwater structures (right)

Analysis of the shoreline position (nominally representing mean sea level) on the east of the groyne for 25 aerial images taken at various times of the year was undertaken. An estimation of the shoreline position in each respective aerial along four transects shown in Figure 2.3 was undertaken with a summary graph that shows the change over the months of the year. The shoreline position is presented relative to the shoreline position in July 2013.



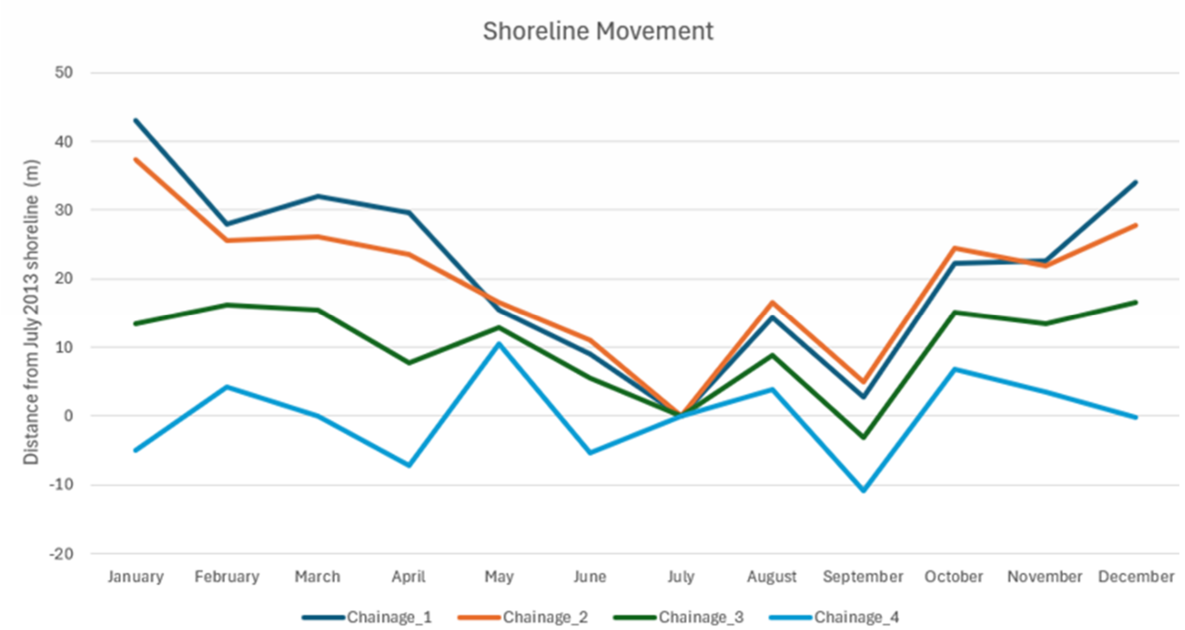


Figure 2.3: Analysis of shoreline movement in shoreline east of the Army Groyne

The coastal processes can be inferred from the analysis of shoreline changes observed in Figure 2.3 on the shoreline east of the groyne as follows:

- shoreline accretion is most active through Summer months (Dec – Mar).
- erosion of the shoreline occurs in the late autumn / early winter storms (April – June / July).
- the shoreline is eroded back to its minimum position on transects through winter months (June – Sep).

- Chainage 1 and Chainage 2 exhibit significant shoreline changes (up to +40m), with accretion rate reducing at Chainage 3 (+20m). The changes in shoreline position at Chainage 4 are much less significant with this representing a largely stable profile over the analysis (+/- 10m).

Chainage 4 is located at a distance 140m east of the present Army Groyne. If this range of influence is adopted as the potential shoreline that will experience accretion post-construction this would extend almost to the limestone rock outcrop on the eastern shoreline identified in Cardno (2022), that is assumed to be 'rocky shoreline'.

The volume of material moving east along the beach between winter and summer has been estimated based on analysis along the transects using survey elevation data from 2017. An estimate of the average sediment volume above the mean sea level that is moving to the area between the transects on the east side of the groyne from winter to summer peak is 800m^3. Note this represents the volume above mean sea level and there would be additional volume below this offshore. The sediment thickness is expected to be up to 0.5m.

In summary, the coastal processes for the shoreline east of the barge development are summarised as:

- sediment moving west under the long shore transport mechanism (approximately 800m^3) in summer months that will accrete on the shoreline along the eastern edge of the breakwater structure post-construction.
- The developed case breakwaters reduce wave energy at the shore. The present mechanism for the sediment to be naturally cleared from the eastern side of the developed structure in the autumn months by N and NE wind driven storm waves and long-shore transport will be reduced or potentially not occur at all post-construction.
- This is expected to result in continual build-up of sediment on the east side groyne in subsequent summers if no management action is undertaken.
- The shoreline on the east of the barge development is projected to experience accretion post-construction for the extent from the breakwater structure to the limestone outcrop noted in the Cardno (2023) report.

The coastal erosion allowances for the shoreline on the east side of the breakwater (in the lee), are based on Cardno (2023). This is considered very conservative, given the projection that the coastal structures are forecast to result in accretion along this section of beach. Until post-construction survey of the shorelines can verify this projected outcome, the coastal erosion allowances are adopted as stated in Table 2.2.

Table 2.2: Coastal Erosion Allowance East of Army Groyne (Transect 24)

Erosion	Planning Timeframe			
Component	**2030**	**2050**	**2080**	**2122**
S1	10m	10m	10m	10m
S2	1m	3m	6m	11m
S3	5m	18m	48m	94m
Uncertainty	2m	6m	12m	20m
Total	**18m**	**37m**	**76m**	**135m**

It is noted there is very limited historical survey data on the section of beach east of the Army Groyne to inform long-shore transport rates and confirm the seasonal changes. The above estimate has been derived using Aerial imagery interpretation. RIA should consider undertaking dedicated shoreline transect survey on this section of beach (prior to the construction of the Barge Development) to confirm the volume and seasonal nature of sediment moving across this shoreline.

2.3.2 Seagrass Wrack Movement

Similar to the analysis of the sediment transport on the east of the groyne, to quantify the volume of seagrass wrack Baird examined 25 aerial images from the site taken at various times of year.

An estimate of the wrack coverage on the shoreline east of the groyne both on land and in the nearshore area was derived from each image. Average depth of wrack was assumed as 0.35m.

The graph in Figure 2.4 presents the average volume estimate on the east side of the Army groyne. It shows that wrack is always present but seasonally the volume changes. The graph shows:

- Wrack volume builds up over the summer months (Nov - Feb) and peaks in March.
- Wrack is 'naturally cleared' from the east of the groyne through autumn / early winter under local wave conditions driven by strong N and NE winds. The wave conditions clear away the sediment build up from the east side of the groyne and resuspend / move wrack.
- The wrack volume along the east of groyne appears to be at its lowest through winter months driven by coastal processes.
- 'New' seagrass wrack from the beds offshore in Thomson Bay comes into the system thru autumn / winter.
- Wrack starts to build up again in spring (Sep, Oct, Nov) as dominant wind conditions swing to the SE and S and local wave conditions reverse to drive longshore current east along Thomson Bay.

