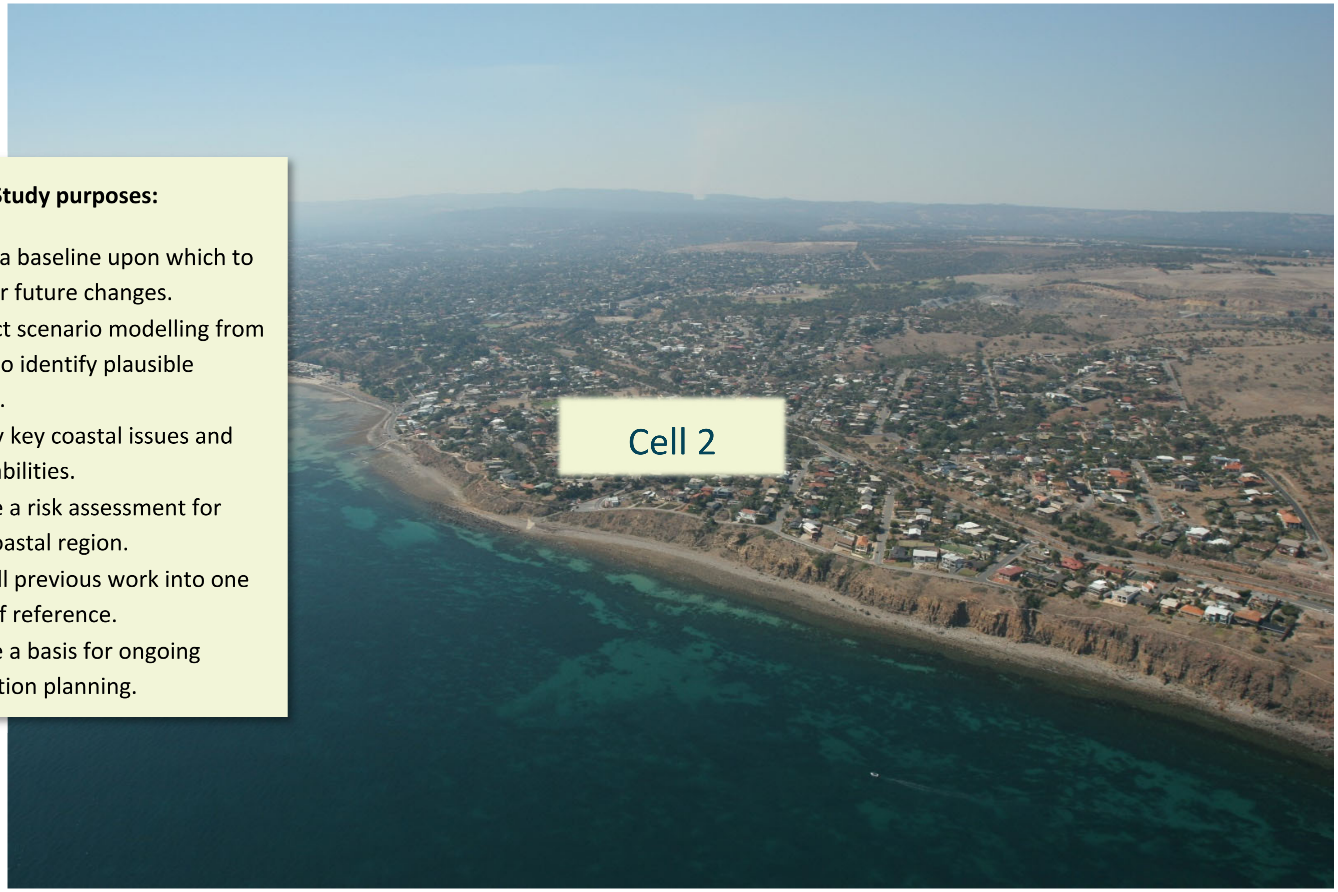
Coastal Adaptation Study

# HALLETT COVE CLIFFS NORTH




**Study purposes:**

- Create a baseline upon which to monitor future changes.
- Conduct scenario modelling from which to identify plausible futures.
- Identify key coastal issues and vulnerabilities.
- Provide a risk assessment for each coastal region.
- Bring all previous work into one place of reference.
- Provide a basis for ongoing adaptation planning.

By Integrated Coasts

Review date 1 December 2022

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**Report reference:**

Western, M. et al, 2022, Coastal Adaptation Study, Marino Cliffs, for City of Marion, Adelaide, South Australia.

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South Australian Coast Protection Board, oblique photograph, 2014.

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# 1. Introduction

This coastal cell report is a review of the *Coastal Adaptation Study for City of Marion, 2018*. These cell reports are now structured within a template so that future reviews can also build upon this report. The final section, *Summary and Recommendations*, is designed as a standalone section that can be used in other reporting contexts and acts in a similar way to an Executive Summary.

## PROJECT SCOPE

### Climate Variables

Managing projected climate change impacts involves dealing with 'deep uncertainty'[1]. This uncertainty is primarily related to the nature of long-term projections which are based on climate models. These models are computer-based simulations of the Earth-ocean-atmosphere system. Models are effective at simulating temperature, but their accuracy is much less for the simulation of rainfall[2]. Overall rainfall is expected to decline in our region over the coming century and the intensity of rainfall events is expected to increase, but these projections are not assigned with as much confidence as for temperature or sea level rise. Furthermore, the climate is a complex system and the variables interdependent. For example, on the one hand we might predict that declining rainfall would produce a more arid climate and therefore less vegetation but a recent study by NASA has found that over the last 35 years the planet has been greening, and that increased carbon dioxide in the atmosphere is 70% responsible[3]. As we learn more about the climate system and obtain more data over time, observable trends and projections will also become more certain.

### Direct and indirect impacts

Some climate change impacts are more direct than others. Rising sea levels will directly impact the landforms adjacent the coast, either through increasing inundation of lower lying areas, or increasing erosion. Other impacts will be less direct. For example, projections for a drier climate are often associated with less vegetation in dunes, and the increased cracking of cliffs[5]. Increased intensity of rainfall events may increase the erosion and gullying of cliff-tops thereby increasing the potential for increased rates of recession and instability. The impact of rising sea levels can be assessed through sea flood modelling within digital models. The impact of vegetation loss cannot be easily quantified and as noted above, is based upon less certain projections. Attempting to incorporate too many impacts into a coastal study is likely to compound the level of uncertainty and deliver less clear outcomes.

### Direct and indirect risks

Direct risks relate to the impact of rising sea level on the fabric of the coast. Different areas of coast will be vulnerable to different risks. Low lying areas will be more likely to be vulnerable to inundation and soft sediment backshores more vulnerable to erosion. In this study we evaluate the direct impact of *inundation* and *erosion* in four main receiving environments:

- Public assets
- Private assets
- Safety of people
- Ecosystem disruption.

Associated with these direct risks are a range of indirect risks. For example, the potential loss of a beach from erosion is a potential social and economic risk (if the beach is related to an activity such as tourism). A political risk may occur when the decision makers act in ways the communities do not support.

### Project focus

To increase certainty, this project evaluates the *direct impacts* of inundation and erosion in the context of *rising sea levels*. In a bid to contain focus, this study assesses the *direct risks* to assets, people and ecosystems that are positioned within coastal regions.

[1] https://coastadapt.com.au/pathways-approach
[2] https://coastadapt.com.au/how-to-pages/how-to-understand-climate-change-scenarios
[3] https://www.nasa.gov/feature/goddard/2016/carbon-dioxide-fertilization-greening-earth
[5] Resilient South (2014) Regional Climate Change Adaptation Plan, URPS and Seed Consulting, p.22 (and technical report p.3)

# 1. Introduction

## ASSESSMENT FRAMEWORK

Coastal hazards experienced along a section of a coastline can be assessed in three main ways.

**Coastal fabric (geology)**

Intuitively we understand that if we are standing on an elevated coastline of granite that the coast is not easily erodible. Conversely, we understand if we are standing on a low sandy dune that erosion may indeed be a factor. It is the geology of the coast upon which our settlements are situated that determines one side of the hazard assessment in terms of elevation (height above sea level), and the nature of the fabric of the coast (how resistant it is to erosion). Coastal geology is assessed in four main ways:

(1) Low erodibility
(2) Moderate erodibility
(3) High erodibility
(4) Very high erodibility

**Coastal modifiers (human intervention)**

In some locations there are additional factors that modify this core relationship between fabric and exposure. For example, an extensive rock revetment has been installed from Brighton to Glenelg which has modified the fabric of the coast from dunes to rock.

**Coastal exposure (actions of the sea)**

If we find ourselves on the shore of a protected bay, or in the upper reaches of a gulf, we intuitively know that the impact from the ocean is likely to be limited. On the other hand, if we are standing on a beach on the Southern Ocean and listening to the roar of the waves, we understand that we are far more exposed. Coastal exposure is assessed in four main ways:

(1) Very sheltered
(2) Moderately sheltered
(3) Moderately exposed
(4) Very exposed

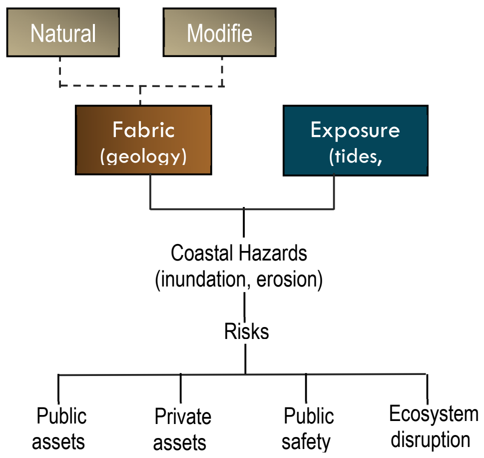
## CHANGES IN THE RELATIONSHIP

Finally, we are also interested to know how this relationship between ***fabric*** and ***exposure*** may change over time, and what this may mean in the context of our coastal settlements.

Our sea levels have been quite stable for several thousand years after a ~1m drop in sea level ~6000-4000 years ago. However, in recent times, the rate of sea level rise has increased. Last century, sea levels rose on average ~1.7mm per year. Since 1990, seas are rising on average at ~3-4mm per year in our region[67]. The consensus is that the rate of sea level rise will escalate towards the end of this century.

While the projected rate of sea level remains uncertain, what is certain is that if seas rise as projected, then the relationship between fabric and exposure will change significantly in coastal locations.

**Figure a: Conceptual framework**




The aim of this project is to evaluate the relationship between the ***fabric*** of the coastline and its current ***exposure*** to actions of the sea and how this relationship may change with rising sea levels. We conduct this evaluation within the regional setting of secondary coastal cell **Adelaide Coast** (CoastAdapt) and within tertiary cell **Hallett Cove Cliffs North, Cell 2.**

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[6] Watson, P., 2020, Updated mean sea level analysis: Australia. Outer Harbor 2.5mm (1945 – 2018), satellite 3.5mm since 1990.

[7] See also sealevel.info and calculate rises from 1945 to 1990 (2.09mm) and compare with 1990 to 2022 (3.6mm).

# 1. Introduction

Regional Setting

Cell 2

Secondary Cell: Adelaide Coast

Secondary Cell

**Australian regional setting**

Hallett Cove Cliffs (north) is situated within Adelaide Coast secondary cell.

**Geomorphology of the cell:**
The northern section of this compartment comprises ~30km of Holocene sandy coast.
South of Adelaide, the coast is dominated by a series of arcuate north-easterly trending faults.
This section of the coastline features uplifted zones associated with prominent cliffs and headlands, with sandy embayments occupying fault angle depressions. There is minimal sediment supply, with small creeks and rivers. Littoral drift is to the north and sand supply is expected to decline causing recession to embayed beaches.

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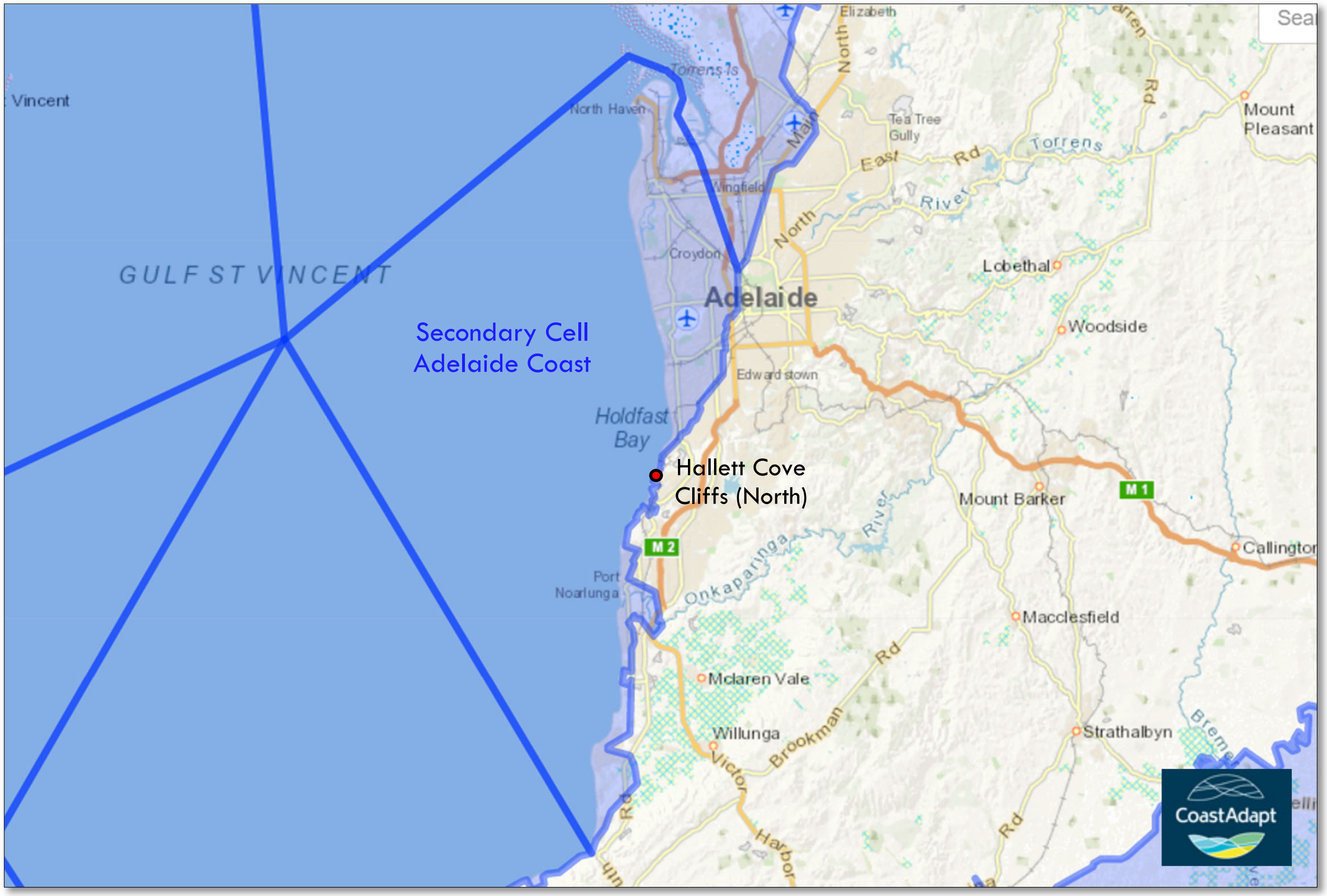


The dominant regional processes influencing coastal geomorphology in this region are the Mediterranean to humid cool-temperate climate, micro-tides, high energy south-westerly swells, westerly seas, carbonate sediments with interrupted swell driven longshore transport, and the Southern Annular Mode (driving dominant south-westerly swells and storms). Much of the Adelaide coast is protected from south-westerly swell waves because of the sheltering effect of Kangaroo Island. The tidal range increases from microtidal to mesotidal towards the head of Gulf St Vincent. **https://coastadapt.com.au/sites/default/files/docs/sediment_compartments/SA02.01.04.pdf**

# 1. Introduction

**Regional Setting**

Cell 2
Tertiary Cell:
Hallett Cove Cliffs North
Tertiary Cell

**Relative Exposure**
Moderate

**Wave energy**
Low

**Shoreline class**
Low tide terrace and Rock.

**Substrate**
Exposed bedrock with both cobble and coarse sand present.

Source: Nature Maps (SA)

Notes:
Minor cells represent in blue are areas where geomorphologic factors are different from neighbouring areas and require independent analysis.

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# 2. SETTLEMENT HISTORY

A historical review ensures that the circumstances in which the settlement was founded are understood, identifies how actions of the sea have interacted with the settlement, and builds appropriately on previous study. In this section we:

- Give a brief history of the settlement
- Review archives at Coastal Management Branch
- Identify key coastal studies
- Identify implementation of key coastal structures

# 2. Settlement history

The first purpose of this section is to identify the key factors of settlement history in the context of the coastal environment. In particular, we identify human interventions, ocean impacts, and past protection and management strategies. The second purpose is to identify key studies and plans so that we build appropriately upon previous work and bring all previous work into one place of reference.

## BRIEF HISTORY

**Aboriginal Settlement at Hallett Cove**

Aboriginal settlement at Hallett Cove is believed to date back 40,000 making it one of the earliest in Australia. The original inhabitants appear to be the Kartan people whose presence is recorded through large stone implements found near the coast and the Waterfall Creek camp site. More recent settlement of the area was by the Kaurna people and their occupation dates back 2000 years before present.

**Early European settlement**

Hallett Cove was first explored by Europeans in 1837 when John Hallett visited the area while searching for wandering livestock. Farming was conducted in the area from 1850s to the 1970s.

**Residential settlement and expansion.**

The research conducted into the cliff collapse at The Esplanade in 1996 (see below) concluded that the initial subdivision was likely to have been completed in England with an esplanade road designed impractically over deep gullies[8]. This may account of the road name and position of 'The Esplanade', on the southern section of this cell.

Residential development occurred either side of Hallett Cove Cliffs (North) first at Marino in early 1900s, and Hallett Cove Beach area in 1970s. Residential development began in this cell in the 1970s and appears to generally have spread northwards culminating with the development of Westcliff Court in the 1990s.

Land was purchased by the State Government in the 1970s for the establishment of Hallett Cove Conservation Park, part of which is situated within this cell (including Waterfall Creek).

**Cliff slump – The Esplanade**

In October 1996, a section of the upper cliff slumped at the Esplanade, Hallett Cove. Investigations concluded that the collapse was caused by a combination of the natural geology and an unusually wet winter. A resident who was living nearby at the time suggested that a leaking water pipe may have caused the slump[9]. Coast Protection Board concurred that the land slide was not as result of any coastal processes, and also refused any funding for rectification works (on that basis). A review of all the reports suggests that both the Council and the State Government received legal advice that neither were liable for the landslide. However, Council did raise funds to further collapse the cliff and stabilise the situation. In addition, two housing allotments were purchased and houses demolished.

Figure a: Cliff slump in 1996. The slope of the coastal cliff was mechanically lowered, and two houses demolished.

[8] Fotheringham, D (1996) Communication to Minister for Environment and Natural Resources regarding potential collapse of cliff at The Esplanade.

[9] Conversation with a resident in the area ~April, 2022.

# 2. Settlement history

## COASTAL STRUCTURES

Due to the elevated coastal terrain and general inaccessibility to the beach, very few coastal structures have been installed to the beach. The walking trail installed in the 1990s is primarily constructed along natural ground, interspersed by stairs and walkways that connect the walkway across the various gullies. One access point is provided to the beach by way of stairs in the vicinity of The Esplanade (Figure a).

Parts of the walking trail were closed in 2019 and repairs undertaken before reopening in 2020.

Figure a: Coastal walking trail with access stairs and ramps and one access point to the beach.

## COASTAL STUDIES AND PLANS

The purpose of this section is to bring all previous work into one place of reference for the Hallett Cove Cliffs (north) Coastal Cell 2. However, it is also recognised that the production of studies and plans is always ongoing, and updated studies can be located from the City of Marion website.

**Hallett Cove Coastal Management Study, 2012.**

This was a comprehensive study produced by Doug Lord with a focus on the Hallett Cove Beach and Field River area but provides a comprehensive review of the geomorphology, coastal processes, and history of the Hallett Cove region (See Cell 3 for a more complete review).

**Coastal Management Strategy Plan, 1997.**

This report prepared by Kinhill Engineers provides insight into issues under consideration at the time, including storm water run-off over cliffs, dune erosion, cliff stability issues. One of the main issues under consideration was the forming of the coastal walkway. The report also provides a full inventory of coastal features including storm water outlets, and coastal protection measures. The study stated,

> 'the coastal management strategy for Marion seeks to promote improvements in the management of the coastal strip by developing a coastal management plan which identifies appropriate uses and adjoining buffer areas, access paths, traffic management, car parking, the location of visitor facilities and tourist opportunities'.

In particular, the report recommends to:

- Develop opportunities for stormwater management improvements,
- Augment existing initiatives to protect sand dune areas where necessary to ensure the retention of dunes,
- Develop a revegetation programme for the coastal areas[10].

**The Hallett Cove Creeks Stormwater Plan (2012).**

This study investigated the storm water system for three catchment areas located in Cell 2 and 3 and made recommendations for improvement.

The study used a 1 in 10 ARI rainfall event which it considered the standard event to use in evaluating the effectiveness of stormwater infrastructure capacity. Coincidently, such an event did occur within the study period and the effectiveness of the system was evaluated in that context.

The report did note that climate change may lead to changes in frequency, intensity, and duration of

[10] Kinhill Engineers (1997) Draft Coastal Management Strategy Plan

# 2. Settlement history

**The Hallett Cove Creeks Stormwater Plan (cont).**

rainfall patterns. However, because the time frame of the study was limited to 2050, no account was taken of increased rain intensity in the study. The report concluded that stormwater infrastructure was assessed as meeting performance standards in line with current expectations (with a few exceptions).

The key issues flagged for improvement were:

- Erosion of Waterfall Creek channel, along most of its length,
- Lack of stormwater quality improvement measures,
- Lack of stormwater harvesting and reuse,
- Various upgrades and strategies, but none relating to ocean outfalls (apart Heron Reserve).

The report noted that while most of the study area is drained to watercourses or gullies which do ultimately drain to the sea, there are a number of stormwater drainage systems that discharge directly to the Gulf. The concern is that these outlets discharge well above beach level, with little or no erosion control or pollutant interception measures in place. Australian Water Environments (AWE) reviewed these outlets in 2005 and developed concept designs to address the issues identified as outlined in the table at right[11].

