APPENDIX 1
ATTACHMENT 1

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ATTACHMENT 2

R1689 Rev 1

June 2022

marinas
boat harbours
canals
breakwaters
jetties
seawalls
dredging
reclamation
climate change
waves
currents
tides
flood levels
water quality
siltation
erosion
rivers
beaches
estuaries

City of Joondalup

Burns Beach Updated Coastal Hazard Risk Management & Adaptation Planning

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1. Introduction

The City of Joondalup (City) is considering a new development near existing amenities on the foreshore at Burns Beach. The location of Burns Beach and the existing foreshore is presented in Figure 1.1. The shoreline in this area is rocky, with coastal limestone cliffs visible along the coast (refer Figure 1.1). Further details on the rocky nature of the shoreline are contained in Section 2 of this report.

Figure 1.1 Location of Burns Beach

The proposed development sits within the coastal zone and as such the potential coastal hazards at the site need to be considered. To assess the coastal hazards, risk and vulnerabilities associated with the proposed development the City engaged specialist coastal engineers M P Rogers & Associates Pty Ltd (MRA) to complete updated Coastal Hazard Risk Management and Adaptation Planning (CHRMAP) for the development.

The requirements and framework for CHRMAP are outlined in State Planning Policy No. 2.6 - State Coastal Planning Policy (SPP2.6) and more specifically in the CHRMAP Guidelines (WAPC 2019). The CHRMAP for the proposed development has been completed in accordance with those documents and covers the following key items:

- Establishment of the context.
- Coastal hazard assessment.
- Risk analysis and evaluation.
- Risk management and adaptation planning.
- Monitoring and review.

This report outlines the methods, data and outcomes of the CHRMAP.

1.1 State Planning Policy 2.6

Within Western Australia, State Planning Policy 2.6: State Coastal Planning Policy (SPP2.6; WAPC 2019) provides guidance for land use and development decision-making within the coastal zone, including the establishment of coastal foreshore reserves to protect, conserve and enhance coastal values. SPP2.6 also provides guidance on the assessment of coastal hazard risks for assets located in close proximity to the coast.

The objectives of SPP2.6 are wide ranging, however a key component of the policy is the identification of appropriate areas for the sustainable use of the coast. This includes use for recreational, tourism and commercial purposes, which are relevant to the proposed development.

The guidance on the assessment of coastal hazard risk is provided within SPP2.6 in the form of a methodology to assess the potential extent of coastal hazard impacts, as well as for the development of a CHRMAP report. Further details in this regard are also provided in the CHRMAP Guidelines (WAPC 2019).

The key requirement of CHRMAP is to develop a risk-based adaptation framework for assets that could be at risk of impact by coastal hazards over the relevant planning timeframe. Importantly, the balance of these risks needs to be considered with reference to the expected lifetime of the relevant assets.

1.2 Concept Plan

The City have provided a concept plan for the proposed development at Burns Beach, this is included in Figure 1.2.

Figure 1.2 Proposed Development Concept Plan

This concept plan has been used as a basis for determining the Key Assets included in the risk assessment.

2. Context

2.1 Purpose

The potential vulnerability of the coastline and the subsequent risk to the community, economy and environment needs to be considered for any coastal development.

SPP2.6 requires that the responsible management authority completes CHRMAP where an existing or proposed development may be at risk from coastal hazards over the planning timeframe. The main purpose of CHRMAP is to define areas of the coastline which could be vulnerable to coastal hazards and to outline the preferred approach to the monitoring and management of these hazards where required.

CHRMAP can be a powerful planning tool to help provide clarity to existing and future developers, users, managers or custodians of the coastline. This is done by defining levels of risk exposure, management practices and adaptation techniques that the management authority considers acceptable in response to the present and future risks posed by coastal hazards.

Specifically, the purpose of this CHRMAP is as follows:

- Determine the specific extent of coastal hazards in relation to the proposed development and the proposed development.
- Determine the coastal hazard risks associated with the proposed development and how these risks may change over time.
- Establish the basis for present and future risk management and adaptation.
- Provide guidance on appropriate management and adaptation planning for the future, including monitoring.

2.1.1 City Wide CHRMAP

The City are in the process of developing a City wide CHRMAP. As part of this process the City's coastline has been broken up into nodes with the proposed development area falling into Node 6 Iluka.

This CHRMAP for the proposed development is more focused and specialised than the draft City wide CHRMAP and will sit within this overarching CHRMAP once it is completed.

2.2 Objectives

The key objectives of this CHRMAP are as follows:

- Inform the proposed development by providing appropriate guidance to the City and key stakeholders with respect to the management of coastal hazards.
- Ensure that the City and key stakeholders understand the potential likelihood of the proposed development being impacted by coastal hazards over the 100 year planning timeframe.
- Outline the required coastal adaptation approach in an Implementation Plan that is acceptable to the City and key stakeholders.

2.3 Scope

The CHRMAP Guidelines (WAPC 2019) provide a specific framework for the preparation of a CHRMAP. This is outlined in the flowchart presented in Figure 2.1 which shows the risk management process adapted to coastal planning.