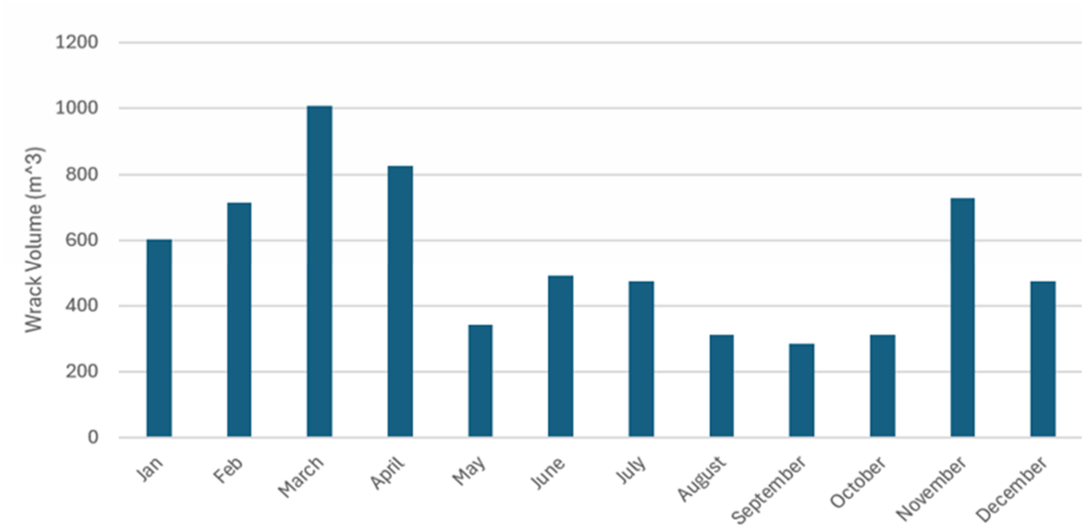


Figure 2.4: Seagrass Wrack Estimation of Volume by Month on Eastern Side of Army Groyne

Based on Figure 2.4 the average volume at the peak (based on 4 surveys in March period) is about 1,000m^3. This is largely concentrated near the eastern side of the groyne and nearshore region.

The present length of the Army groyne extends around 100m from the shoreline into Thomson Bay. Under the proposed developed case the breakwaters will project out into Thomson Bay approximately 160m. The current volume of wrack estimated for the Army groyne are increased by 60%, to account for this additional catchment potential from the extended breakwater structures.

The estimated volume of wrack that would be present on the eastern side inside the project footprint is 1,600 m^3. It is noted the present mechanism for the wrack to be naturally cleared from the eastern side of the developed structure in the autumn months by N and NE wind driven storm waves with long-shore transport will be reduced due to the extent of the breakwater structure.

The accumulation of wrack would have detrimental effects for the barge facility affecting navigation, as well as creating poor aesthetics (sight and smell). It is estimated that a volume of seagrass wrack up to 1,600m^3 will need to be removed during winter months through manual methods (eg excavator). Post-construction the RIA will need to establish monitoring and maintenance protocols to control seagrass wrack.

2.4 Coastal Hazard Mapping

2.4.1 Coastal Erosion

The hazard mapping for coastal processes in the study area is shown in Figure 2.5 for the 100-yr planning period. These erosion setback lines represent the combination of S1, S2, S3 and uncertainty across each respective planning period, for values are stated in Table 2.1 and Table 2.2 with due consideration of construction of the development footprint which provides an impediment to coastal erosion landward.

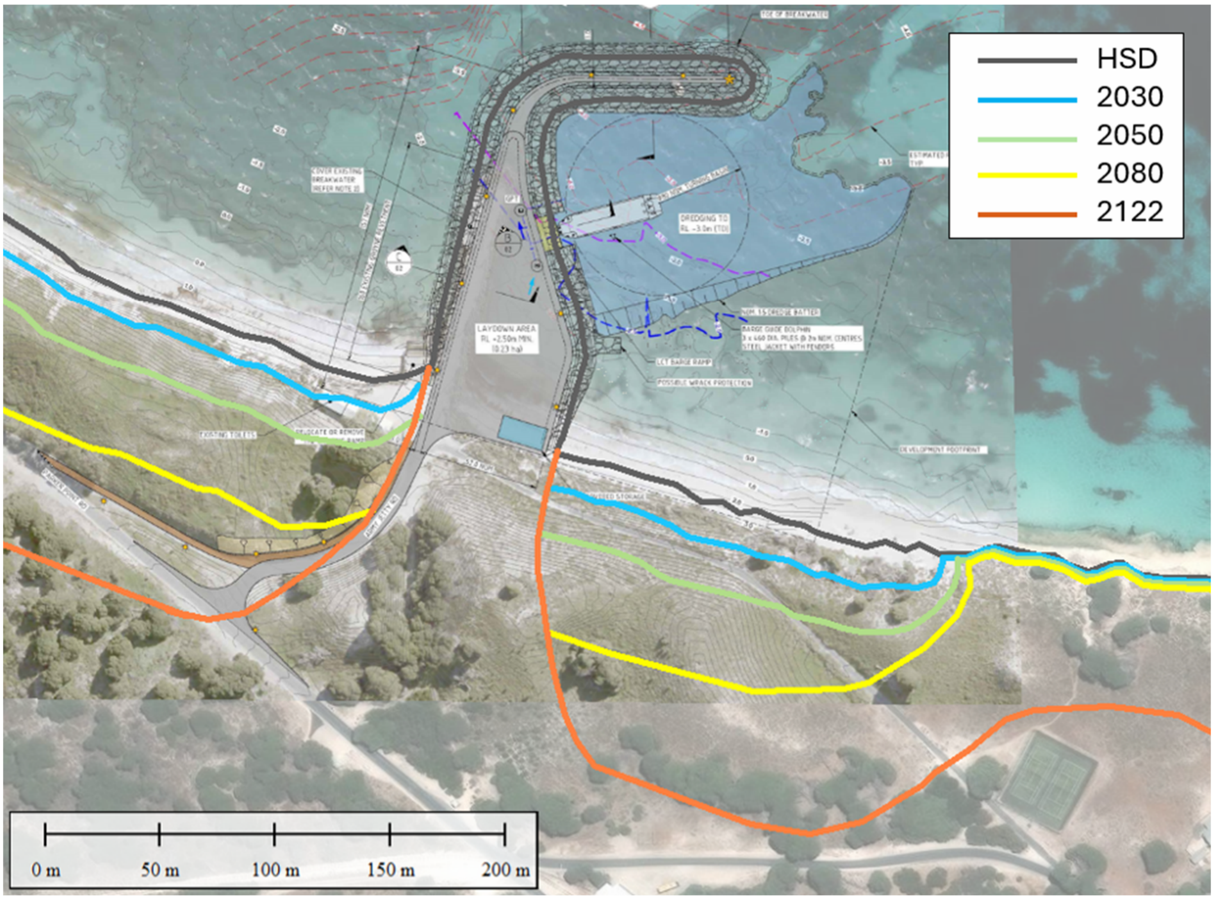


Figure 2.5: Coastal Processes Allowances for Study Site

2.4.2 Coastal Inundation

The coastal hazard from inundation is defined in SPP2.6 guidelines as the storm event that has a 0.2 percent or one-in-five hundred probability of being equaled or exceeded in any given year over the planning time frame. This is referred to as the S4 component for the coastal hazard assessment and is equivalent to a 500-yr ARI event. It is the most severe storm event that is assessed for CHRMAP.