[11] Southfront (2012), Hallett Cove Creeks Stormwater Plan, Table 4.3

**Resilient South, 2014.**

The Southern Adelaide region (Holdfast Bay, Mitcham, Marion and Onkaparinga Councils) cooperated together to produce the Resilient South Climate Change Adaptation Plan (2014). In relation to coastal adaptation, the regional plan explains the general impacts of rising sea levels, changes to rainfall patterns, and increased erosion, but does not specifically review the coastal environs of City of Marion nor identify any preferred coastal adaptation options for City of Marion.

Resilient South now has a website where all studies and projects can be accessed. Resilient South.

| Location | AWE Ref | AWE Recommendation | Status |
|---|---|---|---|
| Westcliff Ct | 11 | No work required | - |
| Nungamoora St | 13 | Install GPT | Outstanding |
| Peera St | 14 | No work required | - |
| Fryer Street | 16 | Install GPT | Outstanding |
| Clifftop Cr | 18 | Install rock-lined overflow swale | Completed (refer photo below) |
| Grand Central Ave | 21 | Install GPT | Outstanding |

Figure a. Table from Hallett Cove Creeks Stormwater Plan (2012). Note, some of these items such as the upgrade works at Grand Central Avenue may have been completed.

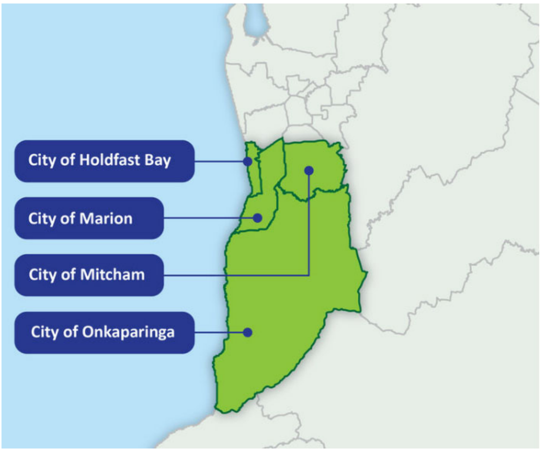


Figure b. Resilient South is a climate change adaptation plan was produced as a cooperation between four Councils.

**Climate Change Adaptation Governance Assessment Report for the City of Marion 2019.**

This study prepared by Climate Planning and Seed Consulting Services in 2019 assessed how well City of Marion is incorporating climate change adaptation governance into their corporate processes and frameworks. The Project Team conducted a governance assessment of the City of Marion to explore how climate change was considered in their corporate documents and assessed against ten quantitative governance indicators.

# 2. Settlement history

**Climate Change Adaptation Governance Assessment Report (cont).**

The report concluded that City of Marion has considerable inclusion of climate change in its formal governance documents. This meant that not only could staff identify key physical climate risks to the functions of Council, they could also identify clear corporate strategic drivers for decision making. There was also consistent understanding of climate change risks from an officer to senior executive level.

The fact that climate change has been considered in all of the ten key governance indicators sees it placed as the leader in Australia (compared to the 200 councils who have been assessed). The project was primarily concerned with governance issues and no specific assessment was made in regard to coastal risks.

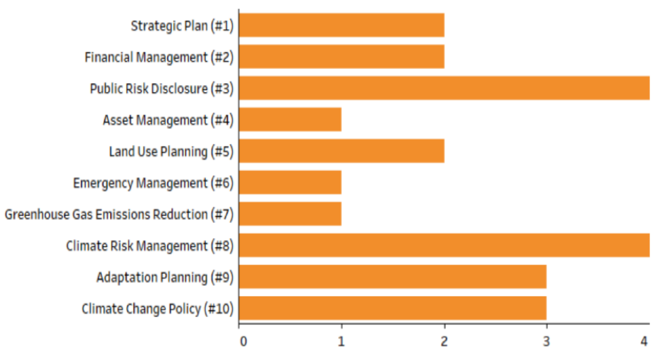


Figure a. Results of governance assessment for the City of Marion, 2019.

## STRATEGIC PLANS AND POLICIES

City of Marion develops and updates strategic plans and policies on a regular basis and these can be located on the City of Marion website:

**Climate Change Policy (2021-2025)**

City of Marion Climate Change Policy was adopted on 11 May 2021 and will be reviewed by 11th May 2025. The primary objectives of the policy are:

- To incorporate climate change mitigation and adaptation into strategic and operational activity…,
- To support residents, businesses, and local ecosystems to build resilience and adapt to the impacts of a changing climate.
- To work in collaboration with regional partners and the wider community.

**Other strategic plans and policies**

- Community Vision: Towards 2040 (adopted 26 July 2016)
- Strategic Plan 2019 – 2029 (endorsed August 2019)
- Business Plan 2019 – 2023 (endorsed June 2019)
- Environmental Policy (endorsed November 2019)
- Carbon Neutral Plan, 2020 – 2030.

[Project note: a full list of plans and updates is available from City of Marion website.]

**Settlement History**
**Key Points**

Hallett Cove Cliffs (north) was developed for residential housing in 1970s, shortly after Hallett Cove Beach. Development generally progressed from the south to the north culminating with Westcliff Crescent in the 1990s.

A large proportion of Hallett Cove Conservation Park is situated in the southern section of this cell, including Waterfall Creek.

A cliff slump occurred in 1996 at the Esplanade which resulted in demolition of two houses and purchase of the allotments by Council. The slope of the cliff was mechanically lowered. The cause of the slump was not deemed due to coastal processes but more likely due to storm water runoff.

There are very few coastal structures due to the elevated and rugged terrain. The coastal walking trail is positioned at the top of the cliff, mostly along natural ground, but connected by stairs and boardwalks in gully locations.

All studies and plans can be located on the City of Marion website, apart from Coastal Management Strategy Plan, 1997. Key studies include:

- Hallett Cove Coastal Management Study (2012)
- Hallett Cove Creeks Stormwater plan (2012)

# 3. GEOMORPHOLOGY

The study of coastal geomorphology analyses how the coast was formed and how the coast has changed over time. The study provides the ‘bigger picture’ for understanding how sea level rise may interrelate with the coastline in the future.

For a fuller explanation of the coastal geomorphology of the region see Hallett Cove Coastal Management Study by D. Lord completed for City of Marion, 2012.

# 3. Geomorphological context

## GEOLOGICAL SETTING

**Structure of the coastline**[12]

The basic structure of the Adelaide Metropolitan coast is influenced by a series of prominent arcuate (curved) faults. In particular, the Eden-Burnside Fault, the Clarendon-Ochre Cove Fault and the Willunga Fault have produced major escarpments, which intersect the coastline and run out to sea, where the faults are best exposed. Uplift and back tilting of the fault blocks has produced associated fault angle depressions occupied by the Adelaide Plains Sub-Basin, the Noarlunga Embayment and the Willunga Embayment (Figure a), which have been infilled with sediments over the past 40 million years. More recently in the Holocene period, the sandy beaches and dunes were formed on the low-lying embayments. The City of Marion coastline is entirely positioned within the elevated Eden-Burnside Fault which separates the Noarlunga embayment to the south and the long stretch of low-lying Metropolitan beaches to the north.

***Resistant*** Neoproterozoic rocks extend from the Marino Rocks boat ramp to Hallett Cove Conservation Park (Cell 1,2). Cliff exposures of siltstone, shales and sandstones from this period get progressively younger from north to south. Despite these sedimentary rocks now being metamorphosed into harder rocks, sedimentary layers are still distinguishable and form distinct shore platforms. There is very little sand, and any beaches comprise of shingles (rocks).

Hallett Cove Beach (Cell 3) is an internationally important site geologically because features of the Permian glaciation are preserved here, and numerous large boulders (glacial erratics) occur on the beach. The host sediments to the boulders, deposited during the Permian glaciation, have been more recently exposed by coastal erosion. The only river in this section of coast is the Field River at the southern end of Hallett Cove.

From Hallett Cove to Port Stanvac (Cell 4), ***resistant*** folded Neoproterozoic strata form cliffs up to 20 m high, with the adjacent serrated shore platforms revealing complex folds of the Delamerian Orogeny period (>500 million years).

Sea levels have cycled between 2m above present sea level during the Last Interglacial Maximum (the last time the earth was free of ice, 132-118ka) to 125m below present sea level during the Last Glacial Maximum (the maximum ice extent, 21 ka). These major cyclic fluctuations in sea level meant that the present area of Gulf St Vincent was periodically exposed as dry land, and some higher sea level events such as the Last Interglacial experienced even larger areas of sea coverage. Furthermore, the climate at that time was warmer and wetter than today, with the Leeuwin Current bringing warmer ocean surface waters from Indonesia and the north-eastern Indian Ocean.

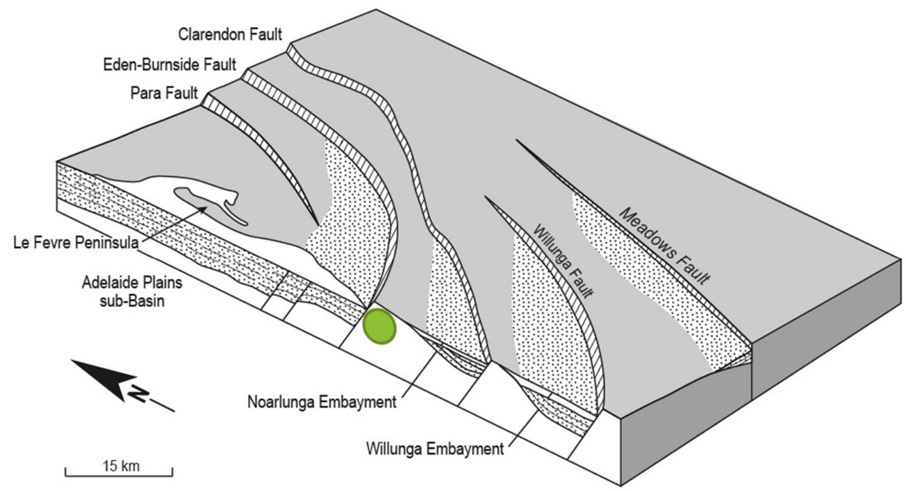


Figure a: The geological setting of the coastline between Sellicks Beach and the metropolitan area. The prominent fault scarps consist of uplifted ancient rocks, resistant to erosion, while the embayments are occupied by younger and more easily eroded rocks and sediments. The City of Marion coastline is positioned within the Eden-Burnside Fault.

[12] Bourman et al, 2016, Coastal Landscapes of SA, University of Adelaide Press.

# 3. Geomorphological context

## GEOLOGICAL SETTING

In simple terms, the geomorphology of coasts is assessed in three main parallel zones: the subtidal, intertidal and backshore. The intertidal zone consists of the area between low and high-water marks. The backshore is typically characterised as up to 500m inland of the intertidal zone[10].

The Marion Coastline has been divided into coastal cells based upon geological layout (Figure a). The Marion coastline is predominantly a combination of *sloping hard-rock shores* and *sloping soft-rock shores*. Sections of *undifferentiated rock shores* refer to locations which are not easily classified as hard or soft rock and can generally be assigned an erosion classification between the two. The Field River area is assigned as 'river mouth'. Hallett Cove Beach is assigned 'sloping soft-rock shores'. The elevated geology of the Marion Council coastline means that the coastline is not subject to inundation. The exceptions are The Esplanade, Marino, and the Field River area, but these are also backed by steeply sloping backshores. The extensive areas of cliff categorised as *sloping hard rock shores and undifferentiated rock shores* suggest that the City of Marion coastline is not subject to rapid erosion. Areas categorised as *sloping soft rock shores* such as Hallett Cove Beach are more likely to be vulnerable to erosion. This assessment is supported by analysis by CoastAdapt which assigns almost the entire coast as *dominantly hard rock shores* with a low erodibility outlook[13].

Dr Miot da Silva and Dr Robert Bourman assess the cliff vulnerability in this region as 'low to moderate' erodibility composed by sedimentary to meta-sedimentary rocks ranging from Pleistocene to Neoproterozoic ages. These rocks are not the very 'low erodibility' type of rock associated with basement rocks such as igneous basalts and granites, nor high erodibility of the unconsolidated sediments of the recent Holocene period, and therefore fall between the two classifications. As such, these rocks are not readily erodible, but the presence of rock platforms indicate that cliffs have eroded and retreated in the past over long time periods.

[10]http://www.ozcoasts.gov.au/coastal/introduction.jsp
[13] https://coastadapt.com.au/coastadapt-interactive-map

Figure a. Geological layout of city of Marion coastline.

# 3. Geomorphological context

## SEDIMENT BALANCE - SAND SUPPLY FOR THE COAST

**Gulf St Vincent**

Sand deposits along the coast were likely deposited by the wind in the last ice age when seas were up to 120m lower than present. As the ice melted and sea levels rose, these sediments formed the current layout of the beaches. Since sea levels stabilised over the last 7000 years the coast has slowly been losing sand which is unable to be replaced. This lack of sand supply to Gulf St Vincent is compounded because littoral drift (sand movement) is to the north and the Adelaide coastline only has small creeks and rivers that deliver minimal sediment to the coast. Therefore, sand supply is expected to decline causing recession to embayed beaches[14].

**Hallett Cove and Marino beaches**

The Hallett Cove Coastal Management Study (HCCMS) has thoroughly evaluated the coastal processes in Gulf St Vincent as they impact upon the Marion coastline and should be relied upon in the final coastal adaptation plan[15].

The HCCMS summarises the sediment environment in Hallett Cove Beach region:

> The foreshores of Hallett Cove present as a slowly receding coastline, starved of sediment. The available coastal process modelling indicates the potential for sand transport out of the Hallett Beach compartment (100,000m$^3$ / year) is an order of magnitude greater than the natural rate of sand supply along the coastline from the south (5000m$^3$/ year)[16]….
>
> While the community perception that the sand cover has reduced over the past 30 years may be true, the likelihood is that over historical times the volume of sand on the beach has always been small and variable, providing a thin sand veneer from time to time over sections of the exposed shingle [and that] additional sand cover is unlikely to be a practically achievable outcome.

**Geomorphology**

**Key Points**

1. The coastal lands of City of Marion are set in the vicinity of the Burnside-Eden fault (area of uplifted land) and therefore generally elevated well-above risk of inundation from current and future storm activity. The exceptions are The Esplanade at Marino and the area around Field River. However, in both these locations the backshores slope upward steeply away from the coast.

2. The coastline consists predominantly of hard-rock sloping shores (Coast Adapt) and Bourman et al (2016) characterise the cliffs areas as 'resistant'. Exceptions to this resistant characterisation exist with Hallett Cove Beach and Field River area (Cell 3) which are backed by softer sediments. Pockets of less resistant rocks also exist at Marino (The Esplanade and Marino Rocks carpark).

3. The City of Marion coastline is much older than the Onkaparinga coastline to the south and the Metropolitan beaches to the north (both which were formed in the Holocene Period, 11.7ka) when seas rose to their current level.

4. Generally, the City of Marion coastline has always consisted of rock platforms and pebble beaches. In relation to Hallett Cove Beach, it is likely that sand levels were higher in the past, but sand cover has always been limited to a thin veneer over a rocky beach.

5. Within Gulf St Vincent sand levels are expected to continue to decline due to the inability of the coastal environment to replace sediments that were deposited at the last interglacial period. The movement of sand is northward, and Gulf St Vincent contains only small rivers and creeks that deliver minimal sediment to the coast.

[14] Bourman et al, Coastal Landscapes of SA, p. 66.
[15] D. Lord., Coastal Management Study, Hallett Cove, SA. 2012, pp 17-26.
[16] HCCMS suggests that this calculation is based on modelling at O'Sullivan Beach boat ramp.

# 4. COASTAL FABRIC

In this section we evaluate coastal fabric in more detail:

- Overview of the current coastal fabric
- Changes to shoreline over seventy years
- Human intervention (coastal modifiers)

**Viewing instruction:**

View the coastal fabric section utilising full screen mode within your PDF software (Control L). Then use arrow keys to navigate.

# 4.1 Coastal fabric - overview

**Introduction**

It is the geology of the coast upon which our settlements are situated that determines one side of the hazard assessment in terms of elevation (height above sea level), and the nature of the fabric of the coasts (how resistant it is to erosion). In some locations, humans have intervened and changed the nature of the coastal fabric. For example, a construction of a seawall changes the fabric from sand to rock. The construction of an esplanade road too close to the coast can install rigidity in the backshore, which formerly could naturally adapt to erosion and accretion cycles. Some interventions change the way in which the beach operates, and new erosion problems are created.

**Why evaluate shoreline change?**

Beaches undergo normal cycles of accretion and erosion which may span time measured in decades. These changes can be observed in two main ways. The position of the shoreline changes, and the levels of sand change on the beach. In times of erosion, the shoreline tends to recede, and sand levels become lower. In times of accretion, the opposite is true. If sea level rises as projected, then shorelines are likely to go into longer term recession. The purpose of evaluating the historical changes to the shoreline is to formulate a baseline understanding of how the coast has been operating in the past. In the context of rising sea levels, identifying future shoreline recession trends will assist us to identify when the beach begins to operate outside its normal historical range.

**What is the shoreline?**

The shoreline is the position of the land-water interface at one instant in time. But in reality, the shoreline position changes continually through time because of the dynamic nature of water levels at the coastal boundary. The best indicator of shoreline position is the location of the vegetation line. In other circumstances the shoreline may be the base of a cliff, an earthen bank at the toe of a slope, or a seawall in locations where humans have intervened.

**How will we analyse the shoreline?**

The analysis includes:

- Comparisons of aerial photography from 1949 to current day. This requires very fine-grained georeferencing of photography to ensure that comparisons are accurate.
- Comparison of surveyed profile lines which have been conducted by SA Coast Protection Board since the 1970s (if within the cell).
- Evaluation as to how humans may have intervened in the coastal fabric and how this intervention may have changed the natural operation of the coast.

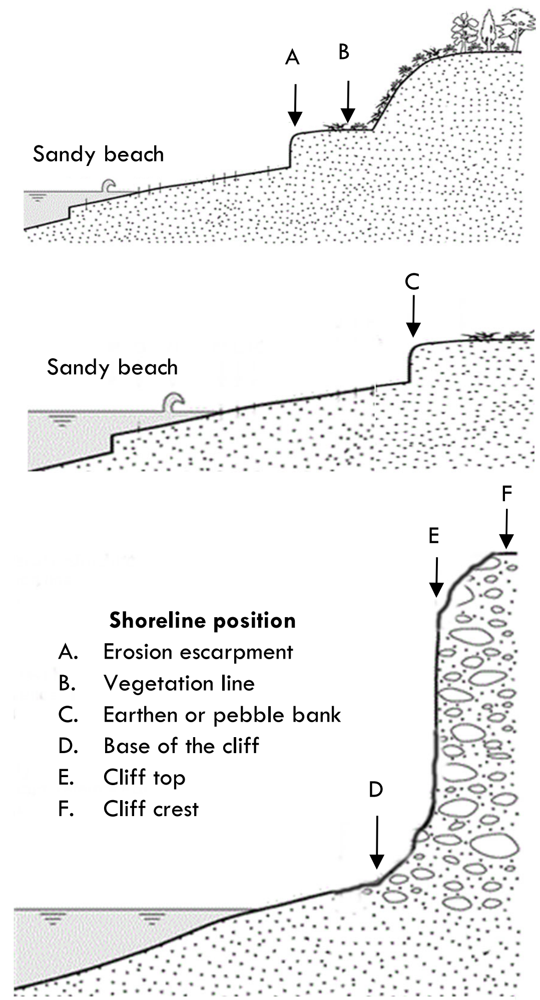


Figure a. Adapted from Boak and Turner (2005), Shoreline definition and detection.

# 4-1 Coastal fabric - overview

| Overview |
|---|
| Marion (Cell 2) |

Secondary Cell: Adelaide Coast

Tertiary Cell: Hallett Cove Cliffs (North)

Form

***Beach***
Rocky platform with areas of high tide cobbles below the cliffs.

***Backshores***
5 – 50m high cliffs which are likely resistant

***Bathymetry***
Overall slope of ocean floor:
-5m ~ 50m to 550m from beach
(overall slope ratio ~1:100).

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# 4-1 Coastal fabric - overview

## Overview

### Marion (Cell 2)

Secondary Cell: Adelaide Coast

Tertiary Cell: Hallett Cove Cliffs (North)

### Geology

**Backshore 2.1:** Cliffs either side of this section are composed of sandstones and siltstone (resistant) but these are intersected by Pleistocene Ochre (pebbly sandstone).

**Backshore 2.2:** A Heterogeneous cliff with resistant Wilmington fm underlying friable Pleistocene Ochre Cove fm (ie base of cliff is likely *resistant*, top of cliff is friable material).

**Backshore 2.3:** In this area Reynella siltstone predominates which is resistant material to erosion.

**Backshore 2.4:** The contact between the Reynella siltstone and the Seacliff sandstone occurs along this section, both Neo-Proterozoic and relatively resistant rocks. However, the Seacliff sandstone seems unstable here and/or covered by an undifferentiated material. Slump/scar and undercutting are visible.