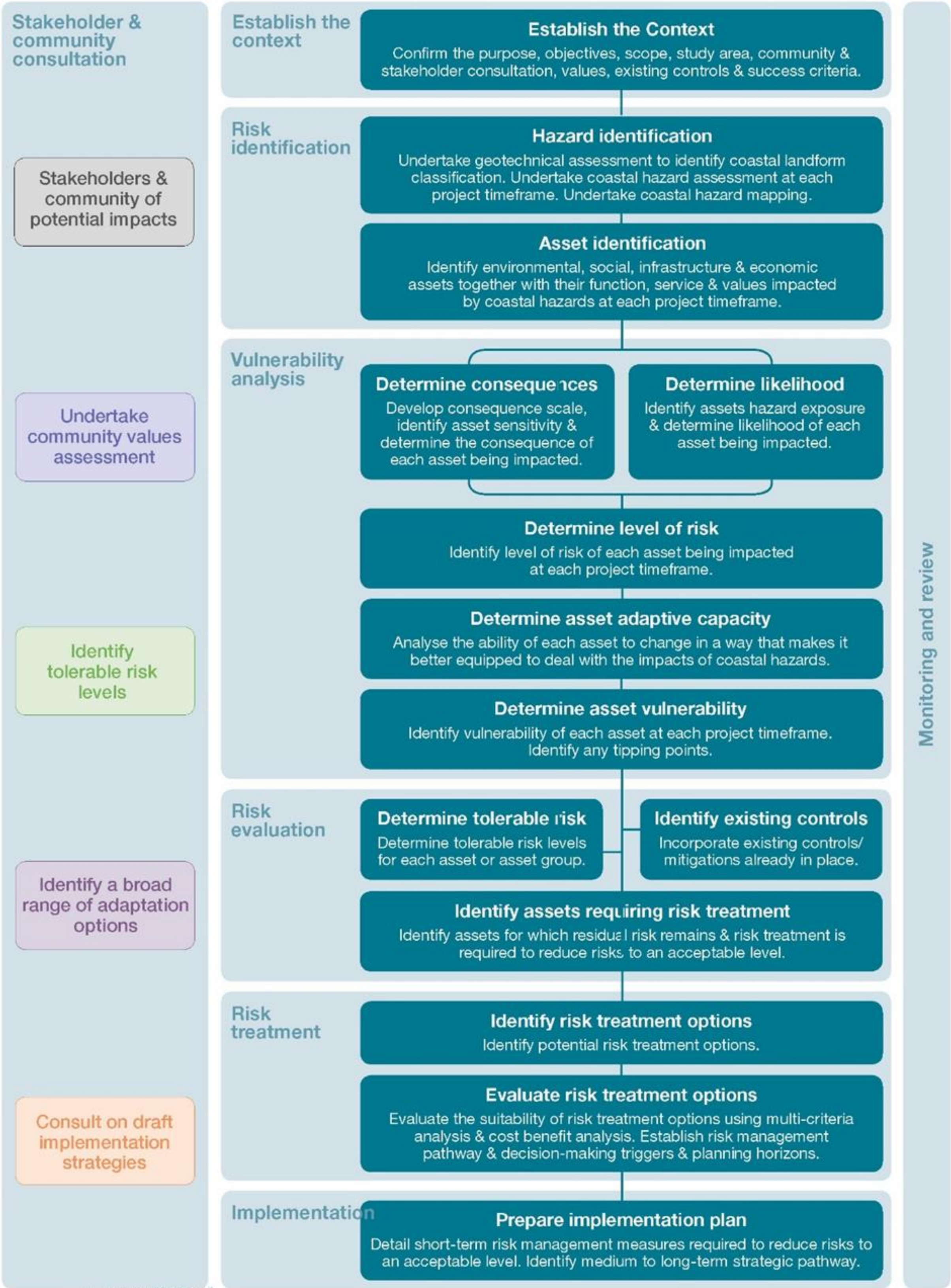

Figure 2.1 Risk Management & Adaptation Process Flow Chart (WAPC 2019)

As presented in the flowchart, the process for the development of a meaningful CHRMAP process requires a number of fundamental inputs. These inputs enable the assessment and analysis of risk, which should ultimately be informed by input received from key stakeholders, to help shape the subsequent adaptation strategies.

The proposed development will require an adaptation plan that is acceptable to all stakeholders. As a result, the approach that has been taken for this plan is to develop a management methodology that allows for flexibility into the future, given the inherent uncertainties associated with long term coastal behaviour.

The development of the adaptation plan will be informed by the assessment of the coastal erosion and inundation hazards at the site. The identification of the coastal erosion and inundation hazards for the proposed development is presented within Section 3 of this report.

This CHRMAP will consider the potential risks posed by coastal hazards over a range of horizons covering the 100 year planning timeframe. This planning timeframe is required by SPP2.6 for development on the coast, though it is noted that the lifetime of a structure on the coastline is unlikely to span this 100 year planning horizon without requiring reconstruction.

Intermediate planning horizons will also be considered to assess how risk profiles may change in the future and to inform the requirement for adaptation strategies. The intermediate planning horizons that will be considered in this CHRMAP are listed below.

- Present day.
- 25 years to 2047.
- 50 years to 2072.
- 75 years to 2097.
- 100 years to 2122.

Based on the results of the risk assessment, risk mitigation strategies will be developed, where required, in order to provide a framework for future management. However, it is important to realise that the risk assessment will be based on the outcomes of the coastal vulnerability assessment, which, by their nature, are justifiably conservative. This is due to the uncertainty around coastal dynamics when predicting impacts over long timeframes. As a result, the framework for future risk management strategies should be considered to be a guide of future requirements. The actual requirement for implementation of these management actions should ultimately be informed by a coastal monitoring regime.

The purpose of the coastal monitoring regime is to identify changes in the shoreline or sea level that could alter, either positively or negatively, the risk exposure of the proposed assets and infrastructure. A recommended coastal monitoring regime is included within the implementation plan, presented within Section 9 of this report.

2.4 The Site

Burns Beach is a 200 m long beach bordered by Calcarenite (Tamala Limestone) cliffs at the end of Burns Beach road (Short 2006). The Burns Beach study area was classified as rocky by the Department for Planning and Infrastructure as part of the Northern Perth Metropolitan Coastal Setback Study (MRA 2005a).

An extract of the nautical chart for the area, showing the reefs and islands and nearshore bathymetry, is presented in Figure 2.2. The nautical chart shows the coastal cliffs that exist along the Burns Beach shoreline, as well as the lines of parallel offshore reefs.

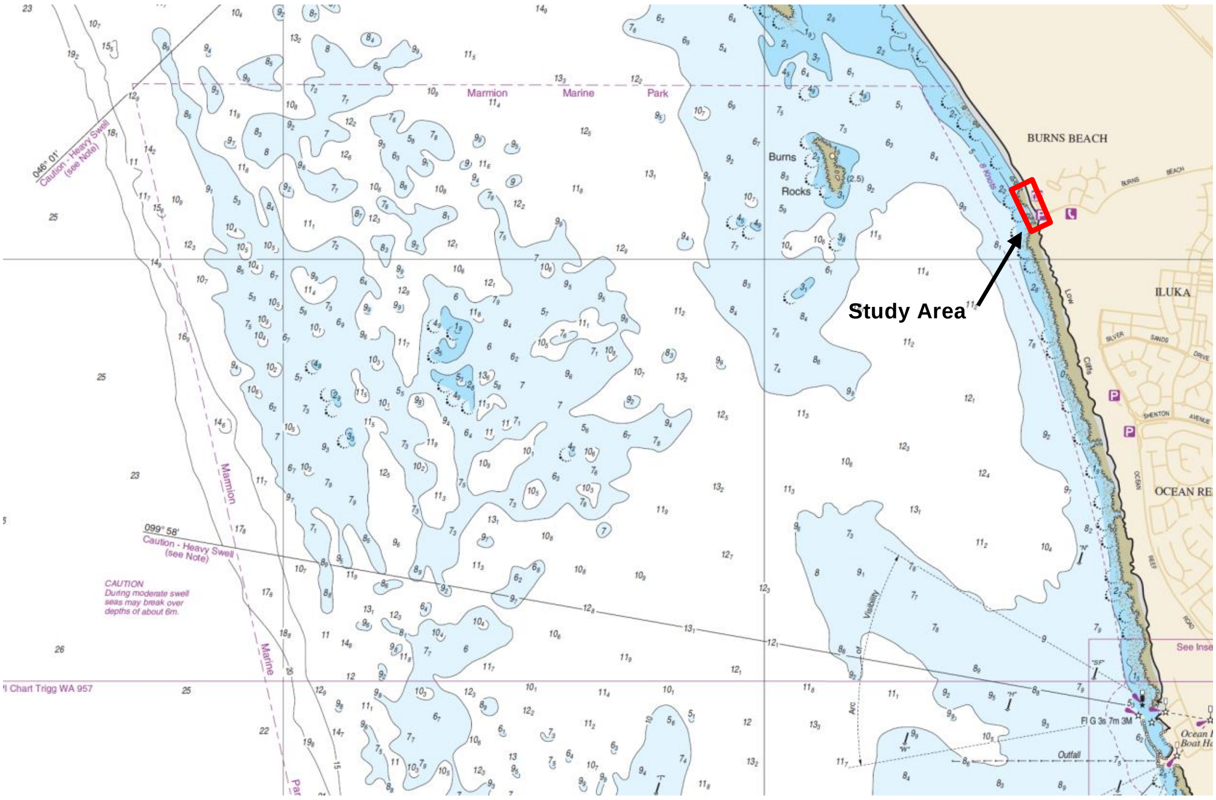

Figure 2.2 Nautical Chart showing Features around Burns Beach

The coastal cliffs presented in Figure 2.2 match the geological mapping for the area, which show limestone extending to the coast at Burns Beach (Figure 2.3).