The levels for the Thomson Bay site are summarised in Table 2.3. These include the wave setup values from Cardno (2022). They do not include wave runup effects.

Table 2.3: South Thomson Bay still water level for 500-yr storm surge level (S4)

Present Day	2030	2050	2080	2122
2.00m AHD	2.05m AHD	2.18m AHD	2.48m AHD	2.94m AHD

The LiDAR data captured over the area in 2017 was used to develop contours shown in Figure 2.6. The 2.0m AHD contour is consistent with the S4 value for the present day and the 3.0m AHD contour is representative of the S4 hazard in the year 2122.

This confirms the dunes along the shoreline in the vicinity of the barge development are at an elevation that will comfortably negate inundation flooding in large design events for the landside areas. It is noted the dune system continues landward and reaches an elevation of 5m to 10m AHD.

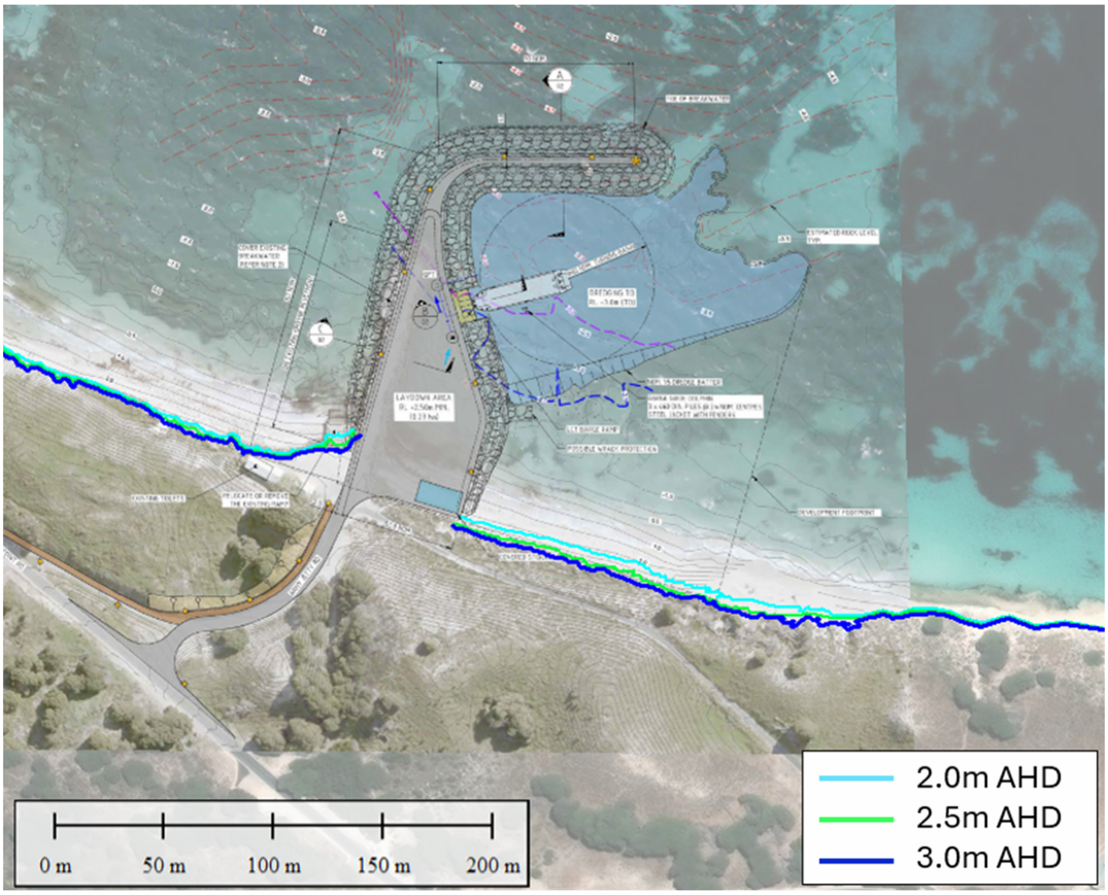


Figure 2.6: Coastal Inundation Levels across Study Site.

The cross section of the breakwater structures is shown in Figure 2.7. This indicates the road and the laydown area is established +2.5m RL, and the crest height of the rock revetments is +3.5m RL. The vertical datum (RL) is Rottnest Island Sounding datum which is 0.72m below AHD. For the road and laydown area this equates to a level of +1.8m AHD. This is below the 500yr ARI inundation level for the present day. The depth of flooding in the 500-yr event for the road and laydown areas is summarised in Table 2.4 for the 500yr ARI.

Table 2.4: Depth of Flooding for walkway and laydown areas for 500-yr storm surge level (S4)

Present Day	2030	2050	2080	2122
0.2m	0.25m	0.4m	0.7m	1.1m

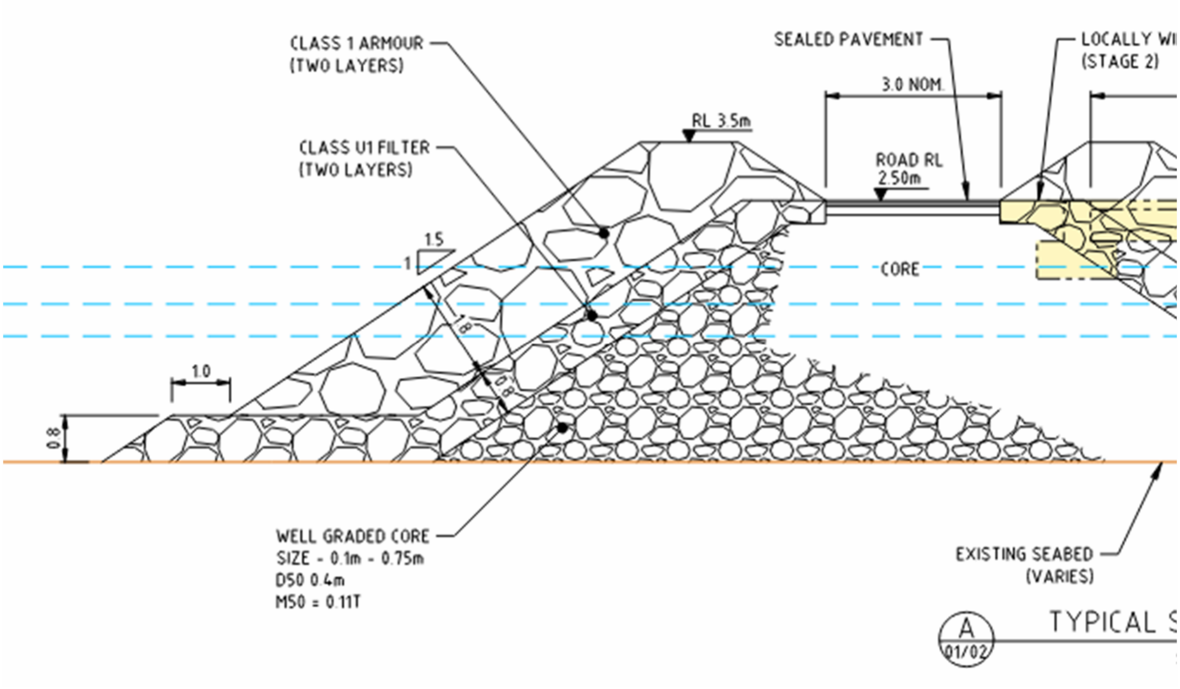


Figure 2.7: Breakwater Structure Cross Section (from Drawing RIA-2520-19180-MAR-02). The vertical datum is Rottnest Island Datum which is 0.72m below Australian Height Datum.