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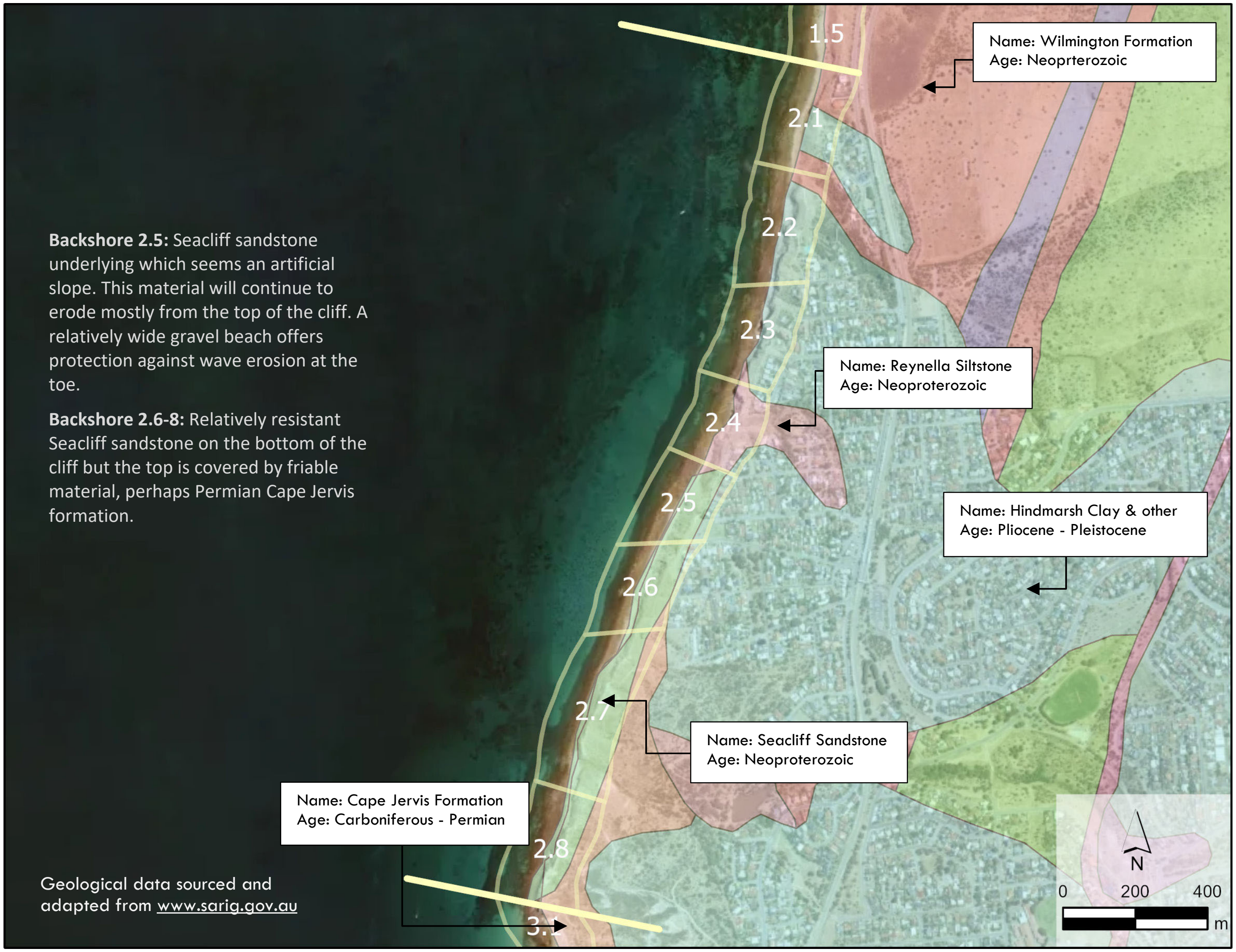
**Backshore 2.5:** Seacliff sandstone underlying which seems an artificial slope. This material will continue to erode mostly from the top of the cliff. A relatively wide gravel beach offers protection against wave erosion at the toe.

**Backshore 2.6-8:** Relatively resistant Seacliff sandstone on the bottom of the cliff but the top is covered by friable material, perhaps Permian Cape Jervis formation.




Geological data sourced and adapted from www.sarig.gov.au

# 4-1 Coastal fabric - overview

Overview

Marion (Cell 2)

Secondary Cell: Adelaide Coast

Tertiary Cell: Hallett Cove Cliffs (North)

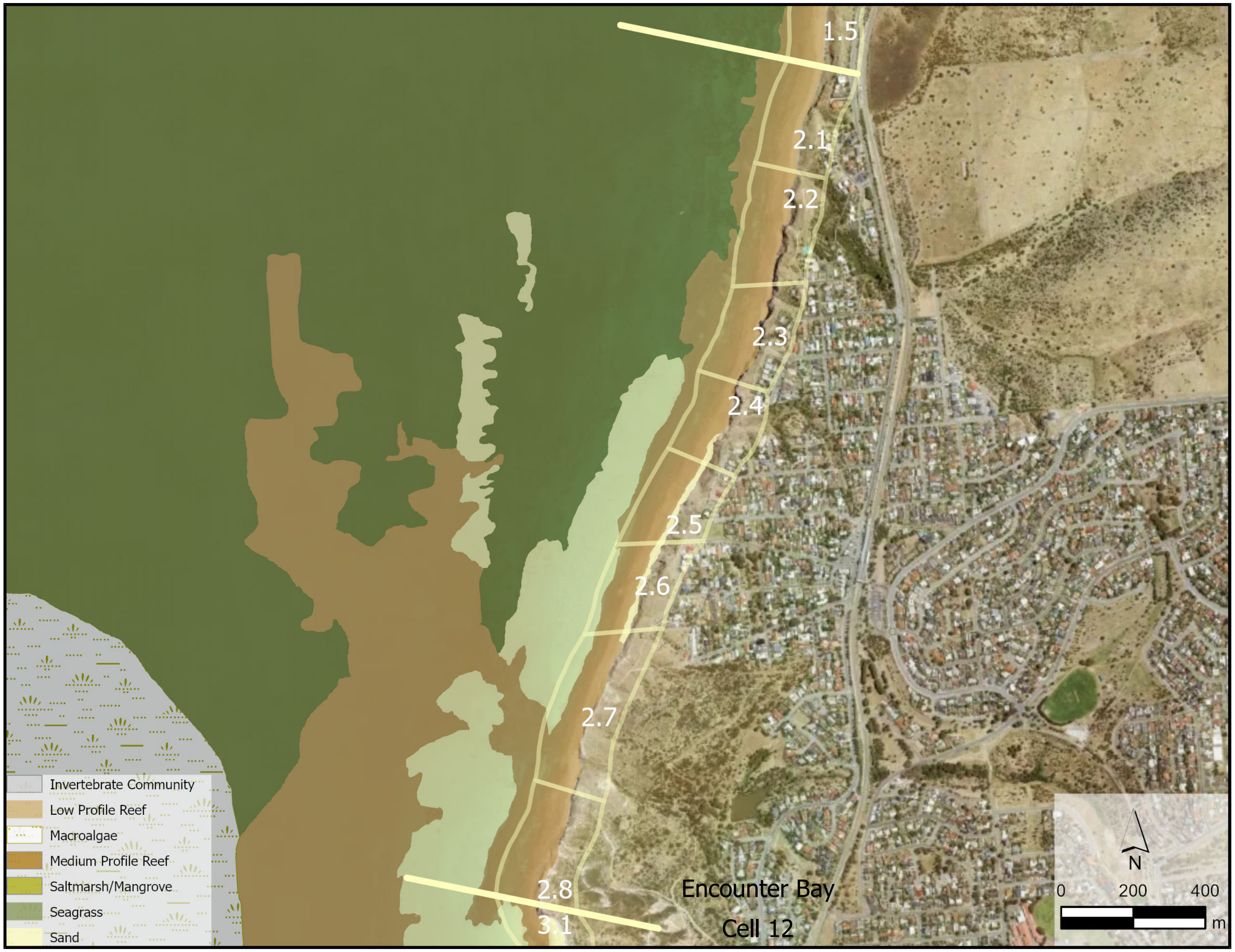
Benthic

**Benthic**

Nearshore dominated low-profile reef and bare sand.

A Large seagrass meadow is present further from shore.

Benthic data sourced from Nature Maps (SA).

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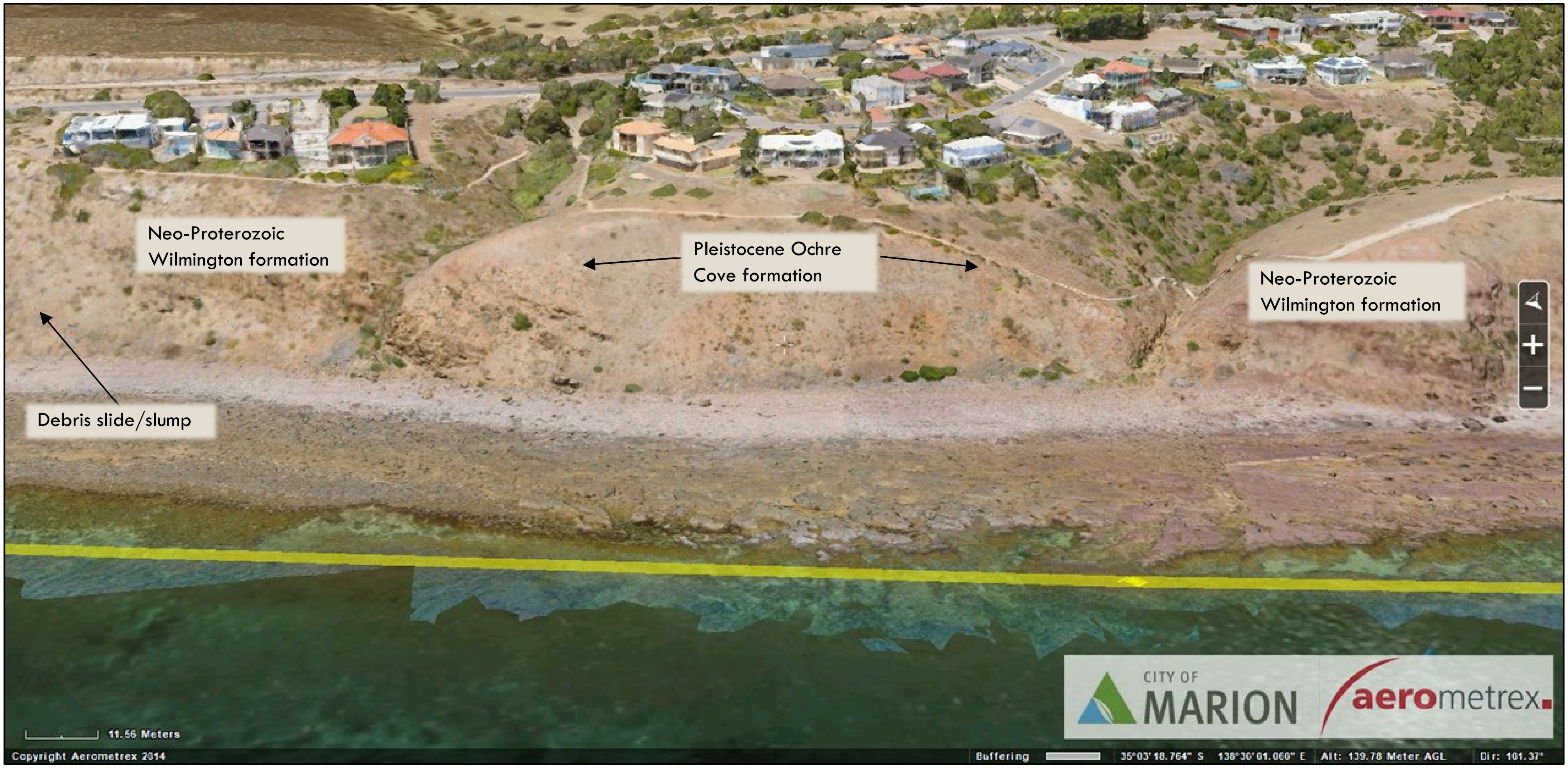
# 4-2 Coastal fabric – geology (Cell 2.1)

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**Notes**

Cliffs composed of Wilmington formation sandstones and siltstones are more resistant, however there is a tongue of friable Pleistocene Ochre Cove formation (pebbly sandstone) intersecting the coast (see between arrows for approximate location) and likely overlying the Wilmington formation. Caution should be taken with management of stormwater. Gullying has developed nearby the contacts between these formations.

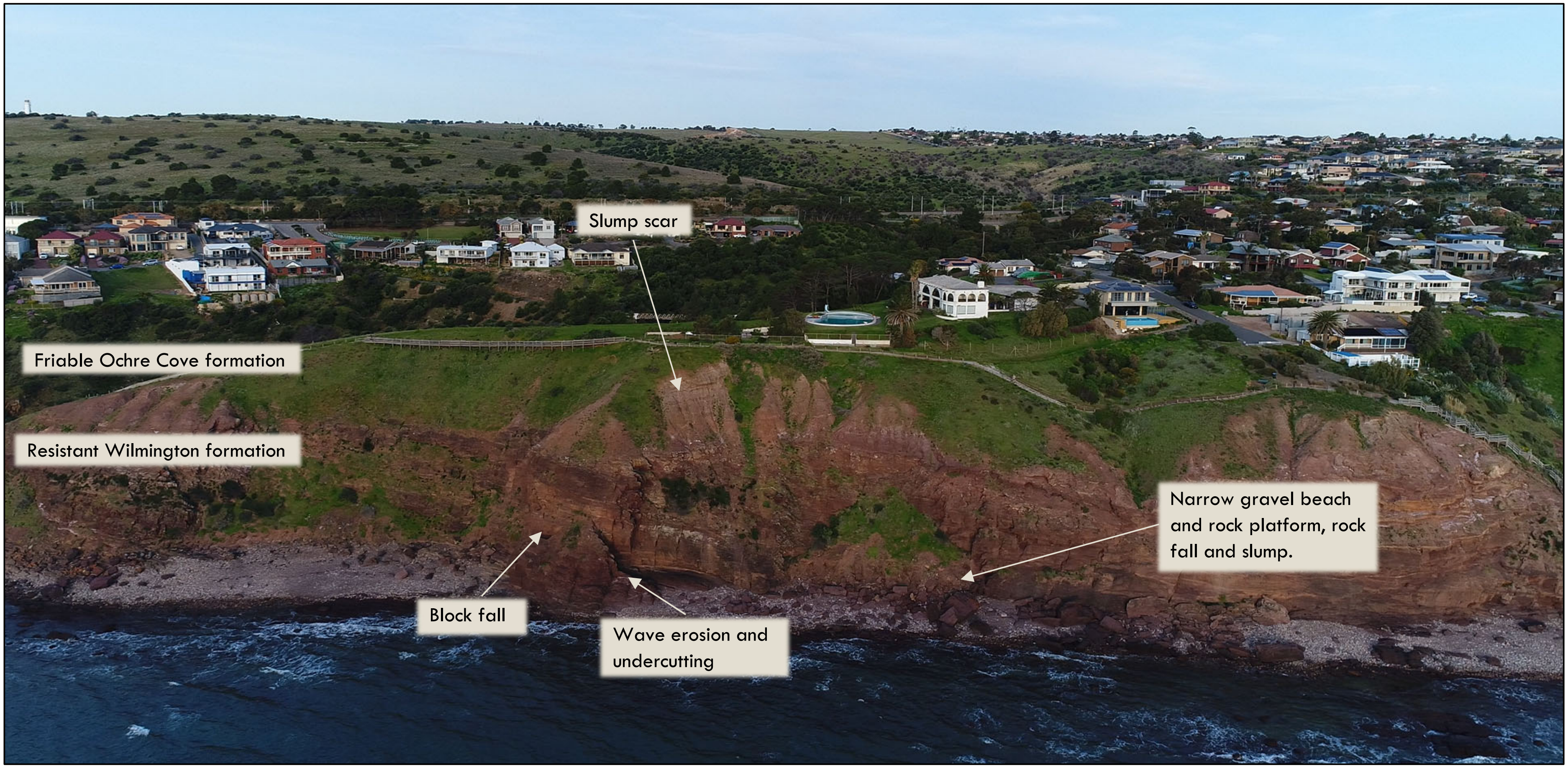
**Map**

Hallett Cliffs North 2.1

Geological assessment

Dr Graziela Miot da Silva (2019)

# 4-2 Coastal fabric – geology (Cell 2.2)

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**Notes**

Heterogeneous cliff with resistant Wilmington formation underlying friable Pleistocene Ochre Cove formation (possibly Pleistocene Hindmarsh clay which is also friable material). Rockfall and slumps are present on the cliff base and there is evidence of wave erosion of the cliff base. The gravel beach is narrow and wave action is routine at the cliff base. If seas rise as projected, the erosional impact will increase.

**Map**

Hallett Cliffs North 2.2

Geological assessment

Dr Graziela Miot da Silva (2019)

# 4-2 Coastal fabric – geology (Cell 2.3)


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**Notes**

There is a contact between the Wilmington formation and the Neo-Proterozoic Reynella siltstone member (left side of photograph). Gullying seems to be on the Reynella siltstone (in proximity to some houses). There is evidence of wave erosion at cliff base however this seems to be a resistant cliff with relatively little slumps and rock fall. If seas rise as projected, the erosional impact will increase (but note the resistant form of rock here).

**Map**

Hallett Cliffs North 2.3

Geological assessment

Dr Graziela Miot da Silva (2019)

# 4-2 Coastal fabric – geology (Cell 2.4,5)


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**Notes**

The contact between the Reynella siltstone and the Seacliff sandstone occurs along this section, both relatively resistant rocks. However, the Seacliff sandstone seems unstable here and/or covered by an undifferentiated material. Slump/scar and undercutting are visible. Wave erosion evident at the cliff toe (where shown). If seas rise as projected, the erosional impact will increase at the base (less resistant cliff on the right of the photo).

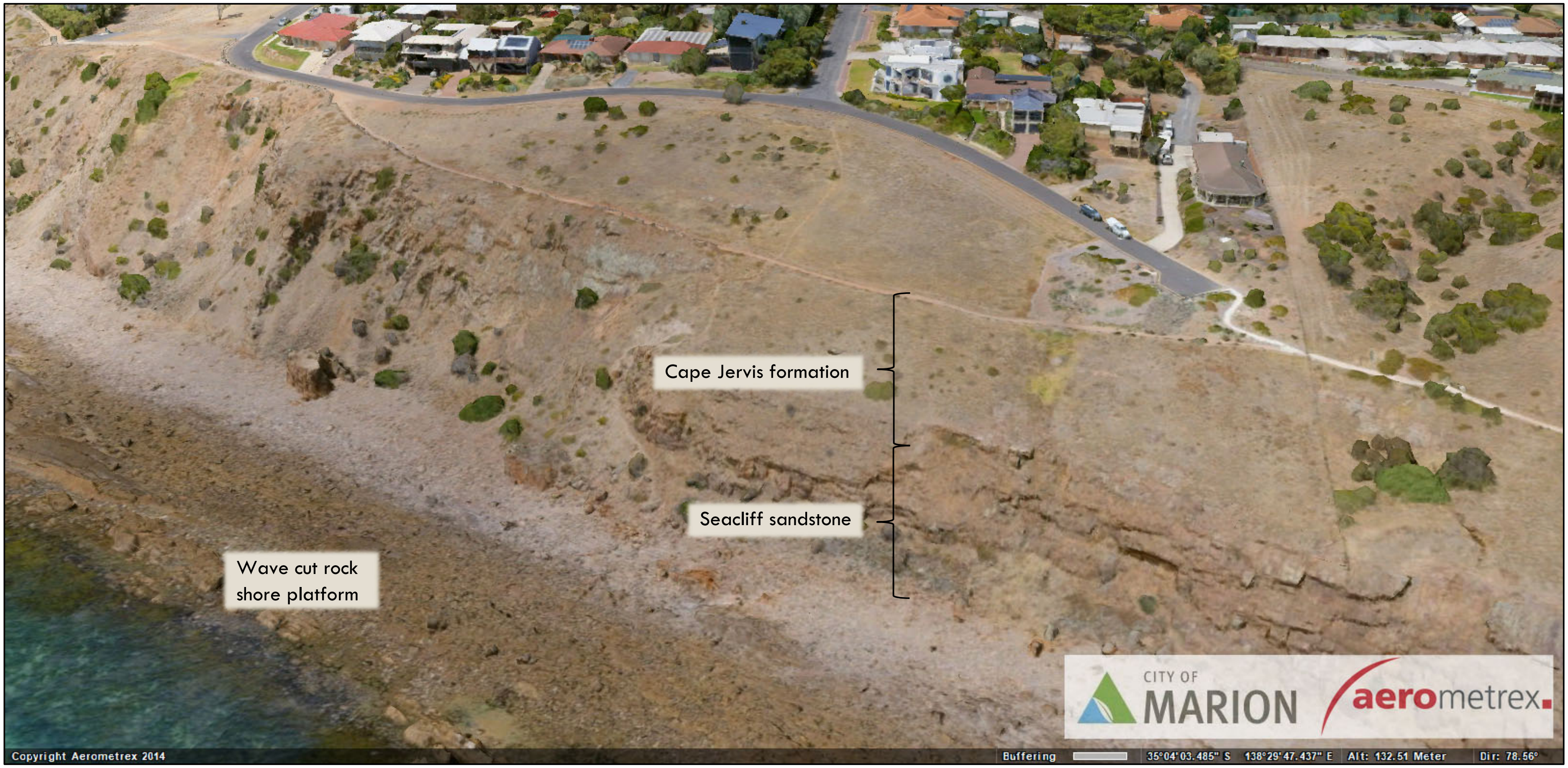
**Map**

Hallett Cliffs North 2.4,5

Geological assessment

Dr Graziela Miot da Silva (2019)

# 4-2 Coastal fabric – geology (Cell 2.6)

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**Notes**

Relatively resistant Seacliff sandstone on the bottom of the cliff but the top is covered by friable material, perhaps Permian Cape Jervis formation (poorly consolidated glacio-marine and fluvioglacial sediments). Erosion seems mostly subaerial rather than wave driven. Especially important to monitor and control stormwater flow and other subaerial factors removing material from the top of the cliff.

**Map**

Hallett Cliffs North 2.6

Geological assessment

Dr Graziela Miot da Silva (2019)

# 4-2 Coastal fabric – geology (Cell 2.7)


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**Notes**

Resistant Neo-Proterozoic Brachina Formation (red and green siltstone and sandstone) on the bottom of the cliff. The top is friable composed of Permian Cape Jervis sediments, underlying Pliocene Hallet Cove sandstone and Pleistocene alluvial deposits. Erosion will be mostly subaerial (e.g. stormwater) rather than wave-driven. The bottom of the cliff is likely resistant, although there is significant rockfall material at the base of the cliff.