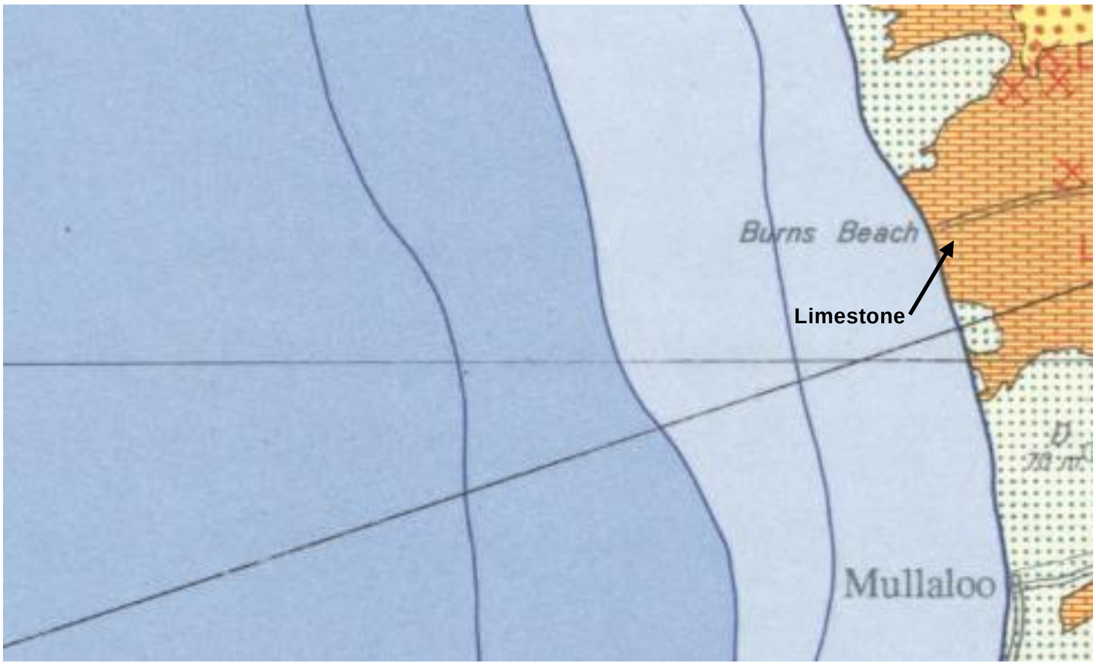

Figure 2.3 Extract from Geological Map of Burns Beach (GSWA 1978)

A geotechnical study of the cliffs to the south of the rock groyne was completed by CMW Geoscience in 2016 (CMW 2016). This study found that the cliffs extended to a height of +4 to 4.5 mAHD in the northern portion of the study area, with a height up to +8 mAHD in the south. The cliff consists of two main units, Upper and Lower, as shown in Figure 2.4. This photograph was taken at the southern end of the car park.

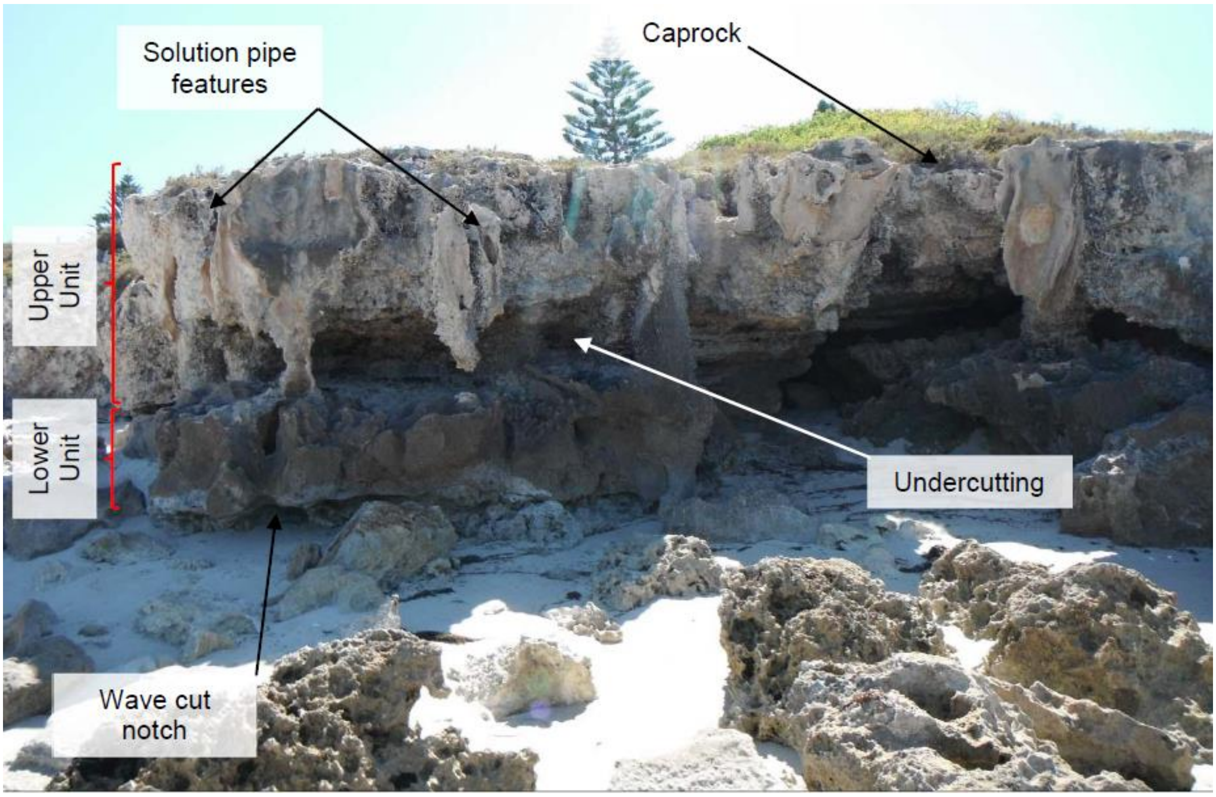

Figure 2.4 Rock Cliff Geology (CMW 2016)

The Upper unit consists of a well cemented, medium to high strength caprock overlying a very low to low strength Calcarenite layer. This overlays the Lower unit, which comprises a medium to high strength Calcarenite layer. Where exposed to wave action, predominantly in the higher cliffs of the south, the differential strength of the layers results in undercutting of the cliff, with rock falls in some areas. Where present, the boulders resulting from the rock topples have formed a natural barrier to further erosion (CMW 2016).

Photographs of the beach and dune in front of the proposed development (Figures 2.5 and 2.6) show the medium to high strength Tamala Limestone caprock in the dunes.

Figure 2.5 Conditions South of Burns Beach Groyne (March 2022)

Figure 2.6 Condition North of Burns Beach Groyne (March 2022)

Given the presence of rock in the area, the shoreline will be classified as rocky under the SPP2.6.

2.5 Key Assets

The proposed development of the Burns Beach foreshore will likely be composed of park areas, carpark, gardens/native vegetation, play area and a café/restaurant. The indicative layout of the proposed development is shown in Figure 2.7. In addition to the components of the proposed development there are existing assets which also need to be considered as part of the CHRMAP. The key infrastructure and assets considered in this CHRMAP are listed in Table 2.1.