3. Risk Assessment

3.1 CHRMAP Framework

The CHRMAP process is a risk-based approach to ensure that the coastal hazard is factored into decision-making for future planning requirements and has been established in Western Australia for the past decade.

The key documents that guide coastal hazard assessment and coastal planning in Western Australia are:

1. State Planning Policy No. 2.6, State Coastal Planning Policy (SPP2.6, WAPC 2013); and
2. Coastal Hazard Risk Management and Adaptation Planning Guidelines (CHRMAP guidelines, WAPC 2019).

The coastal hazard summary presented in Section 2 was prepared in accordance with SPP2.6, with the coastal assets at risk of coastal hazard assessed under the coastal hazard risk management and adaptation planning (CHRMAP) guidelines.

The CHRMAP process incorporates a risk management approach to decision making in the coastal zone, which assesses the risk to assets in the coastal zone for current and future planning periods, through consideration of the likelihood and consequence of coastal hazard impact. The Risk Assessment framework in this CHRMAP is consistent with that presented in Cardno 2023.

3.2 Risk Assessment

3.2.1 Consequence scale

The consequence scale developed for RIA's island wide CHRMAP has been adopted in this site specific assessment. The Consequence scale is attached in Appendix 1 from Cardno (2023).

3.2.2 Potential Impact

The assessment of potential impact to coastal assets uses the product of the likelihood and consequence to determine a level of risk. A risk rating is developed in each planning timeframe for the assets within the study area based on the likelihood and consequence matrix in Table 3.1.

Table 3.1: Potential Impact Scale - Likelihood / Consequences matrix to assess level of risk

		CONSEQUENCE				
		Insignificant	Minor	Moderate	Major	Extreme
LIKELIHOOD	Almost Certain	Moderate	Significant	Significant	High	High
	Likely	Low	Moderate	Significant	Significant	High
	Possible	Low	Moderate	Moderate	Significant	Significant
	Unlikely	Low	Low	Moderate	Moderate	Significant
	Rare	Low	Low	Low	Low	Moderate

3.2.3 Adaptive Capacity

The concept of adaptive capacity recognises that some assets will cope with coastal hazard risk better than others. The coastal assets are rated with a consideration of how well they can recover from coastal inundation or erosion hazard, i.e. their potential to adjust to address risk arising from coastal hazards with minimal disruption and cost.

The adaptive capacity scale of the assets adopts a rating in one of three categories from worst performing ('Poor') to best performing ('Good') as shown in Table 3.2 developed from Cardno (2023).

Table 3.2: Adaptive Capacity Rating for Coastal Assets (based on Cardno 2023)

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

The potential for an asset to recover from the impact of either erosion or inundation is generally different and has been rated separately.

3.2.4 Vulnerability Scales

Using the risk level calculated in the potential impact stage the adaptive capacity of the respective assets was then considered to determine the final vulnerability rating for each of the assets (Table 3.3).

Table 3.3: Asset Vulnerability Matrix

Potential Impact	Adaptive Capacity Rating			
	Very High	High	Moderate	Low
Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Minor	Insignificant	Insignificant	Insignificant	Minor
Moderate	Insignificant	Insignificant	Minor	Moderate
Major	Insignificant	Minor	Moderate	Major
Extreme	Minor	Moderate	Major	Extreme

A vulnerability tolerance scale determines the level at which vulnerability is deemed acceptable, tolerable or intolerable. The vulnerability tolerance scale is shown in Table 3.4 is consistent with Cardno (2023) and used to identify which risk, locations, assets and values require risk management measures as a priority.

Table 3.4: Vulnerability Tolerance Scale

Risk Level	Action Required	Acceptance / Tolerance
High	Significant further adaptation required to ensure impact to asset is avoided. Reconsideration of design / locationif vulnerability cannot be reduced.	Unacceptable
Significant	Further adaption required. All stakefolders should be fully aware of the risks if vulnerability cannot be reduced.	Tolerable / Unacceptable
Moderate	Further adaptation should be investigated, acceptable in certain circumstances. Monitoring programs recommended.	Tolerable
Low	Acceptable; adaption and monitoring may be required over the asset's lifetime.	Tolerable / Acceptable

3.3 Risk Evaluation

The coastal assets and erosion risk ratings are presented in Table 3.5. Ratings have been determined based on the approach outlined in Section 3. The risk ratings for assets previously determined in Cardno (2023) are included.

Table 3.5: Risk Rating - Erosion

		2022	2030	2050	2080	2122
Asset ID	Description	Erosion Risk Rating				
C10-03	South Thomson Beach	Mod	Sig	High	High	High
C10-04	Beach and Dune Vegetation	Mod	Mod	Sig	High	High
C10-38	Public Toilet	Low	Low	Mod	Sig	Sig
C10-39	Pavillion	Low	Low	Mod	Mod	Sig
C10-40	Boat Ramp	Low	Low	Mod	Mod	Sig
B1	Coastal Pathways	Low	Mod	Sig	High	High
B2	Army Jetty Road	Low	Low	Mod	Sig	High
B3	Development Laydown Area	Low	Low	Low	Low	Low
B4	Development Road	Low	Low	Low	Low	Low

The inundation risk is low (non-existent) for all assets on the landside due to the natural elevation of the dunes on the shoreline (refer Figure 2.6). The barge development levels are below the 500yr ARI level (S4) as shown in Table 2.4. The risk of inundation is considered low for the current and 2030 timeframe, with future ratings increasing to moderate (2050, 2080) and significant (2122) due to the depth of inundation.

There is a risk of wave overtopping for the offshore sections of the breakwater which will increase in future periods in extreme storms. The RIA should manage this risk through signage and / or lockable gates that prevent access to the road in extreme storm events.

Table 3.6: Risk Rating - Inundation

		2022	2030	2050	2080	2122
Asset ID	Description	Erosion Risk Rating				
C10-03	South Thomson Beach	Low	Low	Low	Low	Low
C10-04	Beach and Dune Vegetation	Low	Low	Low	Low	Low
C10-38	Public Toilet	Low	Low	Low	Low	Low
C10-39	Pavillion	Low	Low	Low	Low	Low
C10-40	Boat Ramp	Low	Low	Low	Low	Low
B1	Coastal Pathways	Low	Low	Low	Low	Low
B2	Army Jetty Road	Low	Low	Low	Low	Low
B3	Development Laydown Area	Low	Low	Mod	Mod	Sig
B4	Development Road	Low	Low	Mod	Mod	Sig

4. Risk Treatment

4.1 Risk Treatment and Adaptation Hierachy

The Risk Treatment options that are considered in this CHRMAP have been developed from a range of sources. The key guidance comes from the CHRMAP guidelines (WAPC 2019) which describes the general risk treatment categories in a risk treatment and adaptation hierarchy.