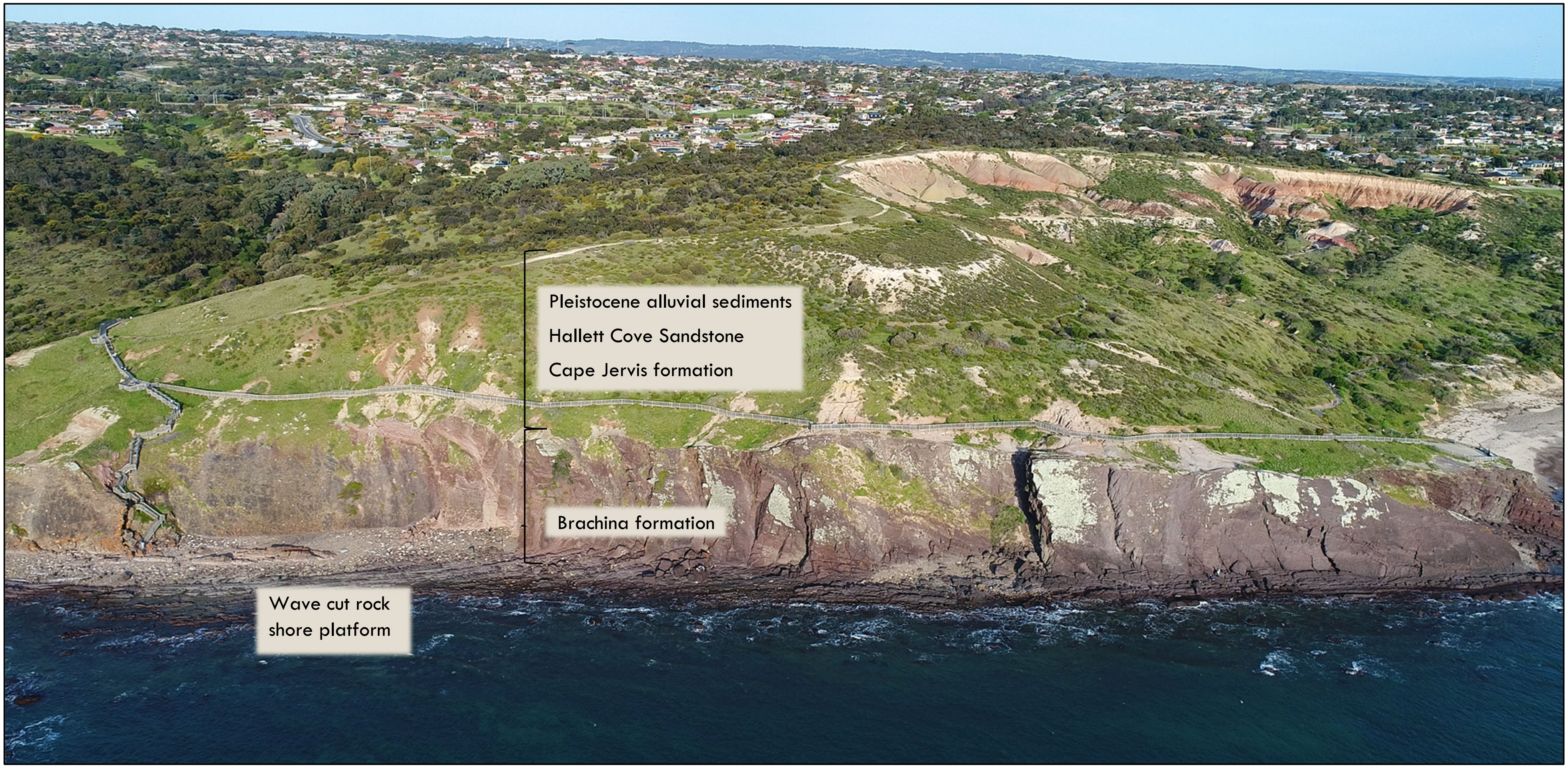
**Map**

Hallett Cliffs North 2.7

Geological assessment

Dr Graziela Miot da Silva (2019)

# 4-2 Coastal fabric – geology (Cell 2.8)

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**Notes**

Resistant Neo-Proterozoic Brachina Formation on the bottom of the cliff. The top is friable composed of Permian Cape Jervis sediments, underlying Pliocene Hallet Cove sandstone and Pleistocene alluvial deposits. Erosion will be mostly subaerial (e.g. stormwater) rather than wave-driven. The bottom of the cliff is likely resistant, although there is significant rockfall material at the base of the cliff.

**Map**

Hallett Cliffs North 2.8

Geological assessment

Dr Graziela Miot da Silva (2019)

# 4-3 Coastal fabric – location map (Cell 2.1)

**Medium Term Changes**

Cell 2.1

Hallett Cove Cliffs North

Historical comparison

Location Map

**Location:**
**West Cliff**

Aerial Photograph from 2017 provides the basis for comparison of coastal change over the last 70 years. Comparisons are made with aerial photography from:

- 1949
- 1976
- 1989
- 2002
- 2007
- 2012
- 2017

In this location the shoreline position is the base of the cliff. Note, the base of the cliff cannot be determined in all locations.

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# 4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 2.1

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**West Cliff**
**Year 1949**

General observations

The photograph is not clear enough to make any assessment.

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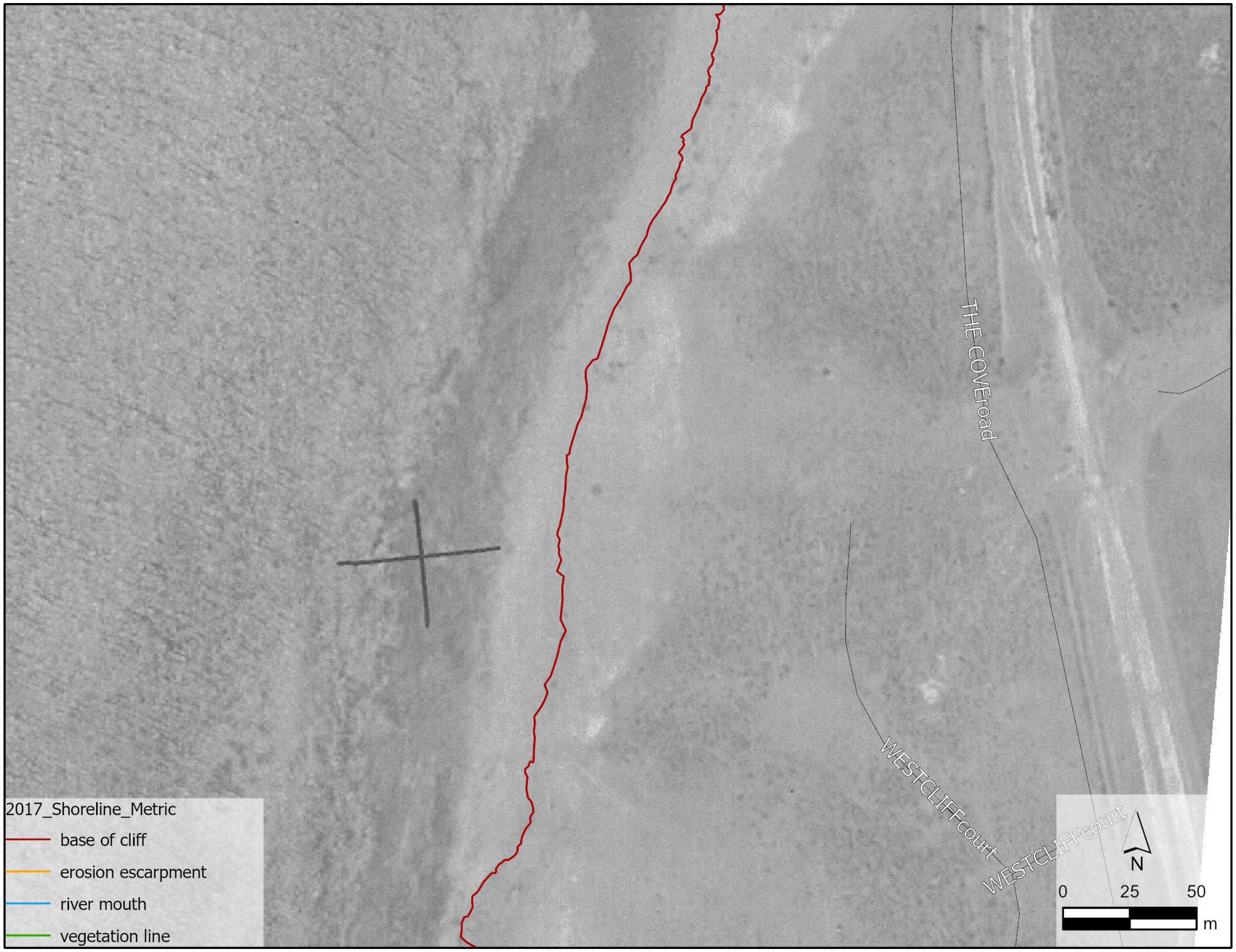

# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.1

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**West Cliff**
**Year 1979**

Shoreline recession:
Minor changes to the vegetation line where shown.

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Sparser than 2017. Planting program prior to 1979 at top of crest.

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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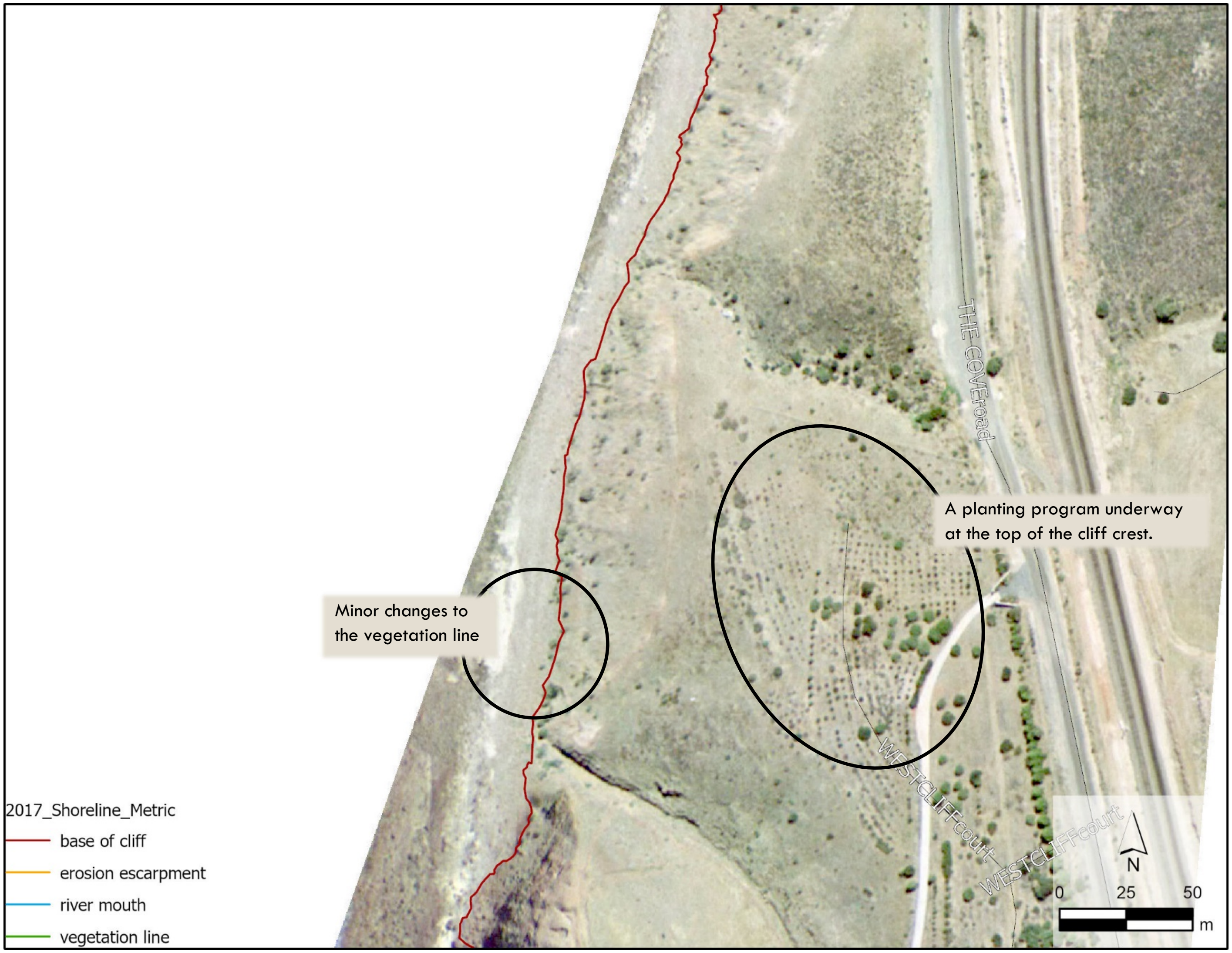

# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.1

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**West Cliff**
**Year 1989**

Shoreline recession:
Minor changes to the vegetation line where shown.

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Sparser than 2017. Planting program prior to 1979 at top of crest.

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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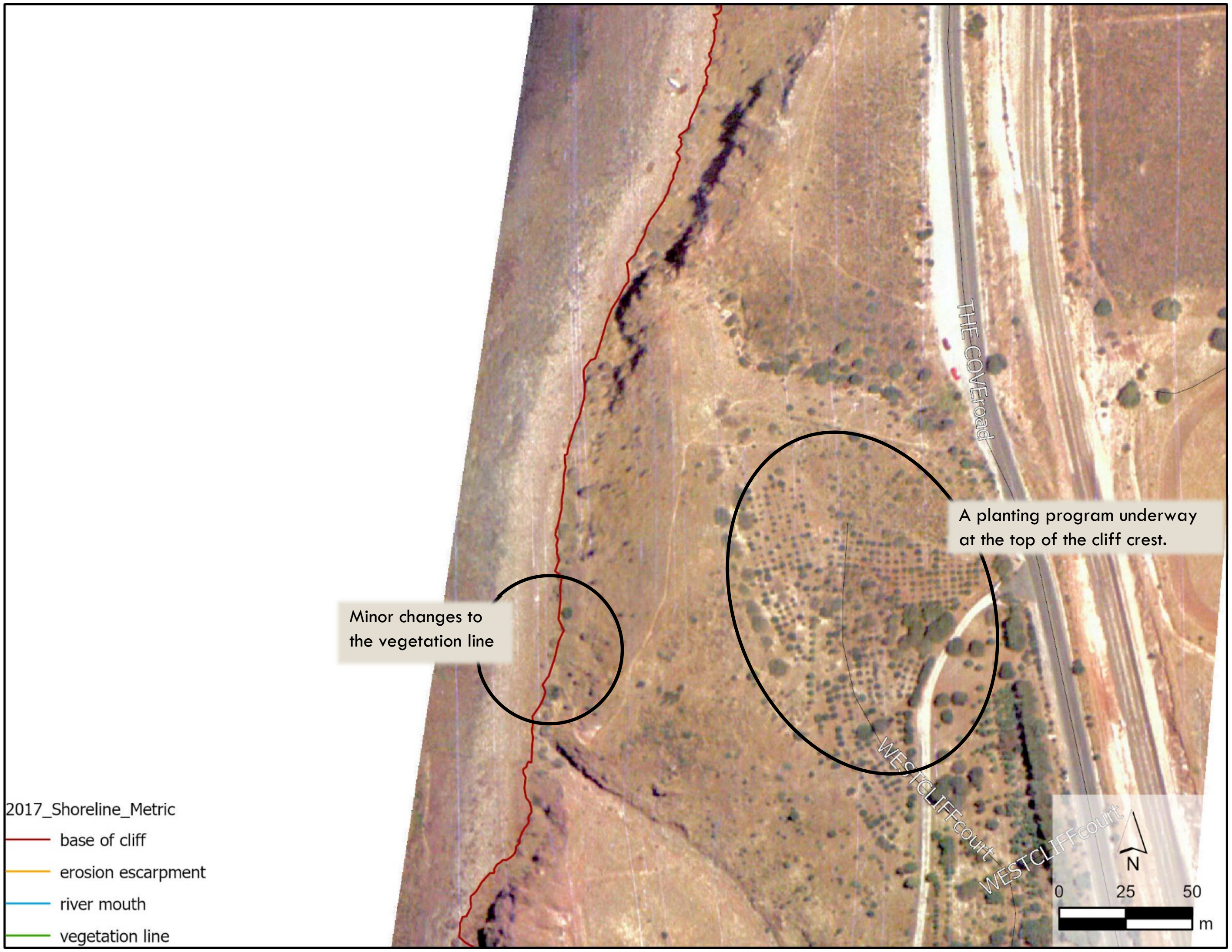

# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.1

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**West Cliff**
**Year 2002**

Shoreline recession:
Minor changes to the vegetation line where shown.

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Vegetation cover increasing in the gullies.

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 2.1

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**West Cliff**
**Year 2007**

Shoreline recession:
Minor changes to the vegetation line where shown.

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Vegetation cover increasing in the gullies.

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 2.1

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**West Cliff**
**Year 2012**

Shoreline recession:
Similar to 2017.

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Vegetation cover increasing in the gullies.

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes (Summary)

Medium Term Changes

Cell 2.1

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**West Cliff**
**Year 2017**

***70 years***
Not assessed – photograph unclear.

***40 years***
Minor changes to the vegetation line at the base of the cliff, increasing vegetation cover within the gullies.

***10 years***
Minor changes to the vegetation line at the base of the cliff.

**Summary**
A stable section of the coastline with minor changes to the vegetation at the base of the cliff. This finding is consistent with cliffs composed of sandstones/siltstones (with some more friable material in the mid-section).

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# 4-3 Coastal fabric – location map (Cell 2.2)

**Medium Term Changes**

Cell 2.2

Hallett Cove Cliffs North

Historical comparison

Location Map

**Location:**
**Grey Road**

Aerial Photograph from 2017 provides the basis for comparison of coastal change over the last 70 years. Comparisons are made with aerial photography from:

- 1949
- 1976
- 1989
- 2002
- 2007
- 2012
- 2017

In this location the shoreline position is the base of the cliff. Note, the base of the cliff cannot be determined in all locations.

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# 4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 2.2

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Grey Road**
**Year 1949**

General observations

The photograph is not clear enough to make any assessment.

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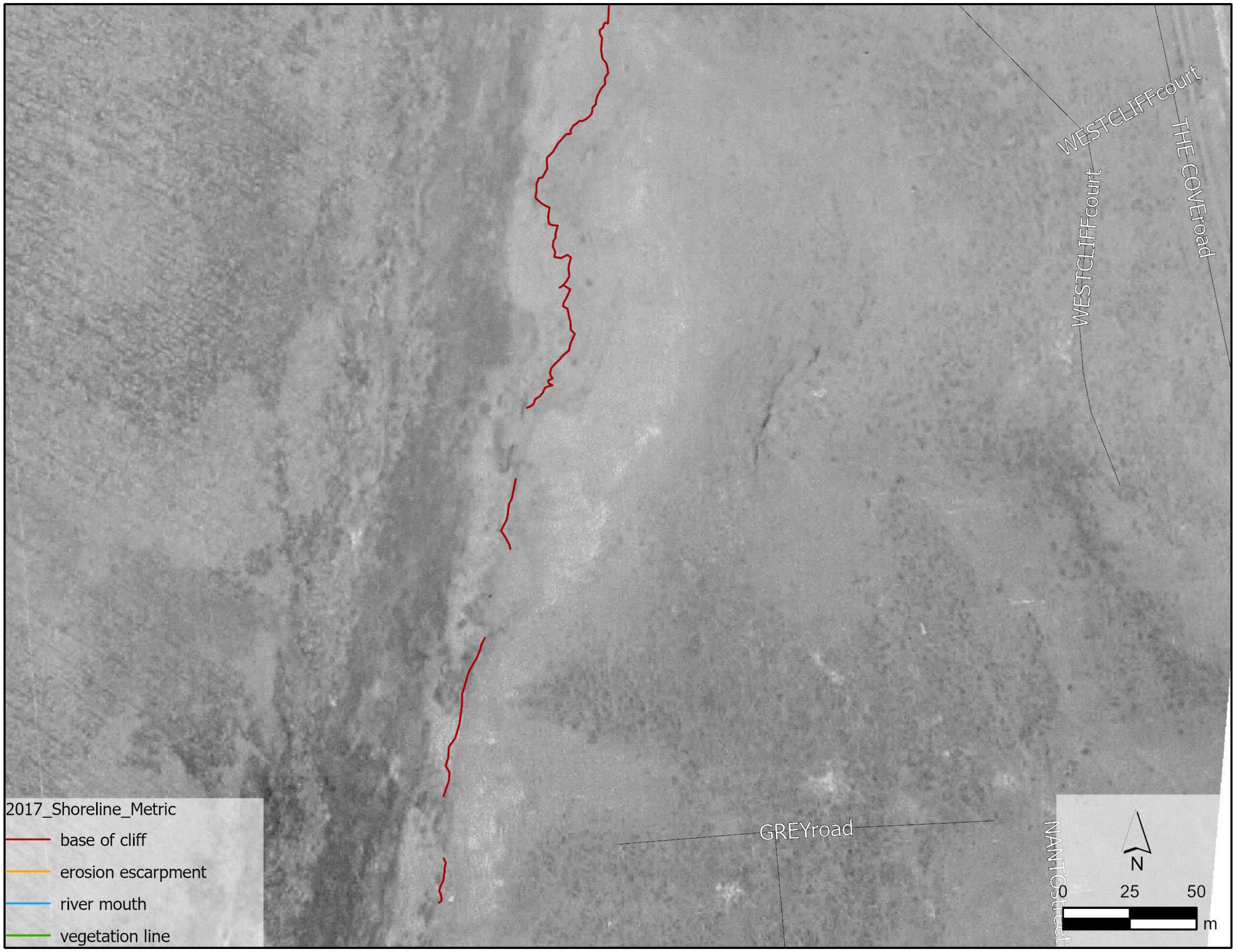

# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.2

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Grey Road**
**Year 1979**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Sparser than 2017. Planting program prior to 1979 at top of crest.

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 2.2

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Grey Road**
**Year 1989**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Sparser than 2017. Planting program prior to 1979 at top of crest increasing in cover.

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 2.2

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Grey Road**
**Year 2002**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Vegetation cover increasing (similar to 2017)

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.2

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Grey Road**
**Year 2007**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Minor rock fall in northern section where shown.

Vegetation
Vegetation cover increasing (similar to 2017)

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 2.2

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Grey Road**
**Year 2012**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil (from 2007)

Vegetation
Vegetation cover increasing (similar to 2017)

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes (Summary)

**Medium Term Changes**

Cell 2.2

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Grey Road**
**Year 2017**

***70 years***
Not assessed – photograph unclear.

***40 years***
No evidence of shoreline change or clifftop change. Minor rock fall observed in north of this minor cell in 2002. Vegetation cover increasing from 1979 to 2017.