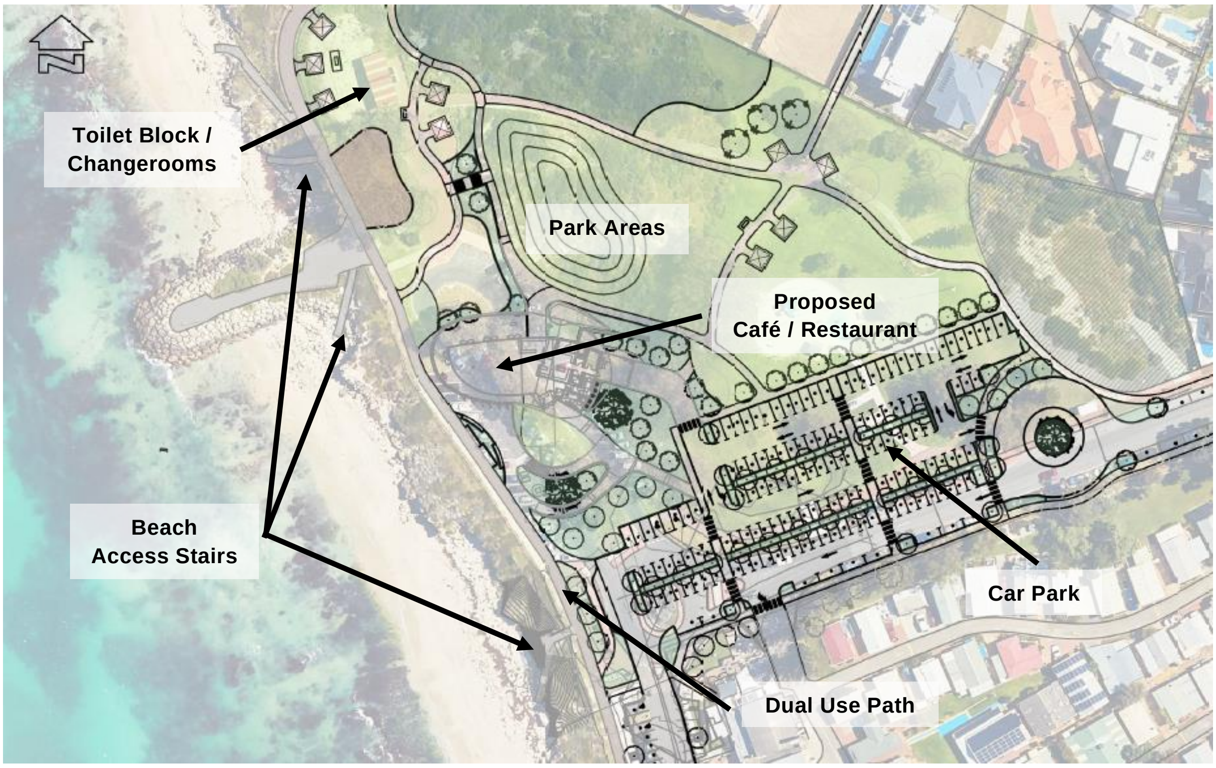

Figure 2.7 Proposed Development Indicative Layout

Table 2.1 Key Infrastructure & Assets

Key Assets	Status
Beach Access Stairs	Existing
Dual Use Path	Existing
Car Park	Existing & proposed
Access Road	Existing
Toilet Block & Changerooms	Existing
Park Areas (including play area)	Proposed
Café / Restaurant	Proposed

The success criteria for the CHRMAP will ultimately be as follows.

- To understand the potential extent of impact of coastal hazards on the development.
- To understand the potential/likelihood of infrastructure within the development being impacted by coastal hazards over each planning horizon.
- To understand the consequences of infrastructure being exposed to the different coastal hazards.
- To determine total risk ratings for each item of infrastructure.
- Development of an acceptable risk management and adaptation strategy for the proposed development whilst considering the reasonable likelihood of protection for existing infrastructure.
- Development of a coastal monitoring strategy to review the actual changes in risk levels over time.

The outcomes of the success criteria listed above are presented in the following sections of the report.

3. Coastal Erosion Hazard Identification

An understanding of the coastal hazards and risks is critical for the assessment and determination of management and adaptation actions.

Schedule One of SPP2.6 presents the recommended methodology for calculation of coastal erosion hazards for coastal development on sandy and rocky coasts. The shoreline fronting the study area is classified as rocky under SPP2.6, which notes that coastal erosion hazard assessment for rocky shorelines should be based on geotechnical assessment of the rocks present on site.

The rock observed on site is Calcarenite (Tamala Limestone), which can offer significant protection from the processes of the ocean. The geotechnical study completed by CMW Geosciences (2016) notes that the erosion of the cliffs at Burns Beach is a naturally occurring process that will occur very slowly and unpredictably over geological time (i.e thousands of years).

The Tamala Limestone material is the same material which is present on the rocky shorelines of Jindalee (10km north of Burns Beach), Cottesloe and Halls Head, Mandurah. At Lot 10 Jindalee, the rocky coast remained stable over the 56 years of shoreline movement records from 1941 to 1997 (MRA 2005b). Similarly in Mandurah, surveys of the rocky cliffs from early last century indicate there has been less than 5 m movement of the cliffs in over 100 years. This demonstrates that competent limestone can provide protection and withstand the erosive effects of the ocean.

Based on the above information, an allowance of 5 m is used to assess risk to the key assets to 2122 (MRA 2016a). This is comparable to measured erosion rates on coastlines with similar Tamala limestone, and consistent with previous assessments in the area (MRA 2012a, 2016a, 2016c). The SPP2.6 also requires that significant development be placed outside of the influence of wave overtopping (WAPC 2013). Further information on wave overtopping is provided in Section 5.

The position of the rocky shoreline HSD was determined by the Department for Planning and Infrastructure (DPI) using rectified aerial photography, and was ground-truthed by the DPI based on a survey conducted in January 2005. The HSD in rocky areas was positioned to account for some undercutting of the shoreline (MRA 2005a), which is likely to provide a conservative estimate of today's rocky shoreline. This rocky alignment was used in the *Joondalup Coastal Hazard Risk Management and Adaptation Plan*(MRA 2022) and is considered relevant to this study.

Figure 3.1 presents the erosion hazard line for Burns Beach.

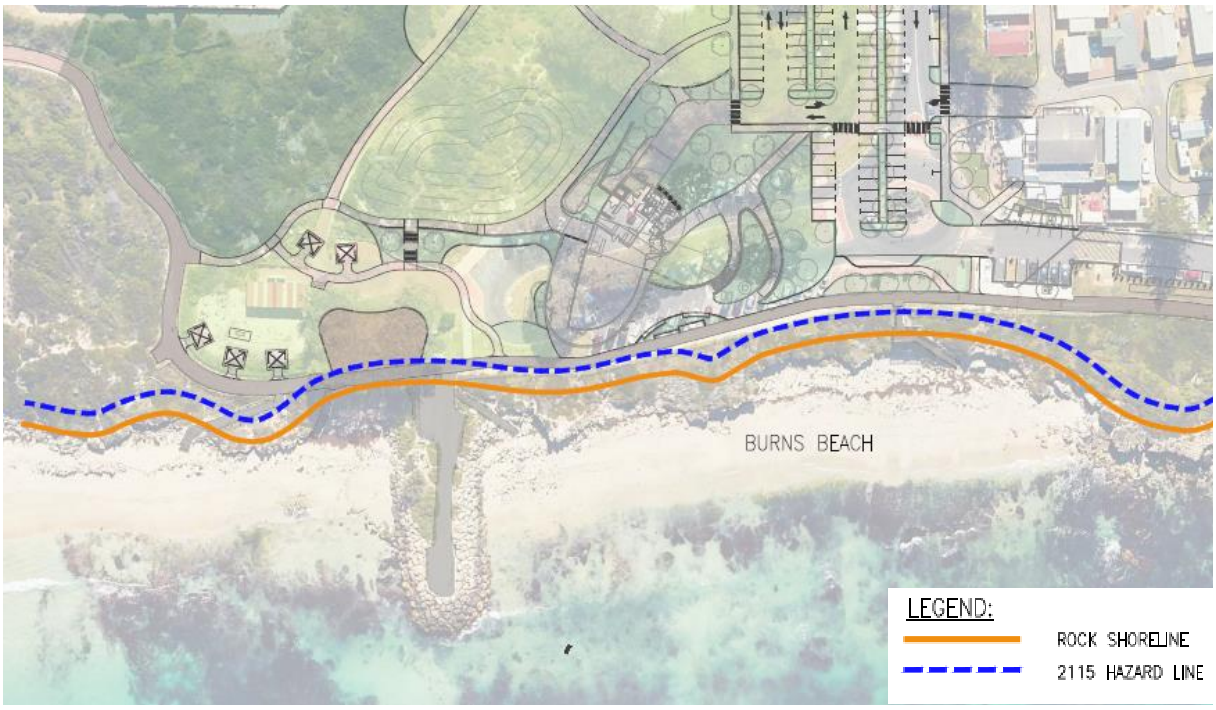

Figure 3.1 Coastal Erosion Hazard Line

4. Coastal Inundation Hazard Identification

SPP2.6 requires that the allowance for inundation (termed the S4 Allowance) be taken as the maximum extent of inundation experienced during a water level event with a 0.2% Annual Encounter Probability (AEP) or the 500 year Average Recurrence Interval (ARI) plus the appropriate allowance for sea level rise.