The hierarchy was developed on the principal of maintaining flexibility for decision makers in the future. The management approaches at the top of the list allow greater flexibility for decision makers in future (eg Avoid), whilst options further down the list in the hierarchy moving towards the final option of Protect limit the future decision-making options available.

The categories in brief are described as follows from highest to lowest management categories:

1. **Avoid**: this approach is to simply avoid new development in areas at risk of coastal hazard. This approach is only applicable to locations where development has not commenced; The aim of this risk treatment option is to avoid the construction of new public and private assets within areas identified to be impacted by coastal hazards. Avoidance risk treatment options are the best form of risk management (mitigation) and where possible should be the risk treatment option of choice (WAPC 2019). Avoidance is particularly applicable to all land use and development in greenfield locations.

2. **Planned or Managed Retreat**: the concept of planned or managed retreat allows existing public assets and private property to remain in place until such time as coastal hazard from erosion or inundation is untenable. Planned or managed retreat for existing development involves relocating or sacrificing infrastructure, both public assets and private property, when erosion and recession impacts reach action trigger points. Under this option the use of temporary coastal protection structures and/or restoration of natural controls such as dunes and shoreline areas is supported to maintain or create a buffer against storm erosion. As existing assets reach the end of their functional life (or if they are substantially damaged by a storm event), they would be removed, including any associated coastal protection structures.

3. **Accommodate**: The accommodate risk treatment option aims to utilise design and management strategies which render the risks as tolerable/acceptable, allowing land to continue to be utilised until risks become intolerable. Design and management strategies may include a mix of structural or non-structural approaches. Structural approaches include minimum finished floor levels and elevated electrical circuitry, and relocatable structures which can be moved to a different location on- or off-site to manage risk arising from inundation coastal hazards. Non-structural approaches such as modifications to local planning frameworks (eg inclusion of a special control area) can also enable accommodate risk treatment options.

4. **Protect**: Protect risk treatment options aim to protect assets from damage resulting from erosion and recession and storm surge inundation. Protect risk treatment options should be primarily proposed in the public interest and enhance or preserve beach and foreshore reserve amenity. The Protect option

is only available when all other options are exhausted and should be justified in terms of the benefit it delivers to the community.

- Common hard protection structures include seawalls; groynes; offshore breakwaters and soft protection measures such as beach nourishment.
- Interim protection structures can be applied to delay shoreline recession over the short to medium term. This might be achieved through soft protection measures such as regular sand renourishment and revegetating shoreline areas.

In addition to the four main categories, additional management approaches considered in the CHRMAP are:

5. **No Regrets**

The no-regrets category is used for approaches that can improve resilience and preparedness against the impact of coastal hazards. These can be implemented where further understanding of the risk to assets is being collected or while the assessments to determine a preferred risk treatment option.

6. **Do Nothing**

The do-nothing risk treatment option assumes that all levels of risk is accepted and that no further action will be taken. This risk treatment option provides a basis for comparison of all other risk treatment options.

4.2 Adaptation Tools

A range of adaptation tools available to mitigate coastal risk applied in the CHRMAP under the key category definitions is summarised in Appendix A.2. These have been adopted from Cardno (2023) and developed from a range of sources including WAPC (2019).

5. Adaptation Pathways

5.1 Risk Management Pathway

The risk management pathways approach is used to inform decision-making at defined trigger points. The trigger points define the point at which a change in risk management approach / measure should be enacted as part of the ongoing strategic planning process.

5.2 Management Triggers

The concept of a trigger point is to have a pre-determined point that is set to 'trigger' the commencement of planning and/or implementation actions relating to a risk management option.

Triggers for the decision points are generally associated with the observation of key events on the ground rather than being time based. Estimated timeframes presented in the CHRMAP are driven by projected sea level rise impacts to inundation hazard and / or erosion of shorelines increasing the erosion hazard.

The Trigger points, Decision Making and Measures that will be applied in the risk management pathways are summarised in Appendix A.3.

The key activities that are used to monitor trigger points and inform where these are reached or close to being reached are:

- Annual Monitoring Program
  - The annual monitoring to examine changes in the shoreline areas and examine triggers for:
    - Erosion: identify the position of the shoreline (HSD) and whether this moves either landward (as a result of erosion) or seaward (as a result of accretion). This will be important for the shoreline in the lee of the structure which is anticipated to experience accretion post-construction.
    - Inundation: track the rate of sea level rise (from Fremantle tide gauge and technical studies) and on the ground impacts from extreme flooding events that occur
- Asset Management and Structure condition reporting
  - Condition reports and asset management performed by RIA to be referenced for understanding when structures need replacement or upgrade.
- Review of CHRMAP (recommended every 5 to 10 years)
  - It is recommended that the CHRMAP be reviewed and updated every five to ten years. As part of this review the following would be included:
    - The improved knowledge of coastal hazards in the shoreline areas from the annual monitoring and additional studies should be incorporated into the review and where this may impact any of the recommendations in the CHRMAP
    - The guidance on sea level rise projections by the DoT (DoT 2010) should be reviewed for any updates. Any change to the projected sea level rise allowances would require assessment of updates to the CHRMAP.
    - Review of changes in the SPP2.6 advice (WAPC 2013) or updates to the CHRMAP guidelines (WAPC 2019) would be assessed as part of the review process.
    - Assets that are predicted to become highly or very highly vulnerable within the next planning timeframe (or within 10 years) would be identified.

5.3 Adaptation Pathways

The general adaptation approach to manage the risk of coastal erosion are summarised in Table 5.1.

Table 5.1: Risk Treatment

Asset / Location	Erosion	Inundation
South Thomson Beach C10-03	Adaptation Option: Soft protect measures such as sand renourishment and/or dune maintenance to improve resilience PR1, PR2. Trigger: T7, T8, T9	Adaptation Option: Do Nothing Accept Risk. DN
Beach and Dune Vegetation C10-04	Adaptation Option: Soft protect measures such as sand renourishment and/or dune maintenance to improve resilience. PR1, PR2 Trigger: T7, T8, T9	Adaptation Option: Do Nothing Accept Risk. DN
Public Toilet C10-38	Adaptation Option: Planned or Managed Retreat in future planning periods once hazard levels are intolerable. MR1, MR2 Trigger: T2, T4, T5, T6, T7	Adaptation Option: Do Nothing Accept Risk. DN
Pavillion C10-39	Adaptation Option: Planned or Managed Retreat in future planning periods once hazard levels are intolerable. MR1, MR2 Trigger: T2, T4, T5, T6, T7	Adaptation Option: Do Nothing Accept Risk. DN
Boat Ramp C10-40	Adaptation Option: Maintain safety with repair consistent with design life. Planned or Managed Retreat in future planning periods once hazard levels are intolerable. MR1, MR2 Trigger: T2, T4, T5, T6, T7	Adaptation Option: Do Nothing Accept Risk. DN