***10 years***
Nil changes.

**Summary**

A stable section of the coastline with one minor rock fall observed in 2007 aerial photograph.

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# 4-3 Coastal fabric – location map (2.3)

**Medium Term Changes**

Cell 2.3

Hallett Cove Cliffs North

Historical comparison

Location Map

**Location:**
**Pindee Street**

Aerial Photograph from 2017 provides the basis for comparison of coastal change over the last 70 years. Comparisons are made with aerial photography from:

- 1949
- 1976
- 1989
- 2002
- 2007
- 2012
- 2017

In this location the shoreline position is the base of the cliff. Note, the base of the cliff cannot be determined in all locations.

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# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.3

Hallett Cove Cliffs North

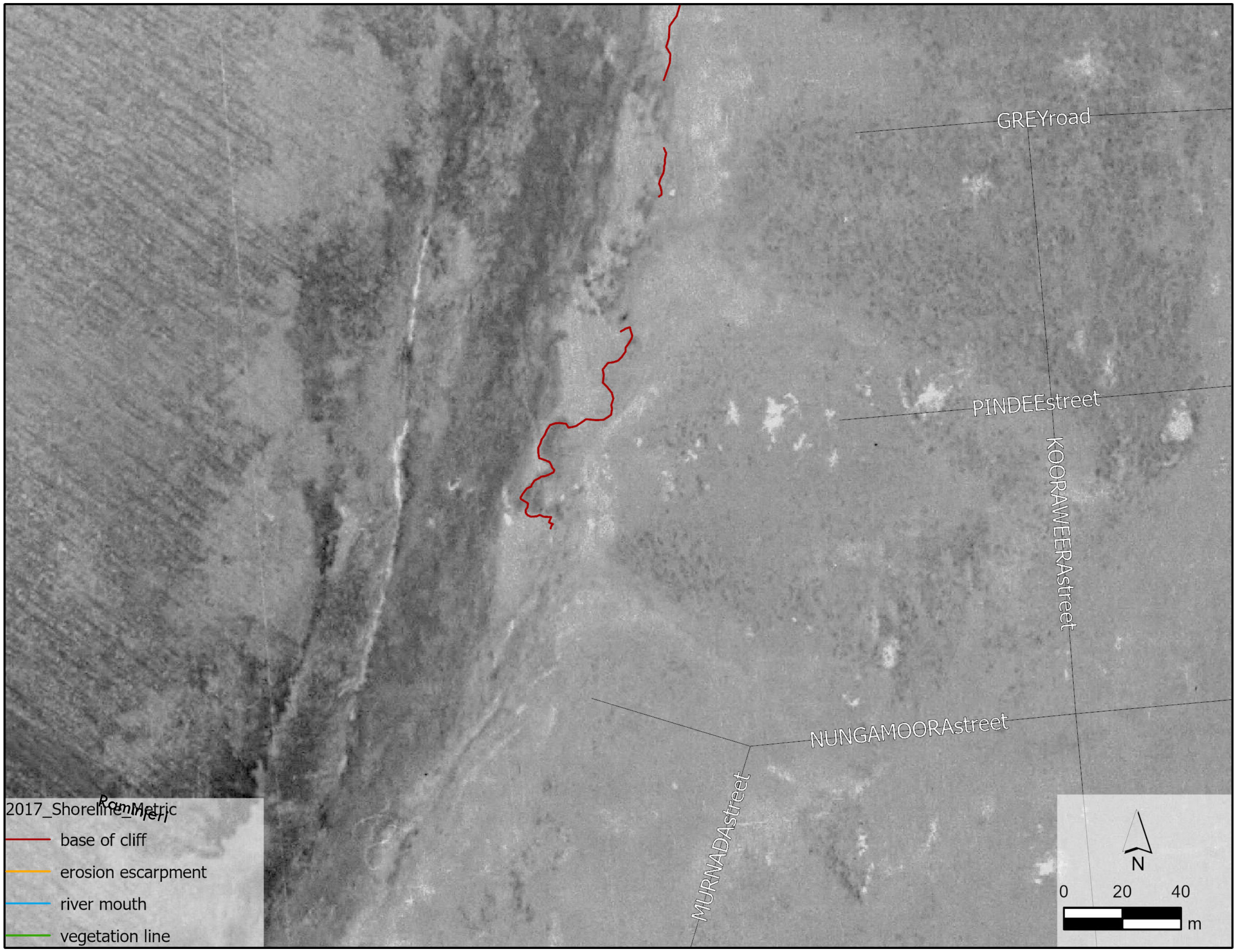
Historical comparison

Shoreline

**Location:**
**Pindee St**
**Year 1949**

General observations

The photograph is not clear enough to make any assessment.

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# 4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 2.3

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Pindee St**
**Year 1979**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Sparser than 2017.

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.3

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Pindee St**
**Year 1989**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Sparser than 2017.

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 2.3

Hallett Cove Cliffs North
Historical comparison
Shoreline

**Location:**
**Pindee St**
**Year 2002**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Vegetation cover increasing (similar to 2017)

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.3

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Pindee St**
**Year 2007**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Vegetation cover increasing (similar to 2017)

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.3

Hallett Cove Cliffs North
Historical comparison
Shoreline

**Location:**
**Pindee St**
**Year 2012**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Vegetation cover increasing (similar to 2007)

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes (Summary)

Medium Term Changes

Cell 2.3

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Pindee St**
**Year 2017**

***70 years***
Not assessed – photograph unclear.

***40 years***
No evidence of shoreline change or clifftop change. Vegetation cover increasing from 1979 to 2017.

***10 years***
Nil changes.

**Summary**

A stable section of the coastline with no rock falls or slumps observed.


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# 4-3 Coastal fabric – location map (Cell 2.4)

Medium Term Changes

Cell 2.4

Hallett Cove Cliffs North

Historical comparison

Location Map

**Location:**
**The Esplanade**

Aerial Photograph from 2017 provides the basis for comparison of coastal change over the last 70 years. Comparisons are made with aerial photography from:

- 1949
- 1976
- 1989
- 2002
- 2007
- 2012
- 2017

In this location the shoreline position is the base of the cliff. Note, the base of the cliff cannot be determined in all locations.

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# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.4

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**The Esplanade**
**Year 1949**

General observations

The photograph is not clear enough to make any assessment.

Bush where shown is still in same position as 1979 (see next page).

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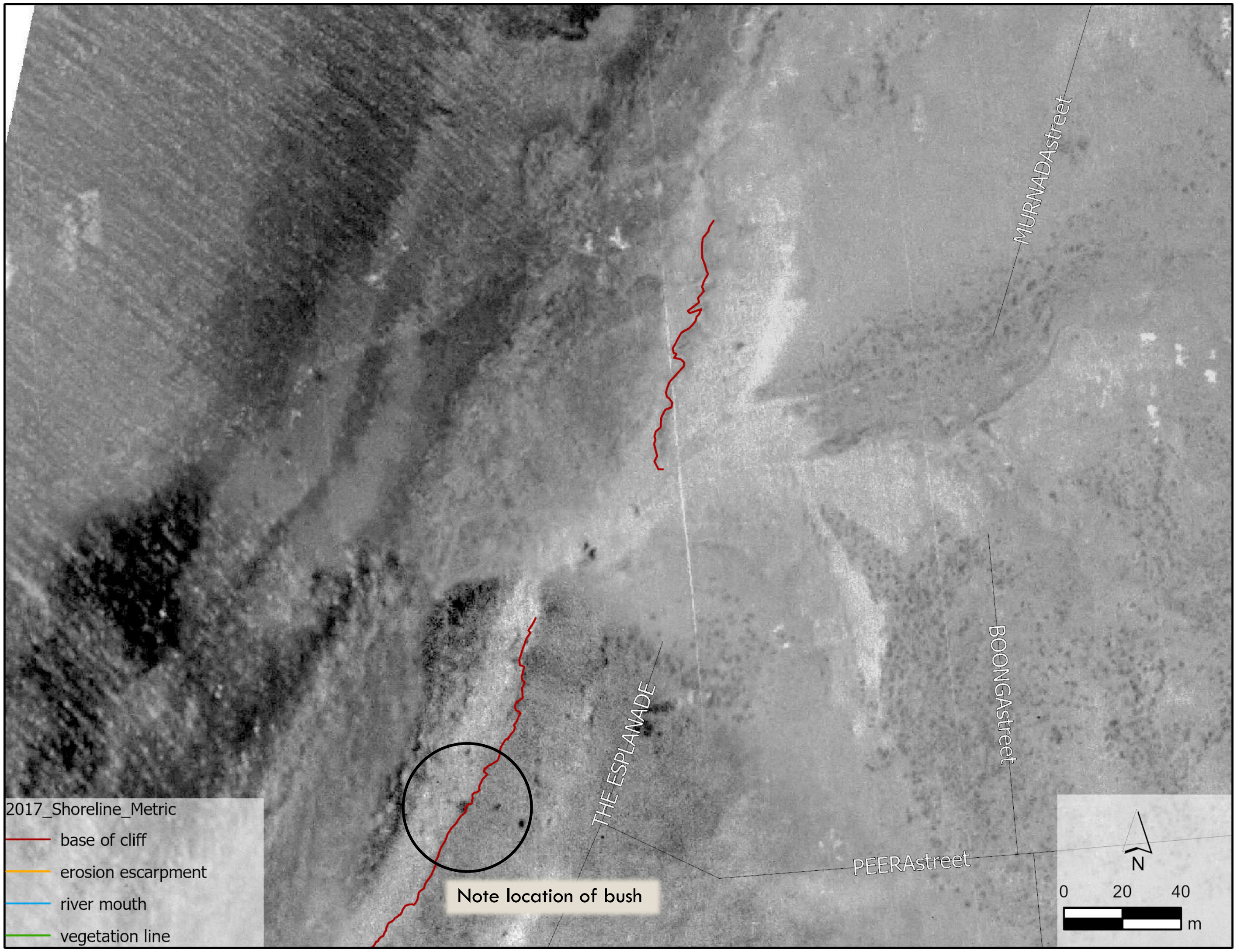

# 4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 2.4

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**The Esplanade**
**Year 1979**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Vegetation increasing in the gully, but overall sparser than 2017

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.4

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**The Esplanade**
**Year 1989**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Vegetation increasing in the gully, but overall sparser than 2017

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.4

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**The Esplanade**
**Year 2002**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Vegetation cover increasing (similar to 2017)

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 2.4

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**The Esplanade**
**Year 2007**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Vegetation cover increasing (similar to 2017)

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces

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# 4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 2.4

Hallett Cove Cliffs North
Historical comparison
Shoreline

**Location:**
**The Esplanade**
**Year 2012**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil (from 2007)

Vegetation
Vegetation cover increasing (similar to 2017)

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes (summary)

Medium Term Changes

Cell 2.4

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**The Esplanade**
**Year 2017**

***70 years***
Not assessed – photograph unclear.

***40 years***
No evidence of shoreline change or clifftop change. Vegetation cover increasing from 1979 to 2017.

***10 years***
Nil changes.

**Summary**
A stable section of the coastline with no rock falls or slumps observed from 1979 to 2017. Possible minor recession of the base of the cliff where shown.

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# 4-3 Coastal fabric – location map (Cell 2.5)

**Medium Term Changes**

Cell 2.5

Hallett Cove Cliffs North

Historical comparison

Location Map

**Location:**
**Kurnabinna Tce**

Aerial Photograph from 2017 provides the basis for comparison of coastal change over the last 70 years. Comparisons are made with aerial photography from:

- 1949
- 1976
- 1989
- 2002
- 2007
- 2012
- 2017

In this location the shoreline position is the base of the cliff. Note, the base of the cliff cannot be determined in all locations.

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# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.5

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Kurnabinna Terrace**
**Year 1949**

General observations

Likely location of cliff crest where shown, but otherwise the photograph is not clear enough to assess.

Vegetation almost nil.

Note location at top of the cliff crest for future comparisons.

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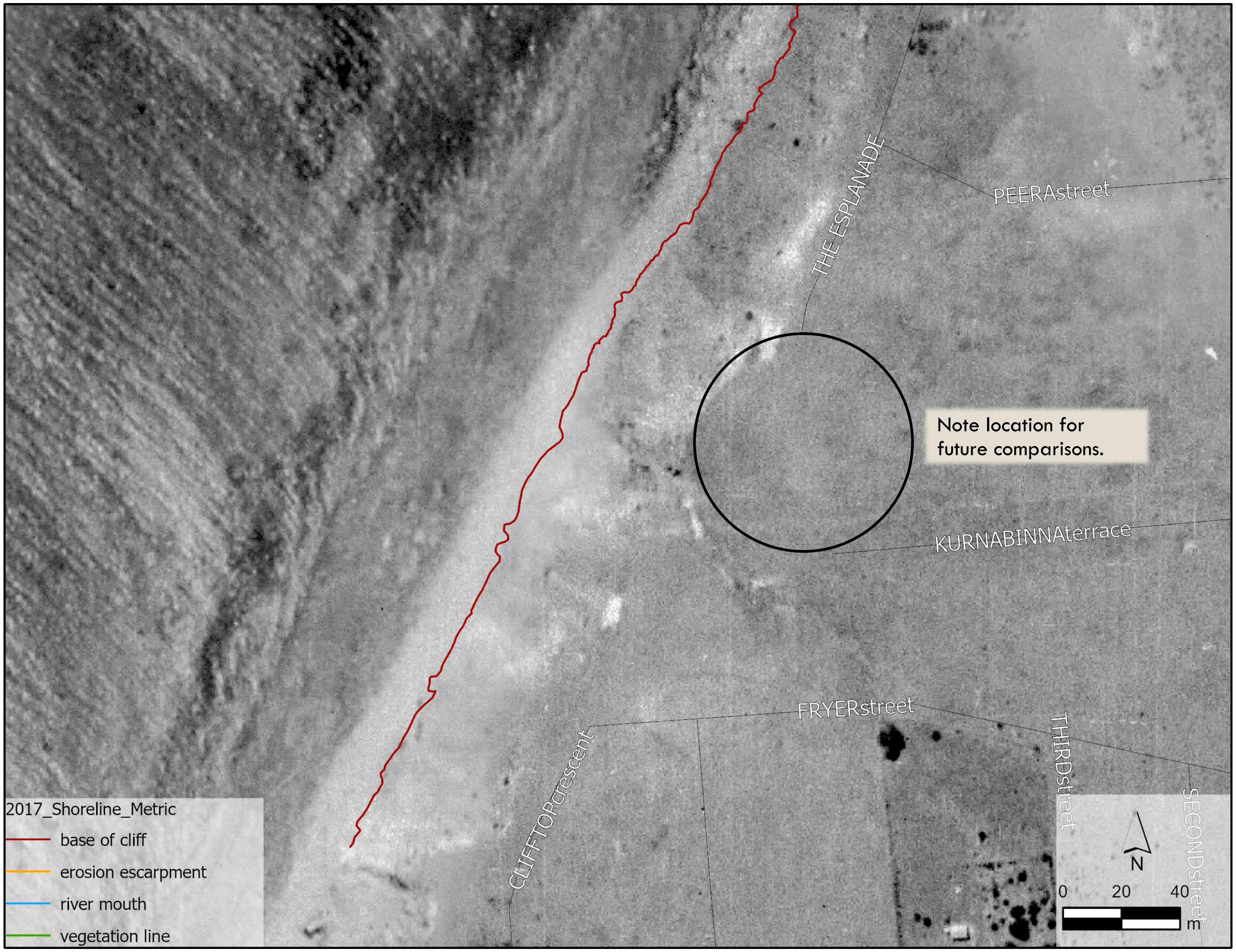

# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.5

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Kurnabinna Terrace**
**Year 1979**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Sparser than 2017.

Note houses constructed where shown (compare to 2002 photograph).

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera


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# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.5

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Kurnabinna Terrace**
**Year 1989**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Sparser than 2017.

Note houses constructed where shown (compare to 2002 photograph).

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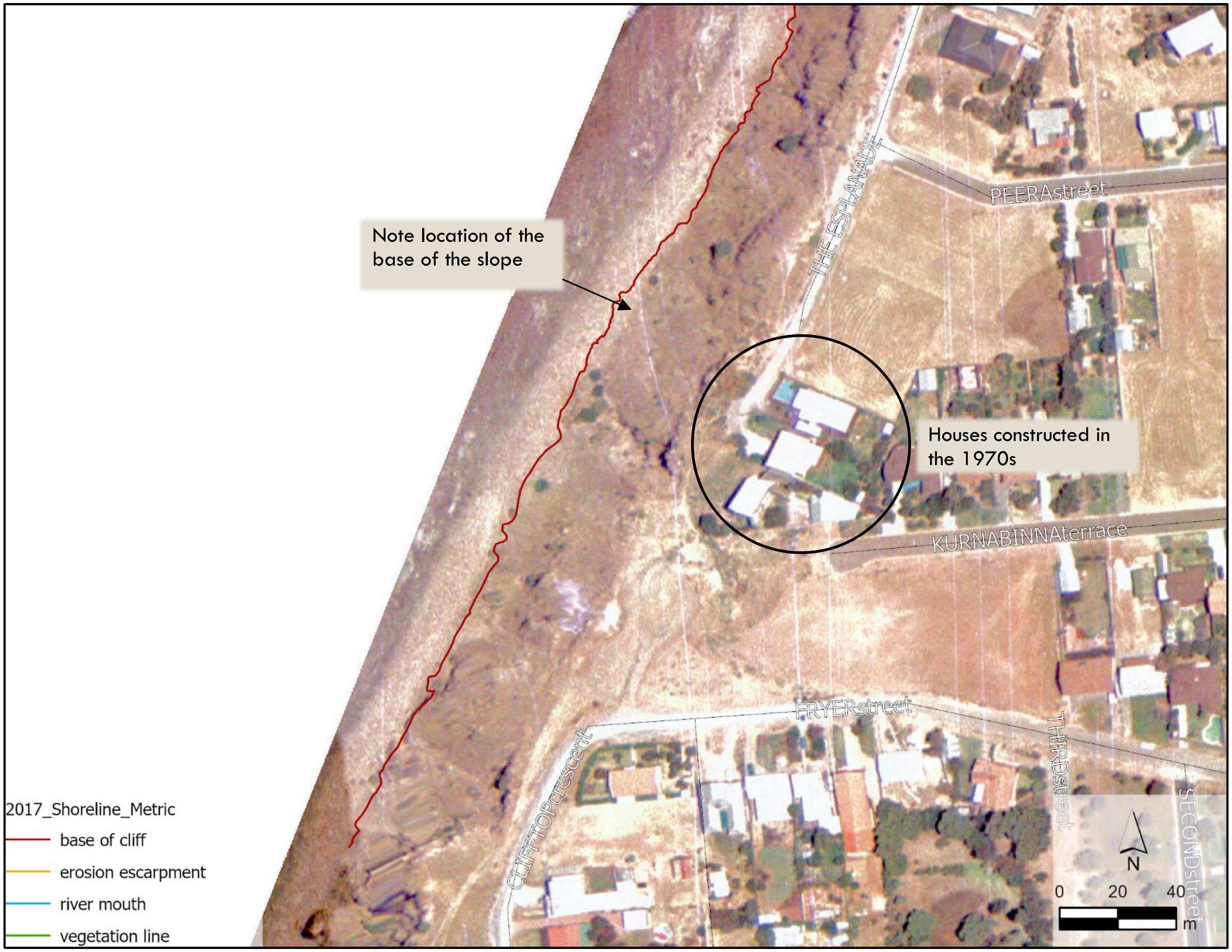

# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.5

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Kurnabinna Terrace**
**Year 2002**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Vegetation cover increasing (similar to 2017)

Note removal of houses after slide at cliff top. The slope of the cliff was intentionally collapsed to provide more stability. See settlement history section.

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# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.5

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Kurnabinna Terrace**
**Year 2007**

Shoreline recession:
Overall, nil (but 1m recession of the base of the constructed slope).

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Vegetation cover increasing (similar to 2017)

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces

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# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.5

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Kurnabinna Terrace**
**Year 2012**

Shoreline recession:
Nil (recession of the base of the constructed slope ~1m)

Cliff top recession:
Nil

Rock falls/slumps:
Nil (from 2007)

Vegetation
Vegetation cover increasing (similar to 2017)

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes (summary)

**Medium Term Changes**

Cell 2.5

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Kurnabinna Terrace**
**Year 2017**

***70 years***
Assessment difficult due to low resolution of the photograph, but the cliff crest appears in similar location as 2017.

***40 years***
A slide in upper cliff crest but otherwise no evidence of shoreline/ clifftop change. Vegetation cover increasing from 1979 to 2017.

***10 years***
Nil changes.

**Summary**
A stable section of the coastline apart from slide in upper cliff crest.

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# 4-3 Coastal fabric – location map (Cell 2.6)

**Medium Term Changes**

Cell 2.6

Hallett Cove Cliffs North
Historical comparison
Location Map

**Location:**
**Clifftop Crescent**

Aerial Photograph from 2017 provides the basis for comparison of coastal change over the last 70 years. Comparisons are made with aerial photography from:

- 1949
- 1976
- 1989
- 2002
- 2007
- 2012
- 2017

In this location the shoreline position is the base of the cliff. Note, the base of the cliff cannot be determined in all locations.

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# 4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 2.6

Hallett Cove Cliffs North
Historical comparison

Shoreline

**Location:**
**Clifftop Crescent**
**Year 1949**

General observations

Large rock on beach, still remains in 2017.

Cliff escarpment in identical position to 2017 (see next page).

Vegetation on upper cliff crest (?). May be a shadow (?).