Assessment of the inundation levels requires consideration of peak storm surge, including wind and wave setup. A storm surge occurs when a storm with high winds and low pressures approaches the coastline (refer Figure 4.1). The strong, onshore winds and large waves push water against the coastline (wind and wave setup) and the barometric pressure difference creates a region of high water level. These factors acting in concert create the storm surge. The size of the storm surge is influenced by the following factors.

- Wind strength and direction.
- Pressure gradient.
- Seafloor bathymetry.
- Coastal topography.

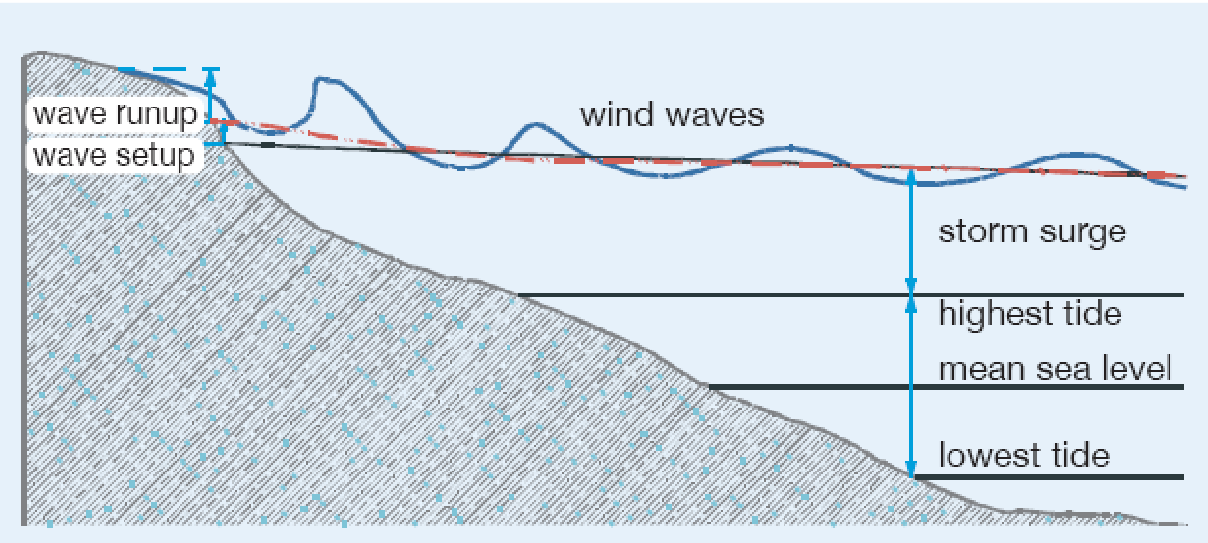

Figure 4.1 Storm Surge Components

SPP2.6 requires that the S4 allowance include consideration of cyclone events. MRA has completed cyclonic storm surge inundation modelling for the Joondalup coastline (MRA 2016b). These results were used in MRA (2016a) to determine inundation levels at the shoreline.

The results of the inundation study at Joondalup gave 500 year ARI water levels of between +3.0 and +4.0 mAHD by 2115 on the City shoreline. The appropriate inundation allowances at the development site have been determined for each of the planning timeframes and are presented in Table 4.1.

Table 4.1 S4 Inundation Levels

Planning Horizon	Potential Sea Level Rise Allowance (m)	500 year ARI (mAHD)
Present Day	0	3.1
2047	0.12	3.2
2072	0.34	3.4
2097	0.61	3.7
2122	0.90	4.0

These levels will be used to identify the extent of the coastal inundation hazard on the shoreline. An extract of the coastal inundation hazard map for the area is presented in Figure 4.2.

Note that due to the very small differences in plan position of the different inundation scenarios for the planning timeframes, only the 2115 line has been used in the mapping. This includes the 500 year ARI event at the end of the planning horizon, with an appropriate allowance for sea level rise.

Figure 4.2 Coastal Inundation Hazard Map (2115)

5. Wave Overtopping

On low permeability or impermeable coasts such as rocky coasts, wave run-up can result in wave overtopping (WAPC 2013). SPP2.6 notes that significant development should be set outside the influence of wave overtopping. At Burns Beach, wave overtopping calculations were completed for the 500 year ARI inundation event in 2122, using the methodology of EuroTop (2018). This used output from Profiles 9 and 10 presented in MRA (2016a) and included appropriate allowances for sea level rise.

Results suggest that the likely volumes of overtopping at the crest of the limestone cliffs are unlikely to result in structural damage to any buildings or structures. The erosion hazard assessment completed in Section 3 suggests that the rocky shoreline could erode around 5 m by 2115. As such the recommended setback for overtopping to 2115 is 5 m from the present day Rocky Shoreline (refer Figure 5.1).

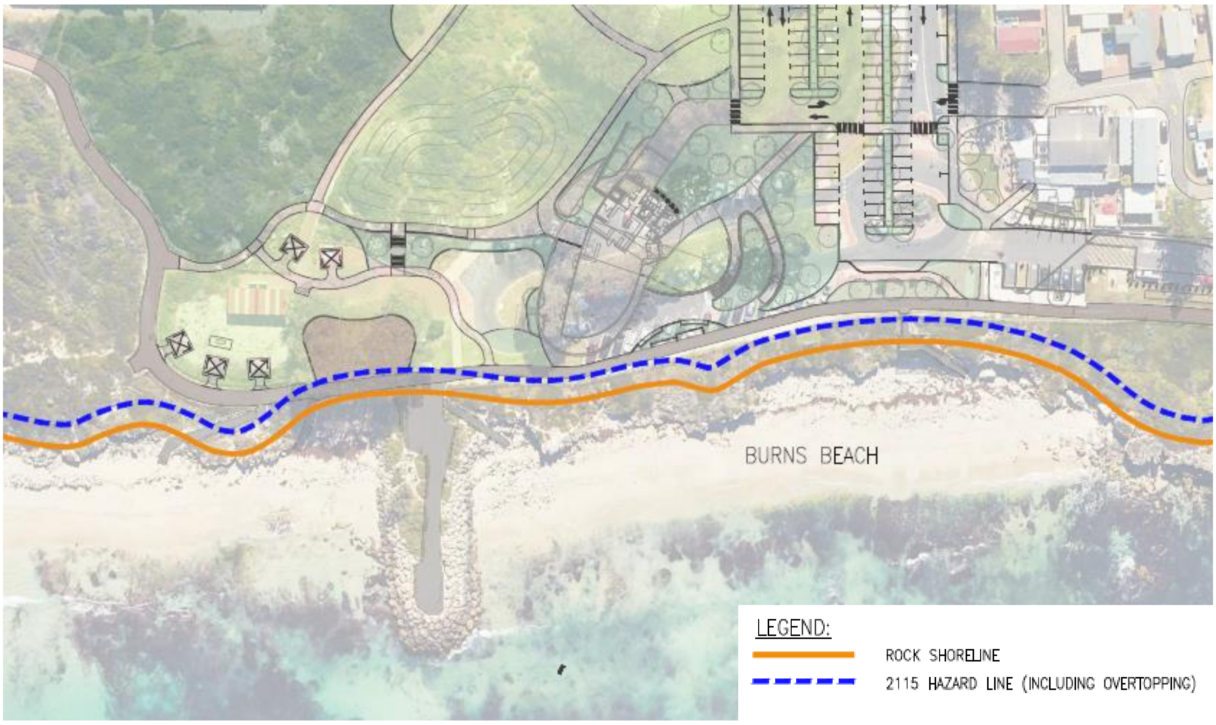

Figure 5.1 Wave Overtopping Hazard Line

Wave overtopping volumes during the 500 year ARI inundation event are likely to be dangerous for pedestrians using the dual use path. However, given that these extreme water levels would be associated with the passage of a significant cyclone event, the wind forces would be too strong for a person to stand in such an exposed location. Therefore, the potential for someone to be on the path during the 500 year ARI inundation event is considered very unlikely.