Asset / Location	Erosion	Inundation
Coastal Pathways B1	Adaptation Option: Planned or Managed Retreat in future planning periods once hazard levels are intolerable. MR1, MR2 Trigger: T3	Adaptation Option: Do Nothing Accept Risk. DN
Army Jetty Road B2	Adaptation Option: Planned or Managed Retreat in future planning periods once hazard levels are intolerable. MR1, MR2 Trigger: T3	Adaptation Option: Do Nothing Accept Risk. DN
Development Laydown Area B3	Adaptation Option: Protected through maintenance of the built structures. PR5	Adaptation Option: For future planning periods raise level to reduce risk of flooding in large events. AC3
Development Road B4	Adaptation Option: Protected through maintenance of the built structures. PR5.	Adaptation Option: For future planning periods raise level to reduce risk of flooding in large events. AC3

As well as the adaptation approaches for identified assets, the following is recommended.

- To address potential safety issues install appropriate signage / gates to reduce access to the structures in storms.
- Avoid development in undeveloped land areas of known coastal hazard over the planning timeframe.
- Annual monitoring program to improve understanding of coastal processes and update adaptation approaches as required.

6. Management Actions

6.1 Recommended Management Actions For Seagrass Wrack.

For the management of Seagrass Wrack the following actions are recommended

1. Shoreline monitoring on the shoreline east and west of the structures for build-up of wrack post development. Can be done on a fortnightly basis by RIA personnel (field observations and photos) supported by a planned seasonal monitoring program utilising drones and / or traditional survey methods to confirm volume of wrack on the shoreline and in the lee of the structures.
2. The options for wrack removal are considered as follows:
   - Removal by mechanical means (excavator) for wrack deposited in accessible shoreline areas in the lee of the eastern side and along the eastern edge of the breakwater. Volume is likely to peak in Dec – Mar period.
   - Removal by long-reach excavator for wrack removal where wrack is in the deeper dredged section of the basin adjacent the structures. Excavator to access via the road on top of the breakwaters.
3. Wrack that enters the deeper dredged area may cause navigation issues.
   - It is noted this wrack will be redistributed by the vessels using the facility. Wrack that is resuspended by propeller action and reaches the edge of the structures has the potential to be removed by long reach excavator. The volumes of wrack that will be redistributed by vessel movement is difficult to estimate and can only be understood more clearly post-construction as part of ongoing monitoring.
   - In the offshore basin area, there is the potential for wrack to settle in the deeper dredged section of the basin, which cannot be redistributed by propeller action or natural processes (eg storms). The annual volume of wrack that will accumulate in the deeper dredge area is difficult to estimate but will be better understood post-construction as part of ongoing monitoring. There is the possibility that dredging may be required to remove this wrack. As a guide based on other similar facilities in Perth with wrack issues, dredging could be required approximately every 5 years. Following extreme storm events this could also be required. This is a guide only and timeframes will need to be informed by post-construction monitoring.
4. Disposal of wrack on-shore is currently undertaken by the RIA, with wrack used to stabilise dunes. RIA should seek to dispose of wrack onshore in this manner where possible. Offshore disposal in Thomson Bay could also be considered, noting this will require approvals to be sought.
5. The analysis presented in this report indicate the peak volume of wrack will be late summer (Feb /Mar period) and is estimated annually to be 1,600m^3 post-development.

6.2 Recommended Management Actions For Sedimentation.

For the management of sedimentation, the following actions are recommended:

1. Monitoring of east side shoreline for build-up of sediment which is projected to build up in the summer months on the eastern edge of the structures (Figure 2.3). RIA to commence fortnightly inspections (photo monitoring). And arrange for transect survey and/or drone (UAV capture) of shoreline elevation to further understand sediment volume and movement seasonally.
2. Monitoring of west side shoreline for shoreline changes (photo monitoring). There is not projected to be a change to coastal processes post-development and the beach should maintain equlibrium.
3. Post-Development the management of sedimentation is expected to be achievable through mechanical means, using an excavator on the beach to remove build-up of sand from the shoreline. The analysis presented in this report indicate the peak volume will be late summer (Feb / Mar period) and be approximately 800m^3.

4. The removed sediment should be placed onto shorelines east of Thomson Bay between Army Groyne and Philip Point to mimic natural processes.

It is noted that in earlier concept designs for the barge development there was a perpendicular breakwater on the eastern beach. This could be considered as a means of managing the sedimentation. This could take the form of a low-rise sandbag seawall groyne (geotextile sandbag containers). Build up would occur on the east of this structure in summer months prior to arriving at the new barge site. This should be designed to allow it to be 'naturally cleared' under winter storm conditions as is the case at the Army groyne currently. This feature may also control wrack movement toward the development that is active nearshore but would not stop all the wrack from entering the basin area.

7. Implementation Plan

The following section outlines the actions that RIA should undertake to support the CHRMAP.

7.1 Annual Monitoring Program

It is recommended that an annual monitoring program commence following the adoption of the CHRMAP. This will be used to support the CHRMAP and to provide up to date information regarding coastal hazard. It would also develop the understanding of the shoreline dynamics in the South Thomson Bay study region.

The annual monitoring program will be key to informing the maintenance activities discussed in this CHRMAP for management and removal of seagrass wrack and sediment from the project area. The volumes of seagrass wrack and sediment are estimated in the CHRMAP from desktop methods and the frequency and nature of removal is outlined in Section 6.1 and 6.2 for the purposes of informing future management actions and planning by RIA post-construction. It is acknowledged that these processes will need to be carefully monitored post-construction to confirm the volumes that need to be managed and the frequency, timing (ie season) and method of removal.

Further detail on the monitoring program is presented in the sections following.

7.1.1 Photo Monitoring and Survey Data Collection

Collection of photos and survey in the shoreline areas post-construction to develop the understanding of coastal processes.

The following methods of capture are recommended:

- Photo Monitoring. Fixed monitoring locations would be established at key locations around the barge development and photos would be captured at various times during the year. As a general guide the photos could be collected monthly as a baseline, during construction (where access is possible) and post-construction. This method develops the understanding of how the shoreline changes seasonally.
- Capture of data using unmanned aerial vehicles (UAV). UAV data capture (drone) provides survey levels of shoreline areas as well as oblique aerial imagery. This method of capture has been used successfully in other locations around Western Australia and offers a cost-effective means of capturing this data across small areas. The data can be used to analyse the way in which shorelines evolve across different seasons and changes following large storm events.

7.1.2 Asset Management and Structural Inspections

The annual monitoring program would summarise key information from the RIA’s asset management and structural inspections from the Thomson Bay site.

The structures of interest would include the following:

- Boat Ramp
- Pavillion
- Toilet
- Roads
- Access paths

7.2 Funding Opportunities

The RIA may be eligible for up to 50% of the cost of its Annual Monitoring program. Future planning and technical studies may also be eligible for co-funding through State grant schemes.