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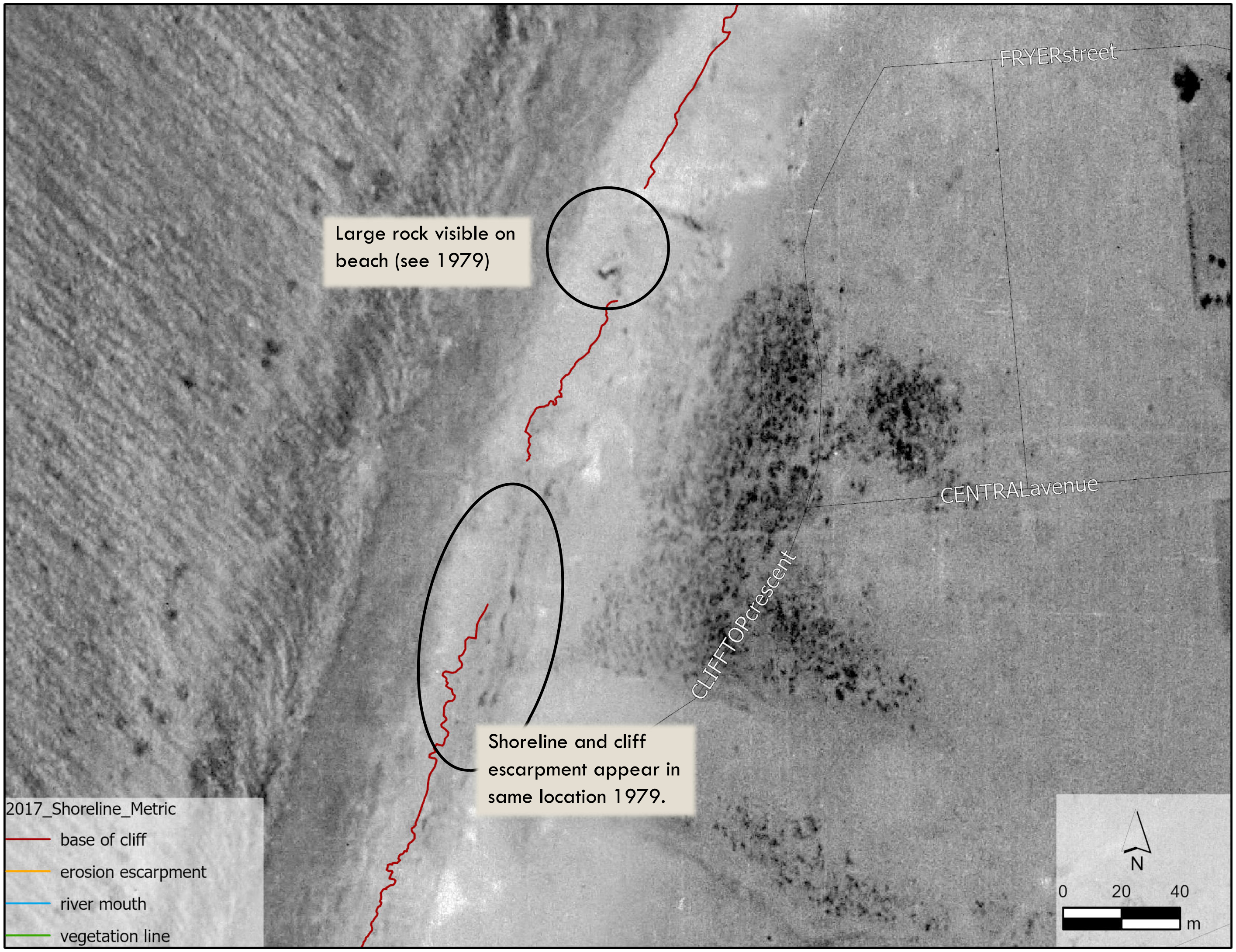

# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.6

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Clifftop Crescent**
**Year 1979**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Vegetation similar to 2017 on cliffs and crests.

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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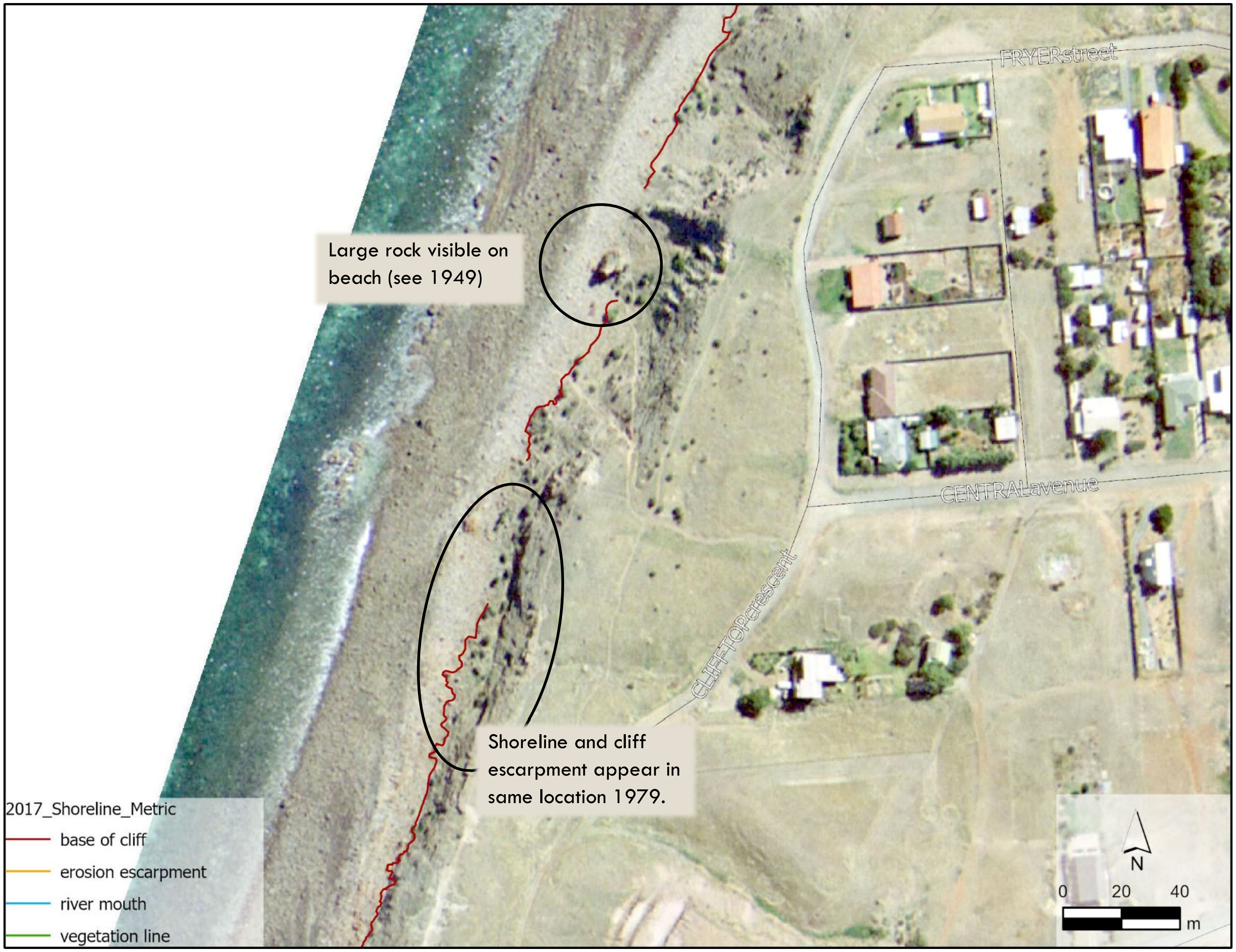

# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.6

Hallett Cove Cliffs North
Historical comparison

Shoreline

**Location:**
**Clifftop Crescent**
**Year 1989**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Vegetation similar to 2017 on cliffs and crests.

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera

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# 4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 2.6

Hallett Cove Cliffs North
Historical comparison

Shoreline

**Location:**
**Clifftop Crescent**
**Year 2002**

<u>Shoreline recession:</u>
Nil

<u>Cliff top recession:</u>
Nil

<u>Rock falls/slumps:</u>
Nil

<u>Vegetation</u>
Vegetation similar to 2017 on cliffs and crests.

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.6

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Clifftop Crescent**
**Year 2007**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Vegetation similar to 2017 on cliffs and crests (photograph taken in May, so more grass cover).

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces

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# 4-3 Coastal fabric – shoreline changes

**Medium Term Changes**

Cell 2.6

Hallett Cove Cliffs North

Historical comparison

Shoreline

**Location:**
**Clifftop Crescent**
**Year 2012**

Shoreline recession:
Nil

Cliff top recession:
Nil

Rock falls/slumps:
Nil

Vegetation
Vegetation similar to 2017 on cliffs and crests.

Project note: Assessment is limited by clarity of photograph, shadows, accurate positioning, and geometric distortion due to different flight paths and camera angles in the context of vertical faces.

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# 4-3 Coastal fabric – shoreline changes (summary)

Medium Term Changes

Cell 2.6

Hallett Cove Cliffs North
Historical comparison

Shoreline

**Location:**
**Clifftop Crescent**
**Year 2017**

***70 years***
Not assessed – photograph unclear.

***40 years***
No evidence of shoreline change or clifftop change. Vegetation cover increasing from 1979 to 2017.

***10 years***
Nil changes.

**Summary**

A stable section of the coastline with no observed rock falls or slumps from 1979.

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# 4-5 Coastal fabric – human intervention (Cell 2)

## MODIFIED COASTS

Human intervention upon the coast is limited in Cell 2 due to the 30-40m high coastal cliffs that form a natural barrier between the coast and urban settlement. A walking trail is situated between urban settlement and the cliff tops, but this is normally set well-back from the more vertical faces of the cliffs. One beach access point is situated in Kurnabinna Gully (Figure b) but proposals are being considered for a walking bridge across the gully (City of Marion, posted 20 October 2021). There are very few esplanade roads along the cliff tops, and usually private property backs on to the coastal reserve. Exceptions are The Esplanade, which is set close to the cliff top, and Clifftop Parade, which is set further back.


Figure a. The cliffs at Hallett Cliffs (North) are natural barrier to human intervention which is generally set well back from the cliff tops. Private property usually abuts the coastal reserve. Exceptions are The Esplanade and Clifftop Parade.

Figure b. The access stairs at Kurnabinna Gully is the only human infrastructure implemented along this section of coast. Proposals are being considered for a walking bridge across the gully (CoM, 20 October, 2021).

# 4-4 Coastal fabric – human intervention (Cell 2)

## LAND USE ZONING

The current urban planning controls are reviewed on this page to ascertain if existing development controls are adequate in the context of coastal areas.

**Zoning and policy areas**

Hills Neighbourhood

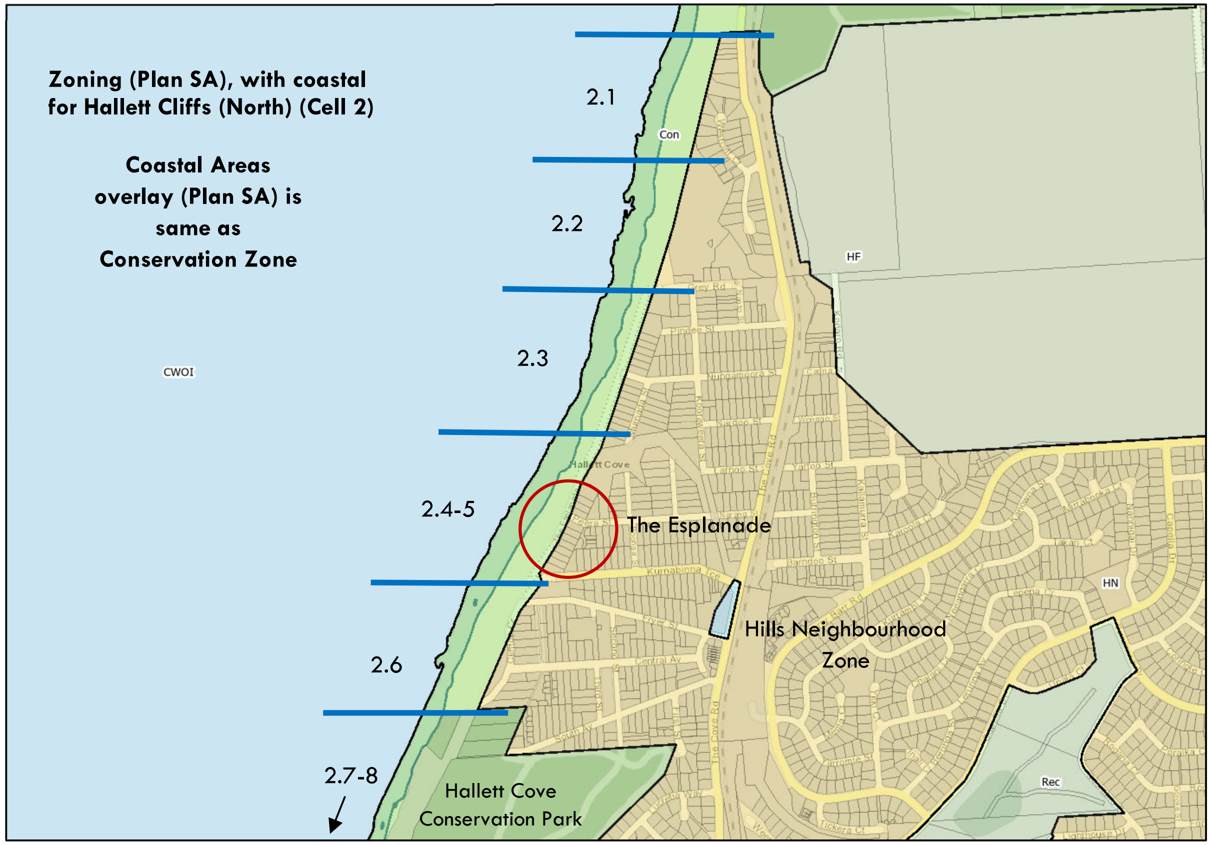
Desired Outcome: Low density housing minimises disturbance to natural landforms and existing vegetation to mitigate the visible extent of buildings, earthworks and retaining walls.

Performance outcome (sample): Predominantly low-density residential development with complementary non-residential uses compatible with natural landforms and a low-density residential character.

Permissible housing types in this zoning are: detached, semi-detached, group, and residential flat dwellings. Site and frontage controls are predicated on the slope of the land with larger land area and frontages required for more steeply sloping land.

Development density is controlled by allowable site frontage, site area, and percentage of site coverage. Within this zoning, density is controlled by the slope of the land in the following categories: less than 1 in 8; 1 in 8 to 1 in 4; and greater than 1 in 4.

See the case study for The Esplanade on the following page for an evaluation of these controls in locations that are close to the coast.




Conservation Zone

A conservation zone is positioned along the coast which includes the road reserve and the Hallett Cove Conservation Park. This zoning significantly reduces development options and can be utilised by Council to effectively control development in the coastal area.

Coastal Overlay

The coastal overlay (not pictured) is positioned in the same location as the Conservation Zone in this cell. Certain types of development proposals would trigger a referral to Coast Protection Board (Coast and Marine Branch) for advice.

# 4-4 Coastal fabric – human intervention (Cell 2)

## LAND USE ZONING

**Case Study: The Esplanade, Hallett Cove**

The Esplanade was constructed near the clifftop in the 1970s prior to the introduction of planning controls which required consideration of impacts of the sea. A 'land slip' occurred at the crest of the cliff in 1996. Council purchased two of the residential sites and mechanically lowered the slope of the cliff below (Figure a). The cause of the slide was likely uncontrolled water from a leaky pipe (See Settlement History). There are currently no known matters of instability in this area. However, if seas rise as projected, then the base of the cliffs will be subjected to more frequent tidal action. It is therefore undesirable that housing density is increased along The Esplanade or land use intensified.

<u>Development controls</u>

The *Hills Neighbourhood Zone* controls density in relation to the slope of the land. The site slope in this area is 1:10 which means that density can be at the highest rate allowed. Development controls include, *minimum site frontage* for detached dwellings (12m), semi-detached (10m), row dwellings[1] (9m), group and residential flat dwellings (20m); *minimum site areas* for detached and semi-detached ($350^2$), row, group and residential flat dwellings ($300m^2$). Most of the sites in the vicinity of The Esplanade have site frontages of ~15m which means that further subdivision would not be permitted. The exceptions are the two properties on either end of The Esplanade (see inset photograph).

<u>Summary</u>

Generally, the development controls appear adequate to control the potential for increased development density along The Esplanade as most sites have frontages ~15m. However, there are some exceptions as noted in Figure a.

[1]By definition, there must be at least 3 row dwellings, therefore the minimum frontage required is 27m.

**General development controls within Hallett Cliffs (Cell 2):**

In most areas of Hallett Cove Cliffs (North) site frontages are less than 18m which limits opportunities for subdivision. There are some exceptions scattered throughout the area; some larger sites as yet undeveloped, and some sites created larger due to their particular location (such as on a corner). Further review could be undertaken to confirm whether necessary development controls are in place.

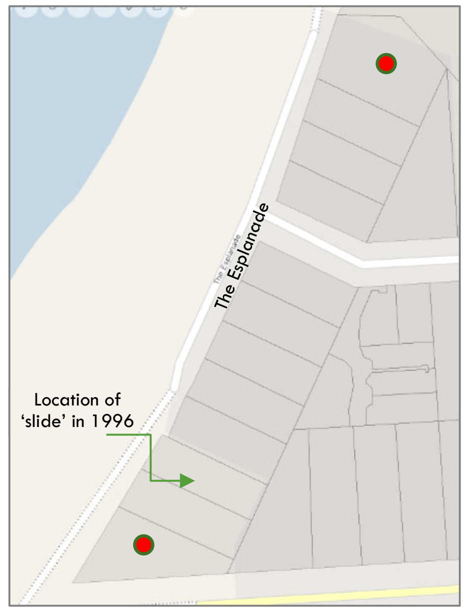
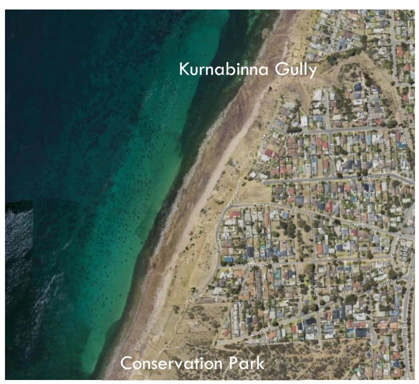



Figure a. Street and site layout of The Esplanade, Hallett Cove, South Australian Property and Planning Atlas, 2022.


Figure b. A few larger allotments remain near the coast, the one pictured positioned within a gully. (This is an example only; no particulars are known about this site).

# 4. Coastal fabric – summary table (Cell 2)

| Hallett Cliffs (N) | | Coastal context - natural | | | | Modified | Coastal changes | | Hallett Cliffs (North) |
|---|---|---|---|---|---|---|---|---|---|
| Cell | Location | Bathymetry | Benthic | Beach | Backshore | Human | 70 years | 10 years | **Erodibility** |
| 2.1 | Westcliff | Slope: -9m at ~540m offshore (1:60). Steeper slope than Cell 1 or 3. | Nearshore dominated by low profile reef to 170m offshore, then seaweed beds. | Rocky platform, shingles below the cliffs. | Steeply sloping cliff 34m high. (Resistant Wilmington Fm. with some Pleistocene clay). | Walking trail along cliff crest, urban development set well back. | Minor changes to shoreline, increasing vegetation cover. No rock falls/ slumps or slides. | Minor changes to shoreline, increasing vegetation cover. No rock falls/ slumps or slides. | **Low erodibility.** |
| 2.2-4 | Grey Rd to Murnada Street. | Slope: -9m at ~500m offshore (1:55) Steeper slope than Cell 1 or 3. | Rock platform, low profile reef to 120m offshore. Bare sand a further 120m offshore. | Narrow rock platform, tide interacts with cliffs. | Vertical cliffs at base (resistant Wilmington or Reynella siltstone) sloping back to 35m high. | Walking trail, urban development set well back (Esplanade excepted). | Minor changes to shoreline, increasing vegetation cover. One minor rock fall ~2004. | Minor changes to shoreline, increasing vegetation cover. No rock falls/ slumps or slides. | **Low erodibility.** |
| 2.5-6 | Esplanade/ Clifftop Parade. | Slope: -9m at ~500m offshore (1:55). Steeper slope than Cell 1 or 3. | Low profile reef to 120m offshore. Bare sand a further 120m offshore. | Rocky/ shingle beach with thin veneer of sand. | Steeply sleeping cliffs to 34m high (Seacliff sandstone with section of undifferentiated material). | Cliff slope mechanically lowered at Esplanade. | Base of cliff slope installed 4-6m seaward in 1996, then eroded back 1m. Increasing Vegetation. | Base of cliff slope installed 4-6m seaward in 1996, then eroded back 3-5m. Increasing vegetation. | **Low erodibility.** (Some recession of the base of the cliff slope installed in 1996). |


**Hallett Cove Cliffs North: key points**

This cell is dominated by steep cliffs to ~32m high. These are more vertical in nature where the beach is the narrowest, the water is deeper, and tides consistently interact with the base of the cliffs (2.2-3). Very few interventions have occurred at the beach level, and urban infrastructure is set well back from the cliffs (The Esplanade is the exception). The slope of the cliff at the Esplanade was mechanically lowered in 1996 after a land slip in the upper crest. The analysis of aerial photography demonstrated that very few changes have occurred along this section of coast. No major slumps or slides were observed, and only minor recession at the base where vegetation was present. Vegetation cover has steadily increased. All sections of Cell 2 are assessed as 'low erodibility'.

# 5. COASTAL EXPOSURE

To evaluate how actions of the sea currently impact the coastal fabric and how actions of the sea are projected to impact in the future in this section we complete the following:

- Review impact of storms (if any)
- Apply current 1 in 100 sea-flood risk scenario,
- Analyse routine high-water impact,
- Analyse these scenarios in time frames: 2020, 2050, 2100.

**Viewing instruction:**
View sea-flood modelling using full screen mode within your PDF software (Control L). Then use arrow keys to navigate.

# 5. Coastal exposure – overview

## COASTAL EXPOSURE EXPLAINED

The concept of coastal exposure is something we tend to understand intuitively. For example, if we find ourselves on the shore of a protected bay, we know that the impact from the ocean is likely to be limited. On the other hand, if we are standing on a beach on the Southern Ocean and listening to the roar of the waves, we understand that we are far more exposed.

In this study we are primarily concerned with the exposure of coastal landscapes to wave energy and ocean swell. However, coastal landforms can also be vulnerable to exposure from rainfall run-off or from the impact of wind. These can also increase the erosion of coastal landscapes, especially in cliff regions of softer constituency.

Due to its location within Gulf Saint Vincent, which is afforded protection by Kangaroo Island from the Southern Ocean, Nature Maps (SA) has assigned the exposure rating for City of Marion coastline as 'moderate' and the wave energy as 'low'[1].