Overtopping impacts on assets such as the car park, access road, dual use path and park areas are expected to be minimal, as they are areas of paved or natural surface. The access stairs are also expected to be designed to accommodate wave forces and as such the wave overtopping impacts are expected to be minimal. The wave overtopping hazard assessment will therefore only be completed for the building assets (toilet / changerooms and proposed café/restaurant).

6. Risk Analysis

In accordance with WAPC (2019) a risk based approach has been used to assess the hazards and required mitigation and adaptation options for the development. As coastal hazards are the focus of this assessment, it is the likelihood and consequences of these coastal hazards that need to be considered.

6.1 Likelihood

Likelihood is defined as the chance of something happening (AS/NZS ISO 31000:2009). WAPC (2019) defines the likelihood as the chance of erosion or storm surge inundation occurring or how often they impact on existing and future assets and values. This requires consideration of the frequency and probability of the event occurring over a given planning timeframe.

The probability of an event occurring is often related to the Annual Encounter Probability (AEP) or the Average Recurrence Interval (ARI). The use of the AEP to define impacts of coastal hazards over the planning timeframe assumes that events have the same probability of occurring each year. In the case of climate change and sea level rise, which can often have a large influence on the assessed coastal hazard risk, this is not true. In addition, there is insufficient data available to properly quantify the probability of occurrence. A scale of likelihood has therefore been developed, which follows the Australian Standard Risk Management Principles and Guidelines (AS/NZS ISO 31000:2009). This is presented in Table 6.1.

Table 6.1 Scale of Likelihood

Rating	Description / Frequency
Almost certain	There is a high possibility the event will occur as there is a history of frequent occurrence 90-100% probability of occurring over the timeframe.
Likely	It is likely the event will occur as there is a history of casual occurrence 60-90% probability of occurring over the timeframe.
Possible	The event may occur 40-60% probability of occurring over the timeframe.
Unlikely	There is a low possibility that the event will occur 10-40% probability of occurring over the timeframe.
Rare	It is highly unlikely that the event will occur, except in extreme / exceptional circumstances. 0-10% probability of occurring over the timeframe.

The likelihood and consequences of coastal hazards are different for erosion and inundation. As a result, the likelihood and consequence of erosion and inundation should be considered separately. The likelihood of the coastal hazard impacts are discussed in the following sections.

6.1.1 Coastal Erosion & Overtopping

An assessment of the relative likelihood of each of the identified key assets being impacted by coastal erosion and overtopping hazards has been completed and is presented in Table 6.2. The assessment was completed using the coastal hazard lines presented in Figures 3.1 and 5.1.

As noted previously, overtopping hazards are considered the critical case for siting of buildings at Burns Beach, whilst overtopping impacts on assets such as the car park, access road, beach access stairs and dual use path are expected to be minimal. Therefore, the buildings have been assessed for overtopping and the non-building assets have been assessed for erosion within Table 6.2.

Table 6.2 Assessment of the Likelihood of Coastal Erosion & Overtopping Impact

Key Assets	Hazard	Planning Timeframe				
		Present Day	2040	2065	2090	2115
Beach Access Stairs	Erosion	Rare	Unlikely	Likely	Likely	Almost Certain
Dual Use Path	Erosion	Rare	Unlikely	Likely	Likely	Almost Certain
Access Road	Erosion	Rare	Rare	Rare	Rare	Rare
Car Park	Erosion	Rare	Rare	Rare	Rare	Rare
Toilet Block & Changerooms	Overtopping	Rare	Rare	Rare	Rare	Rare
Park Areas	Erosion	Rare	Rare	Rare	Rare	Rare
Café / Restaurant	Overtopping	Rare	Rare	Rare	Rare	Rare

The assessment of likelihood of coastal erosion and overtopping impact shows the following.

- The beach access stairs have a requirement to be located directly on top of the rock cliffs and as such are currently at risk of erosion. Given that erosion is likely to be associated with a significant storm event (say >50 year ARI), the Likelihood of erosion is considered rare at present but almost certain by 2115.
- The dual use path in front of the proposed development may experience erosion in the coming century, as it is located within 5 m of the rocky cliffs. Given that erosion is likely to be associated with a significant storm event (say >50 year ARI), the Likelihood of erosion is considered rare at present but almost certain by 2115.
- The car park and access road are more than 5 m from the rocky coast. As such, they do not fall within the coastal erosion hazard extent.

- The toilet block is more than 5 m from the rocky coast. As such, it does not fall within the coastal erosion hazard extent.

6.2 Coastal Inundation

Given the presence of the limestone cliffs on this section of the coast all of the assets aside from the beach access stairs are located above the inundation levels for each of the planning timeframes. The beach access stairs are designed to be inundated and as such are not likely to be at risk due to inundation. Given that inundation does not present a risk to the assessed assets it has been excluded from this assessment.

6.3 Consequence

The second part of the risk assessment is determining the consequence of the coastal hazards on the development. A scale of consequence has been developed which provides a range of impacts and is generally consistent with the Australian Greenhouse Office (AGO, 2006). This is presented in Table 6.3.

Table 6.3 Scale of Consequence

Rating	Social	Economic	Environment
Catastrophic	Loss of life and serious injury. Large long term or permanent loss of services, employment wellbeing, finances or culture (75% of community affected), international loss, no suitable alternative sites exist	Damage to property, infrastructure or local economy > $20M	Major widespread loss of environmental amenity and progressive irrecoverable environmental damage
Major	Serious injury. Medium term disruption to services, employment wellbeing, finances or culture (<50% of community affected), national loss, limited alternative sites exist	Damage to property, infrastructure or local economy > $5M to $20M	Severe loss of environmental amenity and a danger of continuing environmental damage
Moderate	Minor injury. Major short or minor long term disruption to services, employment wellbeing, finances or culture (<25% of community affected), regional loss, many alternative sites exist	Damage to property, infrastructure or local economy > $500,000 to $5M	Isolated but significant instances of environmental damage that might be reversed with intensive efforts. Recovery may take several years.
Minor	Small to medium disruption to services, employment wellbeing, finances or culture (<10% of community affected), local loss, many alternative sites exist	Damage to property, infrastructure or local economy > $50,000 to $500,000	Minor instances of environmental damage that could be reversed. Consistent with seasonal variability, recovery may take one year.
Insignificant	Minimal short-term inconveniences to services, employment, wellbeing, finances or culture (<5% of community affected), neighbourhood loss, many alternative sites exist	Damage to property, infrastructure or local economy < $50,000	Minimal environmental damage, recovery may take less than 6 months.