The grant funding options that could apply for to support the funding of coastal management activities is summarised in Table 7.1. These funding mechanisms generally require a co-funded approach whereby 50% of the funding is matched. The grant programs are designed to support outcomes that support public benefit.

Table 7.1: Summary of Funding Mechanisms

Grant	Brief Description	Potential Application
Coastal Management Plan Assistance Program (CMPAP) Coastal Management Plan Assistance Program (CMPAP grants) (www.wa.gov.au)	CMPAP grants support eligible coastal land managers to develop and implement adaptation and management plans and strategies for coastal areas that are, or are predicted to become, under pressure from a variety of challenges. CMPAP grants are administered by the Department of Planning, Lands and Heritage. CMPAP grants provide up to 50% of the budget for planned projects (co-funded with 50% contribution by the Applicant). Applications are invited for grants of up to $200,000	• Funding of future CHRMAP review (every 5-years). • Funding of additional studies to develop management strategy for shoreline areas eg Foreshore Management Plans • Detailed assessment of economic or adaptation options.
Coastal Adaptation and Protection (CAP) grants Coastal Adaptation and Protection (CAP) Grants and H-CAP Major Project Fund (transport.wa.gov.au)	CAP grants provide financial assistance for local projects that identify and manage coastal hazards. The program seeks to preserve and enhance coastal assets for the community. It aims to build partnerships with local coastal managers and help them understand and adapt to coastal hazards. CAP grants are available for the coastline immediately adjacent to the oceans of WA.	• Annual Monitoring Program. • Funding for shoreline restoration / revegetation programs. • Funding of additional studies to develop management strategy for shoreline areas

Grant	Brief Description	Potential Application
	CAP grants provide up to 50% of the budget for planned projects (co-funded with 50% contribution by the Applicant). The minimum CAP grant limit is $15,000 (excluding GST) and the maximum CAP grant limit is $400,000 (excluding GST)	
Coastwest Grants Coastwest grants (www.wa.gov.au)	Coastwest grants support eligible coastal land managers and community organisations to undertake projects that manage and enhance WA's coastal environments through rehabilitation, restoration and preventative actions. Coastwest grants are administered by the Department of Planning, Lands and Heritage. Grants provide up to 50% of the budget for planned projects (co-funded with 50% contribution by the Applicant). Applications are invited for grants of $5,000 - $60,000.	• Funding for shoreline restoration / revegetation programs with input from community organisations. • Projects which aim to protect and rehabilitate sensitive coastal areas, enhance coastal landscapes and biodiversity including near shore marine habitats.

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Appendix A

Risk Assessment Tables

A.1 Consequence Scale (from Cardno 2013)

RATING	SAFETY / INJURIES	FINANCIAL	NATURAL ENVIRONMENT			HERITAGE	REPUTATION & IMAGE	VISITOR EXPERIENCE AND OPPORTUNITY	INTERRUPTION TO ESSENTIAL SERVICES	OPERATIONAL EFFICIENCY	LEGAL & COMPLIANCE
			Marine & Lakes	Ground and Surface Water Resource	Terrestrial						
Insignificant	*Minor injuries not requiring first aid, or near miss	*Less than $100,000 of operational budget	*Coral communities not affected *No pelagic or reef fish kill *Water quality temporarily affected less than 12 hours *Sea Grass not affected *Iconic fish/mammal/seabird species not involved *Communities will regenerate in less than 6 months with minimal interruption or repair	*No impact to salinity of Ground Water *Water quality temporarily affected less than 12 hours *Wader birds not involved	*Will regenerate in less than 6 months with minimal intervention or repair *No native flora/fauna populations affected	*Minor maintenance, localised, reparable damage affecting items, buildings or areas of little significance	*Credibility not challenged *Low impact or no news item	*Decrease or interruption in visual amenity, activity or experience in areas not accessed by visitors	*Less than 2 hours	*Minor delays in service delivery *Delays against project milestone / deliverables within 1% of project schedule	*Guidance required for compliance *Possible non-compliance with internal procedure
Minor	*First aid treatment	*$100,001 - $500,000 of operational budget	*Less than 10% coral communities affected *Water quality temporarily affected less than 24 hours *Less than 2 iconic fish/mammal/sea birds/reptiles involved *Fish kill of 1-20 pelagic and/or reef fish *50 – 200 ha affected *Communities will regenerate in 6-18 months with low level of intervention	*Fresh Ground Water Bore increases salinity but does not exceed 2000uS/cm *Water quality temporarily affected less than 24 hours *Less than 10 wader birds involved	*20ha - 100ha affected *Will regenerate in 6-18 months with low level of intervention or repair *Limited damage to native flora/fauna populations	*Limited, reparable damage of items, buildings or areas of significance	*Credibility challenged locally by an individual *Minor impact, low news item	*Decrease or interruption in visitor amenity, activity or experience exceeding the boundaries of areas not accessed by visitors	*2 hours – 4 hours	*Inconvenient delays *Delays against project milestones / deliverables within 2 – 4%	*Some non-compliance with internal Policy, procedure or non-regulatory external agreement *Non-compliance with legal obligations not reportable
Moderate	*Medical treatment required	*$500,001 - $1,000,000 of operational budget	*10 – 40% coral communities affected *Water quality temporarily affected 1 – 3 days *201 – 400 hectares affected *2- 10 iconic fish/mammal/seabird affected *Fish kill of 20-100 pelagic and/or reef fish *Communities will regenerate in 18 months to 5 years with some level of intervention and repair	*Fresh Ground Water Bore exceeds 2000uS/cm *Water quality affected temporarily for 4 – 10 days *10-30 wader birds affected	*101ha – 200ha affected *Will regenerate in 18 months – 5 years with some level of intervention or repair *Moderate damage to native	*Limited, irreparable damage of items, buildings or areas of some significance	*Public criticism of moderate impact from a number of sources, moderate news profile, *Minister involved	*Permanent decrease / removal of visual amenity, activity or experience in areas sometimes accessed by visitors	*4 hours – 1 day	*Significant delay in service or product delivery *Delays against project milestones / deliverables equating to 5%	*Repetitive non-compliance with legal obligations or probity infringements