### Storm surges

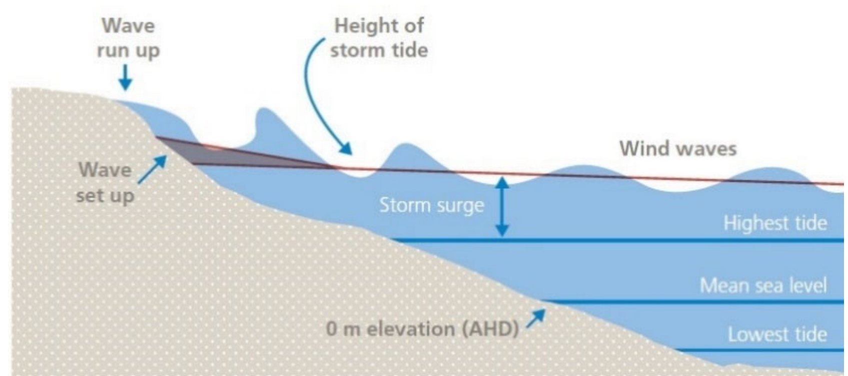
Despite this protection, when several meteorological conditions combine, storm surges can produce water levels up 1-2m higher than the predicted astronomical tide in Gulf St Vincent. To manage the risk of these events upon human infrastructure, SA Coast Protection Board has set storm surge policy risk levels for the 1 in 100-year event. In terms of probability, this event is predicted to occur once every hundred years. However, 'nature' does not read our probability charts and there is no reason why these large events could not occur closer together, albeit less likely. While storm surges may have significant impact on the coast, these by their very nature are rare events. Over time beaches may rebuild and we can repair the damage.

[1] https://data.environment.sa.gov.au/NatureMaps
[2] CD stands for Chart Datum and relates to tide heights recorded in the local tide charts.
[3] Australian Height Datum (AHD) is the same measurement system that a surveyor would utilise and generally relates to mean sea level (the middle height of water between high and low water).

The event of 9 May 2016 was the highest event recorded at the Outer Harbor tide gauge and was recorded at 3.80m CD[2] or 2.35 AHD[3]. This event came close to the *1 in 100-year event* set by South Australian Coast Protection Board at 2.50m AHD. *Wave setup* of 0.30 has been adopted for the entire City of Marion coastline[4]. *Wave runup* allocations have been made for each cell based upon surveys conducted of seaward strands from four storms in 2021-2022 (Figure a).

### Routine high water

While storm surges can have a significant impact on the coast, these are rare events. If seas rise as projected, routine tidal action is likely to have a greater impact on beaches and backshores over time. In the context of a cliff coast, areas that are currently receiving intermittent wave impact will receive constant wave impact and this is likely to increase the rate of erosion. To calculate the height of this tide, the average monthly high tide from March to September from the tidal record at Port Stanvac was calculated at 1.40m AHD[5]. It is likely that this tidal regime would occur on average one to three times per month.




[4] Set by SA Coast Protection Board. In the context of a storm surge, the water from wave action cannot flow back to the sea and water levels rise against the coast. This is known as 'wave setup'.
[5] Port Stanvac gauge operated from 1992 to 2010. Actual height was calculated at 1.42m AHD which represents 90% of the height at Outer Harbor for the same period at 1.59m AHD.

# 5. Coastal exposure – overview

## COASTAL PROCESSES

**Wave action on the Marion Council coastline**

The degree of susceptibility of a coastline to wave erosion is related to the degree of exposure of the coast to wind, current and wave attack. There are two main types of waves which fashion beaches: storm (forced waves); and swell (constructional waves). Forced waves scour the beach, erode sand from beach faces and form offshore bars. When storms subside, constructional waves tend to push sand back onto the beach.

The alignment of Marion's coastline tends more to the north-east/ south-west in contrast to Onkaparinga and Adelaide metropolitan coastline which tends to orientate north-south. Swell waves are generated in the Southern Ocean, but after passing through Investigator Strait, and having 'refracted, diffracted and attenuated due to bottom friction', wave heights are much reduced as they approach the Marion coastline. Swell waves that propagate to the Marion coastline region have 12-16 second periods, heights below 1m, and directions close to 260˚. Sea waves within the Gulf St Vincent are generally of short-wave period and quite steep, frequently with white caps and approach the shore from the direction of the wind, mostly west-south-west winds, but can roll in at range 250˚ - 310˚. Combine with south-west swells, the net wind-wave direction is northward. Wind waves are generally lower than swell waves but have been recorded at 2.6m in Gulf St Vincent[6] (Figure a).

**Storm action on the Marion Council coastline**

The conditions that produce the highest levels of water in Gulf St Vincent have been documented by Flinders Ports[7]. With the passage of a deep depression across the Southern Ocean, the winds are from the North which then swings to the North-West. A strong gusty north-westerly wind, with a depression in the Southern Ocean, backing to the south-west at about the time of low water, will cause a storm surge of maximum amplitude from the Southern Ocean, and heights may be expected from 1m to 2m

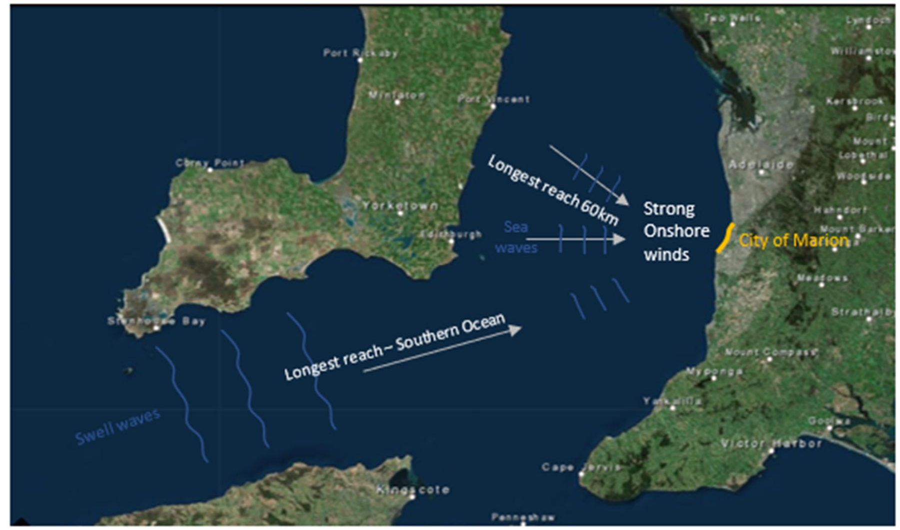



Figure a. The orientation of the City of Marion coastline to wave energy (M. Western, 2018)

**Tidal Range on the Marion City Council coastline**

The effect of tides pushing up through a narrowing Gulf increases the tidal range in the northern parts of the Gulf. In the Marion region, the categorisation is borderline in the upper ranges of micro-tidal as assessed by Doug Lord 2012.

| ***Level*** | **Chart Datum (m)** | **AHD (m)** |
|---|---|---|
| *Lowest astronomical tide* | 0.00 | -1.45 |
| *Mean sea level* | 1.30 | -0.15 |
| *Australian Height Datum* | 1.45 | 0.00 |
| *Mean high water neaps* | 1.30 | -0.15 |
| *Mean high water springs* | 2.40 | 0.95 |

Figure b. The tidal range at City of Marion is characterized as micro-tidal (upper range).

6 D. Lord., Coastal Management Study, Hallett Cove, SA. 2012

7 Flinders Ports (ND) Port User Guide – General Information

# 5. Coastal exposure – overview

## SEA LEVEL RISE

Climate change occurs over long timescales in response to solar variations, changes in the Earth's orbit around the Sun, volcanic eruptions, and natural variability. Sea levels reflect the state of the climate system. During ice ages a large volume of water is stored on land in the form of ice sheets and glaciers, leading to lower sea levels, while during warm interglacial periods, glaciers and ice sheets are reduced and more water is stored in the oceans[8]. Over the last few thousand years sea levels have stabilised, and also within this time frame, urban settlements have been established near the coast all over the world.

### Global mean sea levels

The average level of the ocean is known as *global mean sea level* (GMSL). Long term tide gauges show that seas began to rise in the 19th century and this trend has continued throughout the 20th century at on average rate of 1.7mm per year. However, this average rate of rise was not constant. Rates of sea level rise were higher in the period 1920s to1940s[9] (in the context of higher temperatures and melting of the Greenland ice sheets[10]). In the 1990s sea levels again rose at a faster rate, comparable to that of the 1920s to 1940s. Since 1990, satellites have been tracking mean sea level rise at 3-4mm per year in our region[3]. However, this shorter-term record is likely to contain an element of natural variability and the current rate of rise not unusual in the context of natural variability and the data record from last century[11]

### Regional sea levels

Regional changes occur in sea level, but these do not change the overall mass of the ocean. For example, regional sea levels change in accordance with the climate variability associated with El Nino and La Nina cycles. During El Nino years sea level rises in the eastern Pacific and falls in the western Pacific, whereas in La Nina years the opposite is true. Longer term changes are also associated with changes in the Trade Winds which bring increases in sea levels in the Western Tropical Pacific region[2]. Sea levels can also change in relationship to the vertical movement of land. If an area of land is falling, then in relative terms, sea levels will rise, and vice versa.

### Projected sea level rise

Projections of future climate change are carried out using climate models that use various greenhouse gas emissions scenarios. These models are computer-based simulations of the earth-ocean-atmosphere system that identify plausible futures as to how the climate will respond over the coming century[4]. Sea level rise projections are based upon these various scenarios. In 1993, South Australian Coast Protection Board (CPB) adopted sea level rise allowances into planning policy of 0.3m rise by 2050 and 1.0m rise by 2100. These sea level rise projections are similar to the high emissions scenario shown in Figure a.

### Scenario modelling

In this project we take the current storm surge risk levels and current routine high-water data and model the impact of these in a digital model captured in 2018. We then take the sea level allowances set by CPB at 0.3m by 2050 and 1.0m by 2100 and model the projected impact of sea level rise upon the coast.

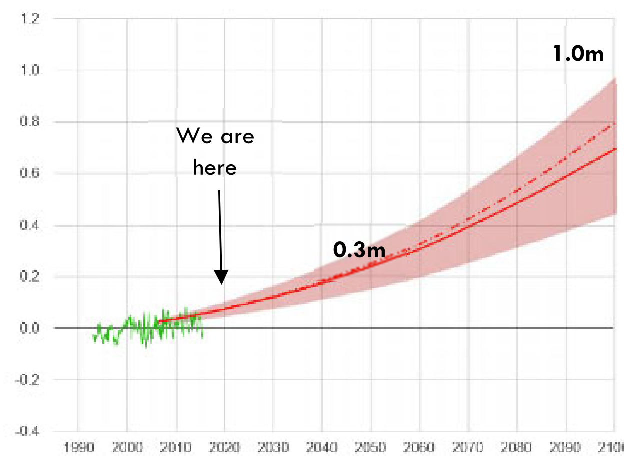



Figure a: Sea level rise high emissions scenario (Coast Adapt, 2017). Coast Protection Board sea-level rise policy added.

[8] Coast Adapt, 2017.
[9] IPCC, WG1AR5, Sea level change, 2014, Watson, P, 2020.
[10] Curry, J., Sea level and climate change, 2019.
[11] CSIRO, 2020, Sea level, waves and coastal extremes.

# 5. Coastal exposure – previous storm impact

The analysis of previous storms provides a window into the past to assist us to identify where the coast is most vulnerable. This analysis also provides a window into the future because it provides a context from which to consider how storms will impact the coast if seas rise as projected. In some ways, storms are 'natures' vulnerability assessment of how resilient our coast currently is, and how it may respond in the future.

**Storm events**

The three highest storm surges on record at Outer Harbor tide gauge occurred:

- 9 May 2016 – 2.35m AHD (3.80 CD)
- 3 July 2007 – 2.27m AHD (3.71 CD)
- 25 April 2009 – 2.22m AHD (3.65 CD)

Using a comparison of Port Stanvac and Outer Harbor gauges from 1992 to 2010 it is likely that the event of 9 May 2016 was 2.12m AHD along the City of Marion coast (see inset table).

There is no local data or photographs relating to how these larger storms have impacted this cell. Based on the sea-flood modelling, impacts are likely to have been very low.

**Event: 17 September 2021**

Seaweed strands were surveyed at 2.95m AHD after this moderate event of 1.69m (3.12 CD) at Outer Harbor tide gauge. Wave effects were 1.25m higher than tide level at Outer Harbor.

<u>Comparison of Port Stanvac and Outer Harbor tidal data</u>

A comparison of all monthly high tides showed Port Stanvac was on average 87% lower than Outer Harbor.

A comparison of monthly high tides (April to September) revealed that Port Stanvac was 90% lower.

A comparison of storm events within the period:

- 3 July 2007 (2.07 PS, 90% of 2.27OH is 2.04m)
- 25 April 2009 (1.95 PS, 90% of 2.22m is 2.00m)

Therefore, 9 May 2016 was likely to have been in vicinity of 2.12 at Port Stanvac and is adopted for this event.

Figure a: The Esplanade, Location of tidal study 17 September 2021. Seaweed strands were surveyed shortly after this event (not pictured).

# 5. Coastal exposure – location map (Cell 2.1)

**Location**

Cell 2.1

Hallett Cove Cliffs North

Location Map

**West Cliff**

**The scenarios modelled are:**

- Routine tidal action is likely to have greater impact on the backshore over time. Routine high-water events are expected to occur a few times per month from April to September.
- 1 in 100-year ARI storm surge event (CPB)

The timing of the scenarios:

- Current
- 2050
- 2100

**Nature Maps (SA) assigns:**

Relative exposure:
Moderate

Wave energy:
Low

Integrated Coasts
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www.integratedcoasts.com


**Viewing instruction:**
View the coastal exposure section utilising full screen mode within your PDF software (Control L). Then use arrow keys to navigate.

# 5. Coastal exposure – routine high water (2020)

**Routine high water**

Cell 2.1

Hallett Cove Cliffs North

Event: Routine high water

**West Cliff**

Routine high-water events are expected to occur a few times per month from April to September.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms in CoM monitoring project (2021, 2022)

The event modelled:

| | |
|---|---|
| Routine highwater | 1.60m AHD |
| Wave set-up | 0.20m |
| Total risk | 1.80m AHD |

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: The modelling is congruent with observations and the current impact on beach and backshore is low.

Integrated Coasts
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# 5. Coastal exposure – routine high water (2050)

**Routine high water**

Cell 2.1

Hallett Cove Cliffs North

2050 scenario

Event: Routine high water

**West Cliff**

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

| | |
|---|---|
| Routine highwater | 1.60m AHD |
| Sea level rise | 0.30m |
| Wave set-up | 0.20m |
| Total risk | 2.10m AHD |

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: Rocky beach backed by resistant rock cliffs. Impact will likely be very low.

Integrated Coasts
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Acknowledgement
The inundation mapping for future events is super-imposed over current beach and backshore. The purpose is to illustrate the potential impact of sea level rise. In this case the impact is likely to be low.

# 5. Coastal exposure – routine high water (2100)

**Routine high water**

Cell 2.1

Hallett Cove Cliffs North

2100 scenario

Event: Routine high water

**West Cliff**

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

| | |
|---|---|
| Routine highwater | 1.60m AHD |
| Sea level rise | 1.00m |
| Wave set-up | 0.20m |
| Total risk | 2.80m AHD |

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. There will be higher impacts on the cliffs but effects unknown (likely low).

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# 5. Coastal exposure – storm surge (2020)

**Storm surge**

Cell 2.1

Hallett Cove Cliffs North

2020 scenario

Event: 1 in 100 sea-flood risk

**West Cliff**

The current 1 in 100-year event risk set by SA Coast Protection Board is:

| | |
|---|---|
| Storm surge | 2.40m AHD. |
| Wave set-up | 0.30m |
| Risk | 2.70m AHD |

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. This event is very rare and therefore no impacts are likely on the backshore.

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# 5. Coastal exposure – storm surge (2050)

**Storm surge**

Cell 2.1

Hallett Cove Cliffs North

2050 scenario

Event: 1 in 100 sea-flood risk

**West Cliff**

The current 1 in 100-year event risk set by SA Coast Protection Board is:

| | |
|---|---|
| Storm surge | 2.40m AHD. |
| Sea level rise | 0.30m |
| Wave set-up | 0.30m |
| Risk | 3.00m AHD |

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. This event is very rare and therefore no impacts are likely on the backshore.

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# 5. Coastal exposure – storm surge (2100)

**Storm surge**

Cell 2.1

Hallett Cove Cliffs North

2100 scenario

Event: 1 in 100-year event

**West Cliff**

The current 1 in 100-year event risk set by SA Coast Protection Board is:

| | |
|---|---|
| Storm surge | 2.40m AHD. |
| Sea level rise | 1.00m |
| Wave set-up | 0.30m |
| Risk | 3.70m AHD |

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. This event is very rare and therefore no impacts are likely on the backshore. However, combined with routine highwater events at 1.00m higher than present the overall impact will be greater.

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# 5. Coastal exposure – summary (Cell 2.1)

**Summary**

Cell 2.1

Hallett Cove Cliffs North

Summary

**West Cliff**

***2020-2050***

Current impact in coastal layout of rocky beach and resistant rock cliffs is low and 0.30m of sea level rise will be unlikely to change this assessment.

***2050-2100***

If seas rise as projected post 2050, then there will be increased impact on the base of the cliff, especially from routine tidal events. However, these cliffs are of a resistant type and therefore any undercutting is likely to be slow but any friable material will be removed and the rock more exposed.

Integrated Coasts
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# 5. Coastal exposure – location map (Cell 2.2)

**Location**

Cell 2.2

Hallett Cove Cliffs North

Location Map

**Grey Road**

**The scenarios modelled are:**

- Routine tidal action is likely to have greater impact on the backshore over time. Routine high-water events are expected to occur a few times per month from April to September.
- 1 in 100-year ARI storm surge event (CPB)

The timing of the scenarios:

- Current
- 2050
- 2100

**Nature Maps (SA) assigns:**

Relative exposure:
Moderate

Wave energy:
Low

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www.integratedcoasts.com

# 5. Coastal exposure – routine high water (2020)

**Routine high water**

Cell 2.2

Hallett Cove Cliffs North

2020 scenario

Event: Routine high water

**Grey Road**

Routine high-water events are expected to occur a few times per month from April to September.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms in CoM monitoring project (2021, 2022)

The event modelled:

| | |
|---|---|
| Routine highwater | 1.60m AHD |
| Wave set-up | 0.20m |
| Total risk | 1.80m AHD |

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: The modelling is congruent with observations and the current impact on beach and backshore is low.

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# 5. Coastal exposure – routine high water (2050)

**Routine high water**

Cell 2.2

Hallett Cove Cliffs North

2050 scenario

Event: Routine high water

**Grey Road**

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

| | |
|---|---|
| Routine highwater | 1.60m AHD |
| Sea level rise | 0.30m |
| Wave set-up | 0.20m |
| Total risk AHD | 2.10m |

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: Rocky beach backed by resistant rock cliffs. Impact will likely be low.

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# 5. Coastal exposure – routine high water (2100)

**Routine high water**

Cell 2.2

Hallett Cove Cliffs North

2100 risk:

Event: Routine high water

**Grey Road**

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

| | |
|---|---|
| Routine highwater | 1.60m AHD |
| Sea level rise | 1.00m |
| Wave set-up | 0.20m |
| Total risk | 2.80m AHD |

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. There will be higher impacts on the cliffs but effects unknown (likely low).

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# 5. Coastal exposure – storm surge (2020)

**Storm surge**

Cell 2.2

Hallett Cove Cliffs North

2020 scenario

Event: 1 in 100 sea-flood risk

**Grey Road**

The current 1 in 100-year event risk set by SA Coast Protection Board is:

| | |
|---|---|
| Storm surge | 2.40m AHD. |
| Wave set-up | <u>0.30m</u> |
| Risk | 2.70m AHD |

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. This event is very rare and therefore no impacts are likely on the backshore.

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# 5. Coastal exposure – storm surge (2050)

**Storm surge**

Cell 2.2

Hallett Cove Cliffs North

2050 scenario

Event: 1 in 100 sea-flood risk

**Grey Road**

The current 1 in 100-year event risk set by SA Coast Protection Board is:

| | |
|---|---|
| Storm surge | 2.40m AHD. |
| Sea level rise | 0.30m |
| Wave set-up | 0.30m |
| Risk | 3.00m AHD |

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. This event is very rare and therefore no impacts are likely on the backshore.

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# 5. Coastal exposure – storm surge (2100)

**Storm surge**

Cell 2.2

Hallett Cove Cliffs North

2100 scenario

Event: 1 in 100-year event

**Grey Road**

The current 1 in 100-year event risk set by SA Coast Protection Board is:

| | |
|---|---|
| Storm surge | 2.40m AHD. |
| Sea level rise | 1.00m |
| Wave set-up | 0.30m |
| Risk | 3.70m AHD |

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. This event is very rare and therefore no impacts are likely on the backshore. However, combined with routine highwater events at 1.00m higher than present the overall impact will be greater.

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Acknowledgement
The inundation mapping for future events is super-imposed over current beach and backshore. The purpose is to illustrate the potential impact of sea level rise. In this location the changes to beach and backshore are likely to be low.

# 5. Coastal exposure – summary (Cell 2.2)

**Summary**

Cell 2.2

Hallett Cove Cliffs North

Summary

**Grey Road**

***2020-2050***

Current impact in coastal layout of rocky beach and resistant rock cliffs is low and 0.30m of sea level rise will be unlikely to change this assessment.

***2050-2100***

If seas rise as projected post 2050, then there will be increased impact on the base of the cliff, especially from routine tidal events. The exact impact is unknown, these cliffs are of a resistant type and therefore any undercutting is likely to be slow.

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# 5. Coastal exposure – location map (Cell 2.3)

**Location**

Cell 2.3

Hallett Cove Cliffs North

Location Map

**Pindee St**

**The scenarios modelled are:**

- Routine tidal action is likely to have greater impact on the backshore over time. Routine high-water events are expected to occur a few times per month from April to September.
- 1 in 100-year ARI storm surge event (CPB)

The timing of the scenarios:

- Current
- 2050
- 2100

**Nature Maps (SA) assigns:**

Relative exposure:
Moderate

Wave energy:
Low

Integrated Coasts
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www.integratedcoasts.com

# 5. Current exposure – routine high water (2020)

**Routine high water**

Cell 2.3

Hallett Cove Cliffs North

2020 scenario

Event: Routine high water

**Pindee St**

Routine high-water events are expected to occur a few times per month from April to September.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms in CoM monitoring project (2021, 2022)

The event modelled:

| | |
|---|---|
| Routine highwater | 1.60m AHD |
| Wave set-up | 0.20m |
| Total risk | 1.80m AHD |

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: The modelling is congruent with observations and the current impact on beach and backshore is low.