Similar to the assessment of likelihood, the consequence rating has been completed separately for coastal erosion and coastal inundation. Typically for infrastructure and assets, the consequences associated with coastal erosion are more significant than those associated with coastal inundation. This arises due to the fact that coastal erosion is generally more permanent and more difficult to overcome than coastal inundation. For instance if the foundations of a house were undermined by erosion it is likely that the house would fall. However if a house was inundated, while there may be some damage, structural failure would be less likely.

The consequence ratings for coastal erosion and overtopping are presented in the following table.

Table 6.4 Assessment of Consequence of Coastal Erosion & Overtopping Impact

Key Assets	Hazard	Present Day	2040	2065	2090	2115
Beach Access Stairs	Erosion	Minor	Minor	Minor	Minor	Minor
Dual Use Path	Erosion	Minor	Minor	Minor	Minor	Minor
Access Road	Erosion	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Car Park	Erosion	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Toilet Block & Changerooms	Overtopping	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Park Areas	Erosion	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Café / Restaurant	Overtopping	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant

The rationale behind the key consequence ratings for coastal erosion and overtopping is provided below.

- The loss of the beach access stairs would limit pedestrian access to the beach. However, there are significant alternative access points and the impact of loss of these assets would be minor.

- The loss of the dual use path in front of the development would limit pedestrian access along the rear of the beach. There are alternative foreshore areas within the City and the assets are relatively minor. The overall impact was therefore assessed as minor.

- The proposed café/restaurant and existing toilet block and changerooms are not expected to be impacted by overtopping in the planning timeframes, so the impact of overtopping is assessed to be insignificant.

7. Risk Evaluation

The risk rating from a risk assessment is defined as "likelihood" x "consequence." The City has developed a Draft Risk Management Framework (City of Joondalup 2013). MRA used the risk matrix presented in that document to define the levels of risk from combinations of likelihood and consequence for the coastal hazards. This risk matrix is generally consistent with WAPC (2019) and is presented in Table 7.1.

Table 7.1 Risk Matrix (City of Joondalup 2013)

RISK LEVELS		CONSEQUENCE				
		Insignificant	Minor	Moderate	Major	Catastrophic
LIKELIHOOD	Almost Certain	Low	Medium	High	Extreme	Extreme
	Likely	Low	Medium	Medium	High	Extreme
	Possible	Low	Medium	Medium	Medium	High
	Unlikely	Low	Low	Medium	Medium	Medium
	Rare	Low	Low	Low	Low	Low

A risk tolerance scale assists in determining which risks are acceptable, tolerable and unacceptable. The risk tolerance scale used for the assessment is presented in Table 7.2.

Table 7.2 Risk Tolerance Scale

Risk Level	Action Required	Tolerance
Extreme	Immediate action required to eliminate or reduce the risk to acceptable levels	Intolerable
High	Immediate to short term action required to eliminate or reduce risk to acceptable levels	Intolerable
Medium	Reduce the risk or accept the risk provided residual risk level is understood	Tolerable
Low	Accept the risk	Acceptable

The risk tolerance scale shows that the extreme and high risks need to be managed.

7.1 Risk Assessment

The risk assessment for the study area has been completed in accordance with the recommendations of AS5334 (Standards Australia 2013), which requires a detailed risk analysis to include a vulnerability analysis to thoroughly examine how coastal hazards and climate change may affect the assets. This includes consideration of the adaptive capacity and vulnerability of an asset.

7.1.1 Coastal Erosion & Overtopping

Based on the results of the risk analysis completed previously, Table 7.3 presents the coastal erosion risk levels for each of the identified key assets.

Table 7.3 Preliminary Assessment of Coastal Erosion Risk Level

Key Assets	Assessed Risk Level				
	Present Day	2040	2065	2090	2115
Beach Access Stairs	Low	Low	Medium	Medium	Medium
Dual Use Path	Low	Low	Medium	Medium	Medium
Access Road	Low	Low	Low	Low	Low
Car Park	Low	Low	Low	Low	Low
Toilet Block & Changerooms	Low	Low	Low	Low	Low
Park Areas	Low	Low	Low	Low	Low
Café / Restaurant	Low	Low	Low	Low	Low

The results of the assessment show that all assets have a Low risk of being impacted by erosion and overtopping at present and over the 25 year planning horizon to 2040.

The beach access stairs and dual use path have an assessed Medium risk of being impacted by erosion over the 50 year planning horizon to 2065. All other assets have assessed Low risks throughout the 100 year planning timeframe.

7.2 Vulnerability

As per the recommendations of AS 5334 Climate change adaptation for settlements and infrastructure, a detailed risk analysis should include a vulnerability analysis to thoroughly examine how coastal hazards and climate change may affect the assets. This includes consideration of the adaptive capacity and vulnerability of the assets previously assessed for coastal hazard risk.

The vulnerability of the proposed development is related to the risk from coastal hazards, as well as the sensitivity to the impacts caused by these hazards and the ability to respond to them (termed adaptive capacity). This is demonstrated in the CHRMAP Guidelines (WAPC 2019) by the following Figure 7.1.

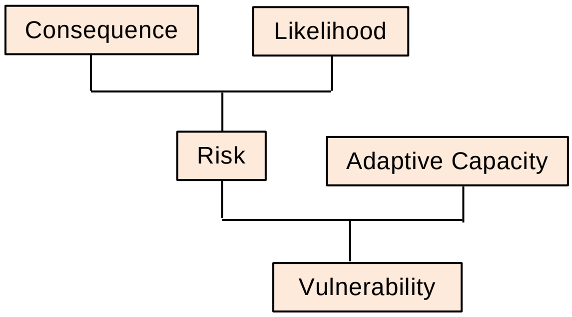

Figure 7.1 Vulnerability Assessment Flowchart (WAPC 2019)

7.2.1 Adaptive Capacity

Adaptive capacity is defined in AS5334 (2013) as the ability to respond to climate change to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

This should be considered in conjunction with any changes to the current risk factors over time which may influence an assets future adaptive capacity. A scale of adaptive capacity has been developed for this assessment and is presented in Table 7.4.

Table 7.4 Adaptive Capacity Ratings

Adaptive Capacity Rating	Description
Low	Little or no adaptive capacity. Asset cannot respond to coastal hazard impact and functionality cannot be restored. For example, roads, carparks or buildings that once impacted will require significant modifications to restore functionality.
Moderate	Some adaptive capacity. Asset can partially adapt to coastal hazard impact and functionality can be somewhat restored. For example, parks or undeveloped lots that once impacted can be modified to restore partial functionality.
High	Good adaptive capacity. Asset can respond to coastal hazard impact and functionality can be restored. For example, drink fountains, furniture or shelters that once impacted can be modified relatively easily to restore original functionality.

7.2.2 Vulnerability

To determine the vulnerability of the proposed development, the following matrix was developed for this assessment. Essentially, the vulnerability to the asset increases or decreases where the asset has a low or high adaptive capacity respectively.

Table 7.5 Vulnerability Matrix

Vulnerability Levels		Risk			
		Low	Medium	High	Very High
ADAPTIVE CAPACITY	Low	Medium	High	Extreme	Extreme
	Moderate	Low	Medium	High	Extreme
	High	Low	Low	Medium	High

A vulnerability tolerance scale is important to define the level at which adaptive capacity is deemed acceptable, tolerable or intolerable/unacceptable. The following tolerance scale has been adopted for this assessment.

Table 7.6 Vulnerability Tolerance Scale

Vulnerability Level	Vulnerability Tolerance	Further Action Required
Extreme	Unacceptable/ Intolerable	Asset has minimal capacity to cope with the impacts of coastal hazards without additional action. Adaptation needs to be considered as a priority.
High	Tolerable, if as low as possible	Asset has limited ability to cope with the impacts of coastal hazards. Adaptation should be considered to reduce vulnerability to acceptable levels.
Medium	Tolerable/ Acceptable	Asset has some ability to cope with the impacts of coastal hazards. Actions should be considered to reduce vulnerability as low as reasonably practical (ALARP).
Low	Acceptable	Asset has high resilience and is able to cope with the impacts of coastal hazards without additional action.