					flora/fauna populations						
Major	*Death or severe injury	*$1,000,001 - $5,000,000 of operational budget	*40 – 75% of coral communities affected *Water quality affected temporarily for 4 - 10 days *401 – 2000 ha affected *11 -20 iconic fish/mammal/seabirds/ reptiles affected *Fish kill of 100-250 pelagic and/or reef fish *Communities will regenerate in 5-10 years with some intervention and repair	*Fresh Ground Water Bore exceeds 4000uS/cm *30-100 wader birds affected.	*201ha - 1000ha affected *Will regenerate in 5-10 years with high level of intervention or repair *Significant damage to native flora/fauna populations	*Localised or limited, irreparable damage of items, buildings or areas of considerable or exceptional significance	*Public criticism with high impact, widespread high news profile *Minister and Government required to make public statement	*Permanent decrease / removal in visual amenity, activity or experience in areas often accessed by visitors	*1 day – 3 days	*Service or product not delivered *Delays equating to 6 – 9%	*Non-compliance reportable, results in termination of process or imposed penalties <$5000
Extreme	*Multiple deaths or severe injuries	*More than $5,000,000 of operational budget	*More than 75% of coral affected *Water quality affected for more than 10 days *2001 to 3828ha affected *21 or more iconic fish/mammal/seabirds/reptiles affected *Fish kill of >250 pelagic and/or reef fish. *Communities may regenerate in more than 10 years with some intervention or have no regeneration	*Salt water ingress causing the loss of fresh ground water *Water quality affected for more than 10 days *>100 wader birds affected	*1001ha - 1900ha affected *May regenerate in more than 10 years with considerable high level of intervention or repair, or have no regeneration *Potential extinction of native flora/fauna species	*Permanent, widespread, irreparable damage, serious loss of heritage values	*Public criticism from multiple sources *Very high impact, international and national multiple media coverage *Community groups involved, *Public Ministerial and Government involvement *Government censure or disclaimer	*Permanent decrease / removal in visual amenity, activity or experience in accommodation areas	*More than 3 days	*Non-achievement of major key objectives *Delays against milestones/project deliverables >10%	*Non-compliance results in criminal charges or loss of required accreditation or licence *Fines / infringement exceed $5000

A.2 Adaptations Options Toolbox (from Cardno 2013)

Option Category	Option Name	Option Code	Description
Avoid	Avoid (permanent) development	AV	Avoidance of inappropriate development within the coastal hazard zone.
Planned / Managed Retreat	Leave unprotected / repair	MR1	Assets are left unprotected and loss is accepted following hazard event. Repairs may be implemented to extend life and for public safety in the short-term. In the case of natural assets, such as beaches and vegetation, allow the impacts of hazards to occur.
	Remove / relocate	MR2	Assets located in the hazard zone are permanently removed or relocated prior to hazard impact.
	Planning controls for managed retreat	MR3	Use of planning controls to allow continued use of the current infrastructure until such time that impacts arise or risk is intolerable, but restrict further development as the area/asset is known to be vulnerable. This option also includes mechanisms for ensuring that lessees are aware of risks.
Accommodate	Planning controls to accommodate/identify risk	AC1	Indicates that an asset is at risk from coastal hazards over the planning timeframe. Helps to make informed decisions about the level of risk they are willing to accept and that risk management and adaptation is likely to be required at some stage.
	Emergency plans and controls	AC2	Implement plans for assets/areas that are at risk of coastal erosion and/or inundation. Have procedures in place for before, during and after the events for safety. E.g. signage/barriers to prevent access.
	Redesign to accommodate hazards	AC3	Redesign infrastructure to accommodate coastal hazards. Generally applicable for inundation only.
Protect	Dune care / sand management	PR1	'Soft' options to improve retention of sand on the beach and dunes. Ongoing revegetation and rehabilitation of the dune system. Sand fencing to manage wind-blown erosion also falls under this category.
	Beach nourishment / sand management	PR2	Addition of sand to the beach, dune and/or nearshore area to replace lost material and/or create additional buffer. This option is often a temporary measure and can be more effective in association with hard protection options, such as groynes or offshore breakwaters. The sand may be from an external source or from a nearby part of that coastal area.
	Groyne(s)	PR3	Construct groynes along the beach to restrict longshore sediment movement and stabilise sections of shoreline. This option is often accompanied by beach nourishment.
	Nearshore reef(s) / breakwater(s)	PR4	Construct offshore reef(s)/breakwater(s) or raise existing natural nearshore reef structure to maintain level of protection from wave energy as sea level rises.
	Seawall(s) / Revetment(s)	PR5	Construct seawall in front of assets or along length of coastline to protect them from coastal hazards.
No Regrets	Long term monitoring program	NR	This risk monitoring option involves long-term monitoring and event-based monitoring following storm erosion events. It is not an adaptation option but better informs risk management and response.
Do nothing	Do nothing	DN	Take no action. No limitations on development or implementation of adaptation planning. Accept risk.

A.3 Trigger Points (from Cardno 2013)

Trigger ID	Description	Method(s) of assessment	Example response(s)
T1	The HSD is within the S1 distance of an asset's most seaward extent.	– Ongoing shoreline monitoring (survey profiles) to determine location of HSD. – S1 defined by modelling, with data collected during shoreline and storm monitoring used to validate/refine the S1 value.	– Remove or relocate major infrastructure such as buildings, paths and roads. – Provide interim protection for major infrastructure such as buildings, paths and roads. – Prepare response plans for minor infrastructure that could be impacted.
T2	Infrastructure lies within the extent of the most up to date 100-year coastal hazard extent.	– Definition of hazard extents through this CHRMAP. – CHRMAP and hazard extent updates due to the availability of more relevant/recent information (such as updated SLR predictions) and changes in environmental conditions (such as changes to MSL).	– Include all affected land in a SCA and ensure the hazard information is incorporated in RIA GIS system. – Incorporate reference to the CHRMAP and SCA in relevant RIA policies, guidelines and plans.
T3	An asset is damaged, destroyed or becomes unsafe due to coastal hazards.	– Inspection of coastal assets following storm events or during times of increased erosion (e.g. by works staff, Rangers). – Remote coastal monitoring cameras. – Notification by the public.	– Remove asset and relocate to less hazardous area if possible/appropriate.
T4	Assets are predicted to move to high or extreme risk within the next planning timeframe.	– Definition of hazard extents through the CHRMAP. – CHRMAP and hazard extent updates due to the availability of more relevant/recent information (such as updated SLR predictions) and changes in environmental conditions (such as changes to MSL).	– Undertake detailed cost-benefit analysis and assessment of community acceptance of interim protection vs managed retreat of the affected assets. – Assess remaining useful/design life of the asset(s). – Identify sources and begin to allocate funding for management.
T5	The overall community and stakeholders are no longer supportive of a specific coastal management technique or approach.	– Ongoing community/stakeholder engagement.	– Investigate, identify and implement a change in the adaption pathway.
T6	A specific coastal management technique is forecast to no longer be	– Ongoing shoreline and coastal asset monitoring. – Budget expenditure and forecasts.	– Investigate, identify and implement a change in the adaption pathway

Trigger ID	Description	Method(s) of assessment	Example response(s)
	economically or physically feasible within 10 years.		
T7	The beach and coastal foreshore reserve are being diminished with respect to its original state and function.	– Long-term coastal monitoring program. – Assessment of aerial imagery. – Feedback through ongoing community/stakeholder consultation.	– Investigate, identify and implement a change in the adaption pathway.
T8	Localised ongoing erosion of beach and dune systems is identified.	– Ongoing shoreline monitoring program. – Community/stakeholder engagement. – Aerial imagery.	– Soft protection measures such as minor nourishment, wind/sand fencing and revegetation of dunes.
T9	Community support for current shoreline position to be maintained.	– Ongoing community/stakeholder engagement.	– Implementation of new, or strengthening of existing, coastal controls.
T10	Undeveloped land is identified as lying within the hazard extents.	– Definition of hazard extents through this CHRMAP. – CHRMAP and hazard extent updates due to the availability of more relevant/recent information (such as updated SLR predictions) and changes in environmental conditions (such as changes to MSL).	– Implement planning controls to avoid inappropriate development of the land.