The vulnerability tolerance scale shows that assets with ***High*** and ***Extreme*** vulnerability need to be managed to reduce vulnerability levels to ***Medium*** or ***Low***. Despite being considered acceptable, assets with ***Medium*** or ***Low*** vulnerabilities should also be considered and adaptation measures should be implemented to reduce vulnerability levels as low as reasonably practical (ALARP). This is discussed in Section 8 of this CHRMAP.

The vulnerability of the identified assets has been calculated based on the guidelines outlined in Table 7.6 in addition to the completed risk assessment and are shown in Table 7.7.

Table 7.7 Assessment of Vulnerability of Coastal Erosion and Overtopping Impacts

Key Assets	Assessed Risk Level				
	Present Day	2040	2065	2090	2115
Beach Access Stairs	Low	Low	Medium	Medium	Medium
Dual Use Path	Low	Low	Low	Low	Low
Access Road	Low	Low	Low	Low	Low
Car Park	Low	Low	Low	Low	Low
Toilet Block & Changerooms	Low	Low	Low	Low	Low
Park Areas	Low	Low	Low	Low	Low
Café / Restaurant	Low	Low	Low	Low	Low

As can be seen in Table 7.7 all of the key assets have a Low or Medium vulnerability to coastal erosion and overtopping over the 100 year planning horizon to 2115. None of these assets will require risk mitigation adaptation for the coastal erosion and inundation hazards.

8. Risk Adaptation & Mitigation Strategies

SPP2.6 outlines a hierarchy of risk adaptation and mitigation options, where options that allow for a wide range of future strategies are considered more favourably. This hierarchy of options is reproduced in Figure 8.1.

Figure 8.1 Risk Management & Adaptation Hierarchy

These options are generally outlined below.

- Avoid – avoid new development within the area impacted by the coastal hazard.
- Retreat – the relocation or removal of assets within an area identified as likely to be subject to intolerable risk of damage from coastal hazards.
- Accommodation – measures which suitably address the identified risks.
- Protect – used to preserve the foreshore reserve, public access and public safety, property and infrastructure.

The assessment of options is generally done in a progressive manner, moving through the various options until an appropriate mitigation option is found.

8.1 Proposed Strategy

Despite the risks over the 100 year planning timeframe to 2115 generally being tolerable for all of the key assets, the As Low As Reasonably Practical (ALARP) approach has been adopted for the planning to reduce the extent of impacts should a severe event occur.

The overarching strategy for the proposed development is the use of the Avoid and Planned or Managed Retreat risk management options. Wherever possible all key assets included as part of the proposed development have been located outside of coastal hazard areas. Assets that need to be located within coastal hazard areas will adopt a Planned or Managed Retreat strategy.

The strategy for the proposed development will also need to comply with the adaptation option selected for the Iluka Coastal Node as part of the City's draft overarching CHRMAP (MRA 2022). An adaptation option being considered for the Iluka node is sand nourishment of the sandy beaches within the node. This nourishment would likely provide a small amount of additional erosion protection to the Beach Access Stairs and the Dual Use Path assets.

The beach access stairs and dual use path have low coastal hazard risks over the 50 year planning timeframe to 2065. However, after 2065 the coastal hazard risk increases for these assets.

Managed retreat of these assets is recommended when they are to be replaced or when coastal monitoring indicates that they are under threat from undercutting/erosion of the cliff. It is likely these assets would be replaced several times over the 100 year planning horizon and they could therefore be relocated in more appropriate locations at the end of their service life. A geotechnical assessment should be completed at the time of relocation to ensure they are constructed in a suitable location that won't be undercut by waves or eroded over the design life.

All other assets are recommended to adopt an Avoid adaptation strategy through the 100 year planning timeframe. This has already been included in the layout of the proposed development through the location of the key assets landward the coastal hazard lines.

9. Monitoring & Review

Coastal monitoring and review is essential to track changes to the shoreline over time. Whilst the results of Section 3 provide an indication of the potential changes to the shoreline (and incorporate a justifiable level of conservatism), the unpredictable nature of erosion of the rock shoreline is inherently complex and the actual shoreline response could be different to that presented.

Monitoring of the rock cliffs should therefore be completed to track changes over time and indicate whether the timing for risk mitigation should be adjusted. This is in line with the recommendations of the geotechnical assessment for Burns Beach (CMW 2016), which recommended that ongoing observations of the coastal cliffs be undertaken on a regular basis. This would allow any infrastructure at risk of erosion to be identified, as well as public safety hazards associated with cliff overhangs to be highlighted.

The rock cliff monitoring should be completed using a combination of onsite measurements and photographic monitoring. Such monitoring could be undertaken by City staff who may seek expert advice from external sources as considered appropriate. This monitoring would likely be completed as part of the City's overarching coastal monitoring program, which covers the whole City coastline.

If the rate of change in shoreline position observed during the monitoring is materially different from that allowed for with the erosion hazard assessment, it is recommended that this CHRMAP be updated to quantify any changes to the risks posed by coastal hazards. Likewise, should the State Government guidance on the required allowances for sea level rise change as a result of new information becoming available, the CHRMAP should also be updated.

10. Conclusions

CHRMAP has been completed to provide guidance to the City on required adaptation and management actions associated with the proposed development of the foreshore at Burns Beach. This assessment has also included existing and ongoing assets in this area. It has been completed in line with the recommendations of SPP2.6 and WAPC (2019).

The coastal erosion and inundation hazards for the site were determined for a range of planning timeframes. Using geotechnical data available from the site and historical measurements of limestone rock erosion from around south-west Australia, appropriate coastal erosion hazard lines were determined.

The appropriate coastal inundation levels were determined through cyclone modelling of the 500 year ARI event and include allowances for sea level rise. The extent of wave overtopping influence during the 500 year ARI inundation event was also calculated.

The risk assessment has shown that the proposed development should be located at least 5 m behind the current rocky shoreline. This would provide a low risk of impact from coastal erosion, inundation and wave overtopping over the 100 year planning timeframe to 2115. All risks to the proposed development are tolerable and as such no adaptation planning is required. However adaptation planning measures have been suggested to maintain an ALARP approach.

Monitoring of the rocky shoreline should be completed on a regular basis to identify any rapid changes that may occur on the slope that create an immediate or increased erosion or public safety hazard. This is in line with the recommendations of the CMW (2016) geotechnical report for Burns Beach. Such monitoring could be completed as part of the city wide coastal monitoring program.

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12. Appendices

Appendix A Coastal Hazard Map

Appendix A Coastal Hazard Map

AT CORRECT SCALE THIS IS 100 mm

AT CORRECT SCALE THIS IS 100 mm

LEGEND:

- ROCK SHORELINE
- 2115 HAZARD LINE (INCLUDING OVERTOPPING)

NOTES:

1. AERIAL PHOTOGRAPH FROM LANDGATE TAKEN IN OCTOBER 2021.
2. LANDSCAPE PLAN PROVIDED BY CITY OF JOONDALUP ON 28 APRIL 2022.
3. HORIZONTAL DATUM IS MAP GRID OF AUSTRALIA IN GDA2020. VERTICAL DATUM IS AUSTRALIAN HEIGHT DATUM (AHD).

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DRAWN	R BORJA	BURNS BEACH - COASTAL HAZARD LINE	JUNE 2022
CHECKED	T HUNT	CITY OF JOONDALUP	SCALE AT A3 1:1,000
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