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# 5. Coastal exposure – routine high water (2050)

**Routine high water**

Cell 2.3

Hallett Cove Cliffs North

2050 scenario

Event: Routine high water

**Pindee St**

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

| | |
|---|---|
| Routine highwater | 1.60m AHD |
| Sea level rise | 0.30m |
| Wave set-up | 0.20m |
| Total risk | 2.10m AHD |

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: Rocky beach backed by resistant rock cliffs. Impact will likely be low.

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Acknowledgement
The inundation mapping for future events is super-imposed over current beach and backshore. The purpose is to illustrate the potential impact of sea level rise. In this location the changes to beach and backshore are likely to be low.

# 5. Coastal exposure – routine high water (2100)

**Routine high water**

Cell 2.3

Hallett Cove Cliffs North

2100 scenario

Event: Routine high water

**Pindee St**

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

| | |
|---|---|
| Routine highwater | 1.60m AHD |
| Sea level rise | 1.00m |
| Wave set-up | 0.20m |
| Total risk | 2.80m AHD |

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. There will be higher impacts on the cliffs but effects unknown (likely low).

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# 5. Coastal exposure – storm surge (2020)

**Storm surge**

Cell 2.3

Hallett Cove Cliffs North

2020 scenario

Event: 1 in 100 sea-flood risk

**Pindee St**

The current 1 in 100-year event risk set by SA Coast Protection Board is:

| | |
|---|---|
| Storm surge | 2.40m AHD. |
| Wave set-up | 0.30m |
| Risk | 2.70m AHD |

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. This event is very rare and therefore no impacts are likely on the backshore.

Integrated Coasts
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# 5. Coastal exposure – storm surge (2050)

**Storm surge**

Cell 2.3

Hallett Cove Cliffs North

2020 scenario

Event: 1 in 100 sea-flood risk

**Pindee St**

The current 1 in 100-year event risk set by SA Coast Protection Board is:

| | |
|---|---|
| Storm surge | 2.40m AHD. |
| Sea level rise | 0.30m |
| Wave set-up | 0.30m |
| Risk | 3.00m AHD |

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. This event is very rare and therefore no impacts are likely on the backshore.

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Acknowledgement
The inundation mapping for future events is super-imposed over current beach and backshore. The purpose is to illustrate the potential impact of sea level rise. In this location the changes to beach and backshore are likely to be low.

# 5. Coastal exposure – storm surge (2100)

**Storm surge**

Cell 2.3

Hallett Cove Cliffs North

2100 scenario

Event: 1 in 100 sea-flood risk

**Pindee St**

The current 1 in 100-year event risk set by SA Coast Protection Board is:

| | |
|---|---|
| Storm surge | 2.40m AHD. |
| Sea level rise | 1.00m |
| Wave set-up | 0.30m |
| Risk | 3.70m AHD |

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. This event is very rare and therefore no impacts are likely on the backshore. However, combined with routine highwater events at 1.00m higher than present the overall impact will be greater.

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# 5. Coastal exposure – summary (Cell 2.3)

**Summary**

Cell 2.3

Hallett Cove Cliffs North

Summary

**Pindee St**

***2020-2050***

Current impact in coastal layout of rocky beach and resistant rock cliffs is low and 0.30m of sea level rise will be unlikely to change this assessment.

***2050-2100***

If seas rise as projected post 2050, then there will be increased impact on the base of the cliff, especially from routine tidal events. The exact impact is unknown, these cliffs are of a resistant type and therefore any undercutting is likely to be slow.

Integrated Coasts
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www.integratedcoasts.com

# 5. Coastal exposure – location map (Cell 2.4)

**Location**

Cell 2.4

Hallett Cove Cliffs North

Location Map

**The Esplanade**

**The scenarios modelled are:**

- Routine tidal action is likely to have greater impact on the backshore over time. Routine high-water events are expected to occur a few times per month from April to September.
- 1 in 100-year ARI storm surge event (CPB)

The timing of the scenarios:

- Current
- 2050
- 2100

**Nature Maps (SA) assigns:**

Relative exposure:
Moderate

Wave energy:
Low

Integrated Coasts
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www.integratedcoasts.com

# 5. Coastal exposure – routine high water (2020)

**Routine high water**

Cell 2.4

Hallett Cove Cliffs North

2020 scenario

Event: Routine high water

**The Esplanade**

Routine high-water events are expected to occur a few times per month from April to September.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms in CoM monitoring project (2021, 2022)

The event modelled:

| | |
|---|---|
| Routine highwater | 1.60m AHD |
| Wave set-up | 0.20m |
| Total risk | 1.80m AHD |

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: The modelling is congruent with observations and the current impact on beach and backshore is low.

Integrated Coasts
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# 5. Coastal exposure – routine high water (2050)

**Routine high water**

Cell 2.4

Hallett Cove Cliffs North

2050 scenario

Event: Routine high water

**The Esplanade**

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

| | |
|---|---|
| Routine highwater | 1.60m AHD |
| Sea level rise | 0.30m |
| Wave set-up | 0.20m |
| Total risk | 2.10m AHD |

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: Rocky beach backed by resistant rock cliffs. Impact will likely be low.

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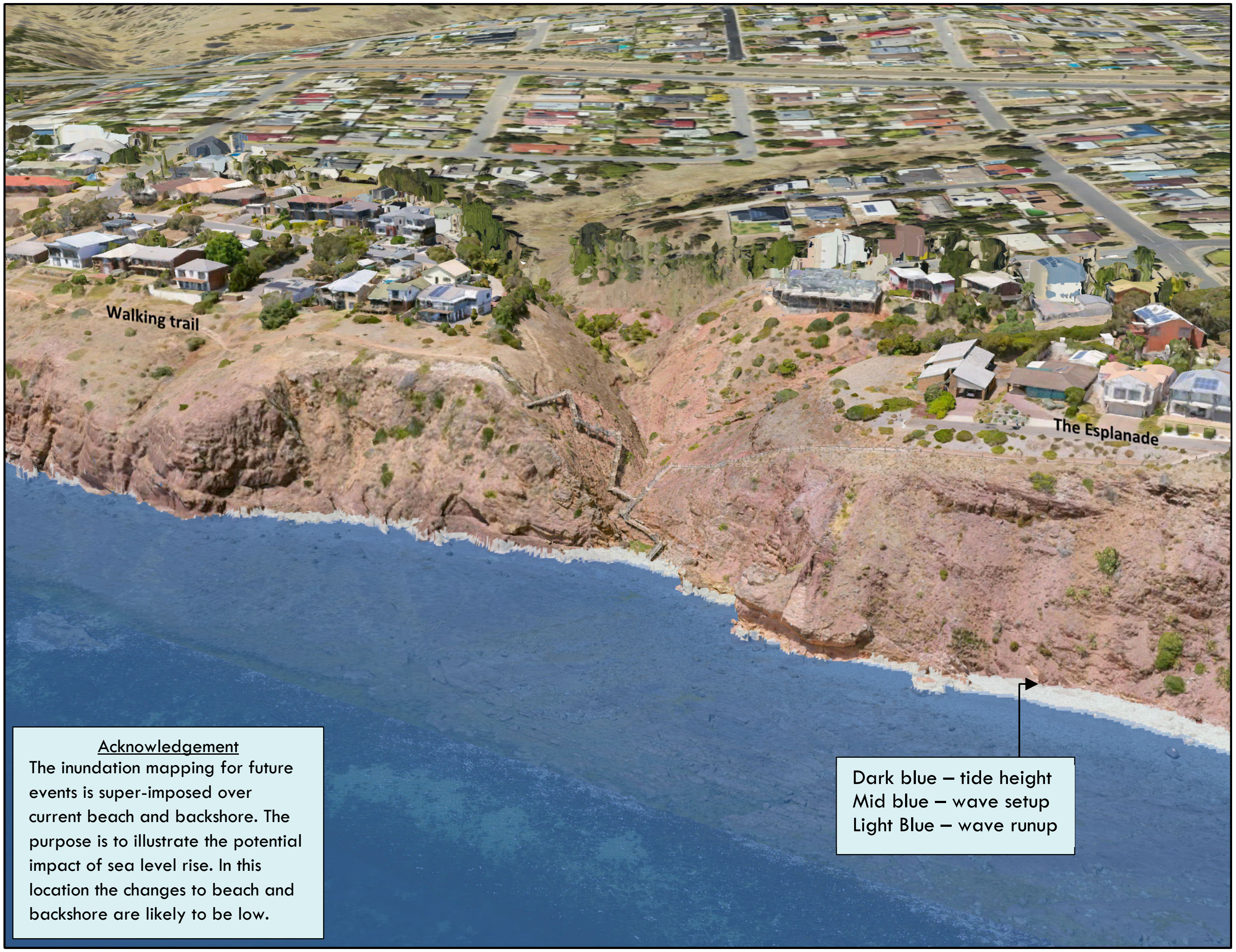


Acknowledgement
The inundation mapping for future events is super-imposed over current beach and backshore. The purpose is to illustrate the potential impact of sea level rise. In this location the changes to beach and backshore are likely to be low.

# 5. Coastal exposure – routine high water (2100)

**Routine high water**

Cell 2.4

Hallett Cove Cliffs North

2100 scenario

Event: Routine high water

**The Esplanade**

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

| | |
|---|---|
| Routine highwater | 1.60m AHD |
| Sea level rise | 1.00m |
| Wave set-up | 0.20m |
| Total risk | 2.80m AHD |

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. There will be higher impacts on the cliffs but effects unknown (likely low).
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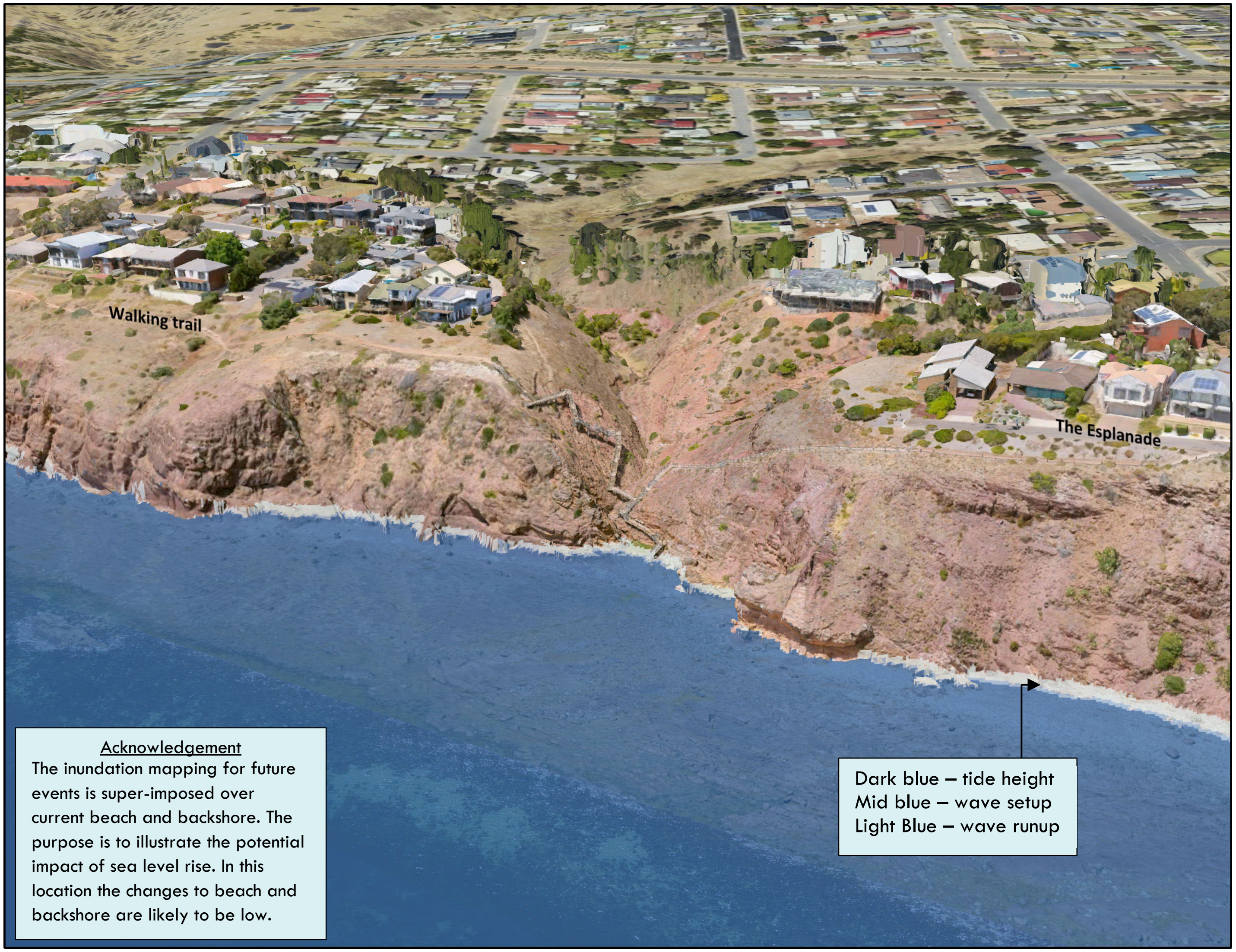

# 5. Coastal exposure – storm surge (2020)

**Storm surge**

Cell 2.4

Hallett Cove Cliffs North

2020 scenario

Event: 1 in 100 sea-flood risk

**The Esplanade**

The current 1 in 100-year event risk set by SA Coast Protection Board is:

| | |
|---|---|
| Storm surge | 2.40m AHD. |
| Wave set-up | 0.30m |
| Risk | 2.70m AHD |

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. This event is very rare and therefore no impacts are likely on the backshore.

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# 5. Coastal exposure – storm surge (2050)

**Storm surge**

Cell 2.4

Hallett Cove Cliffs North

2050 scenario

Event: 1 in 100 sea-flood risk

**The Esplanade**

The current 1 in 100-year event risk set by SA Coast Protection Board is:

| | |
|---|---|
| Storm surge | 2.40m AHD. |
| Sea level rise | 0.30m |
| Wave set-up | 0.30m |
| Risk | 3.00m AHD |

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. This event is very rare and therefore no impacts are likely on the backshore.

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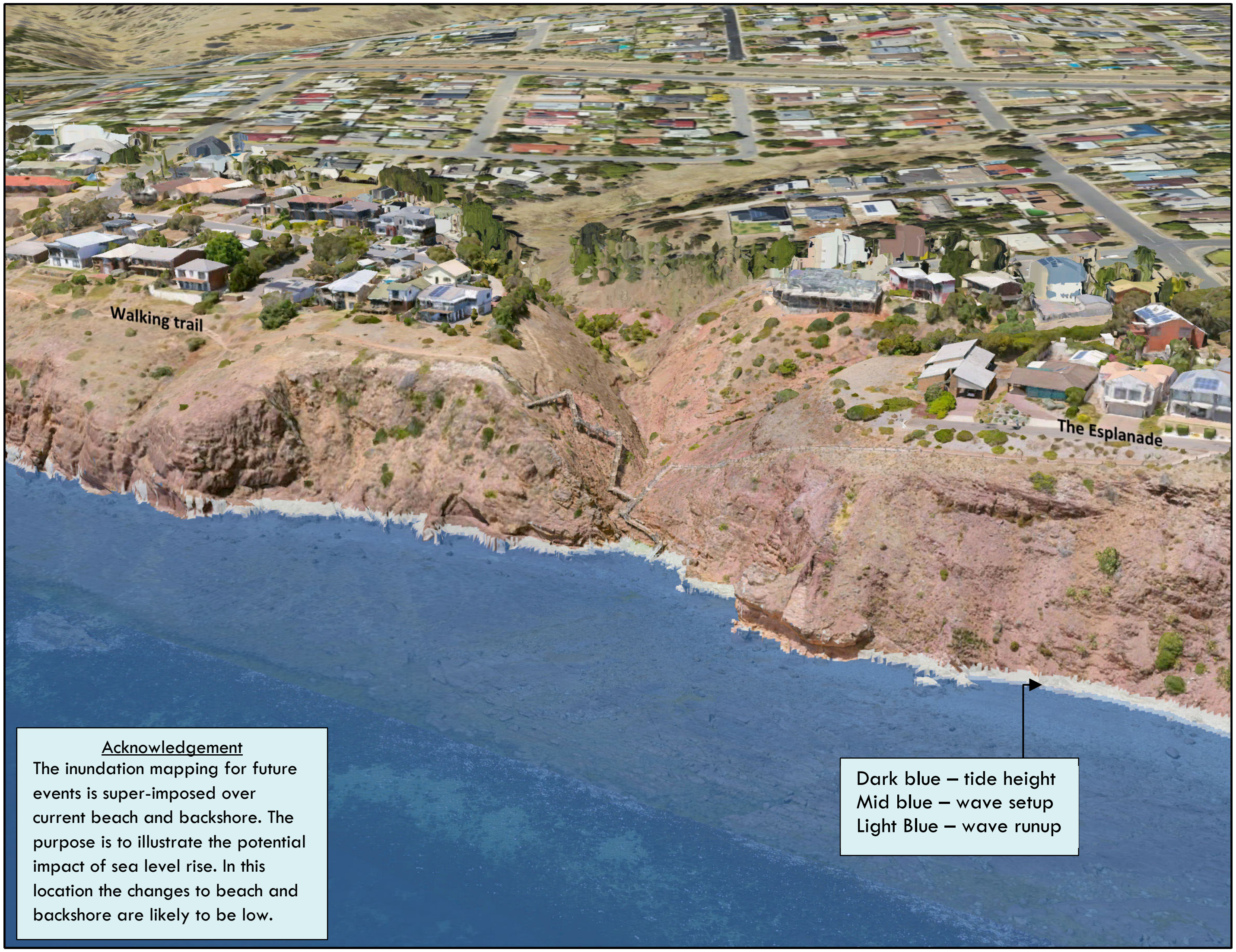


# 5. Coastal exposure – storm surge (2100)

**Storm surge**

Cell 2.4

Hallett Cove Cliffs North

2100 scenario

Event: 1 in 100 sea-flood risk

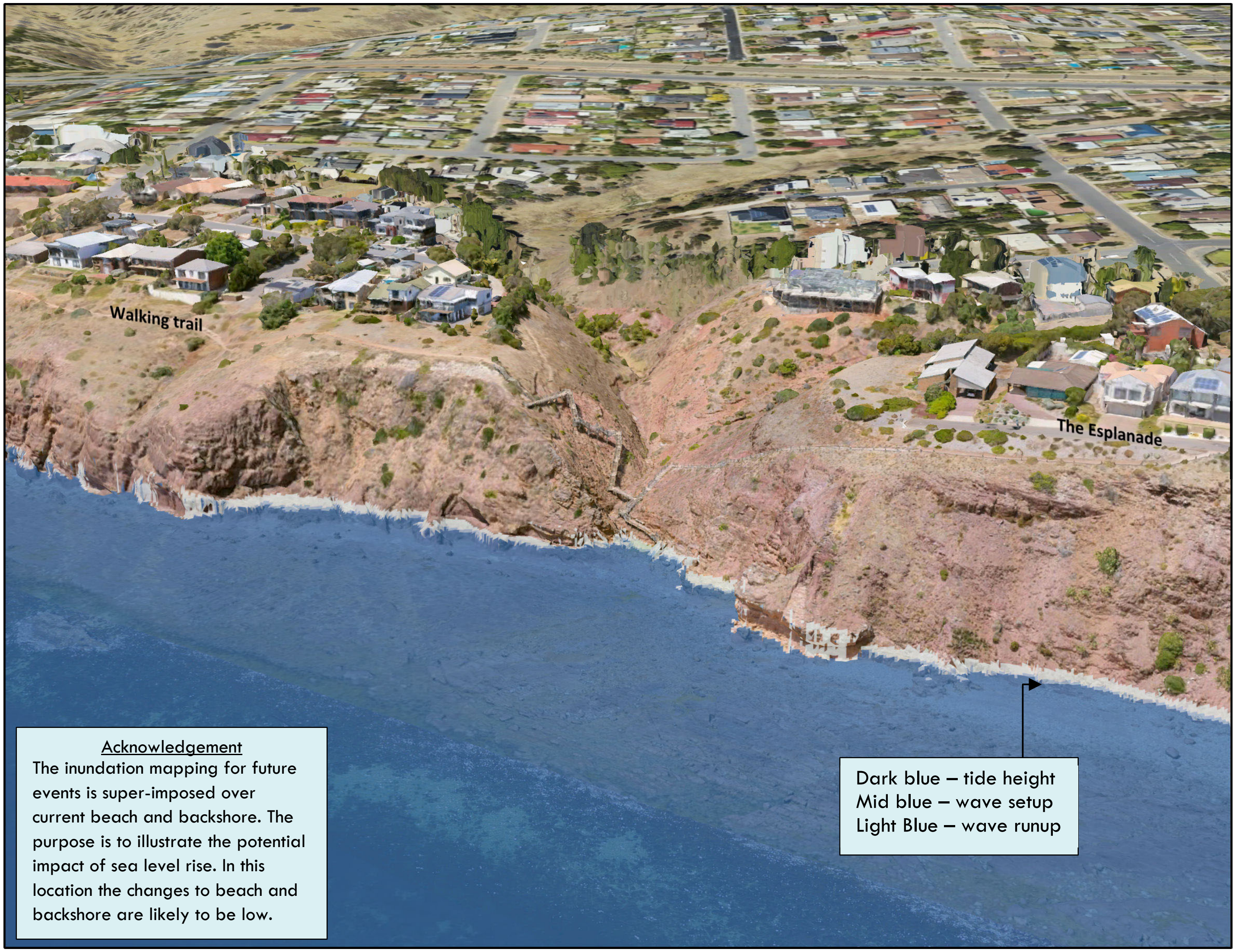
**The Esplanade**

The current 1 in 100-year event risk set by SA Coast Protection Board is:

| | |
|---|---|
| Storm surge | 2.40m AHD. |
| Sea level rise | 1.00m |
| Wave set-up | 0.30m |
| Risk | 3.70m AHD |

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. This event is very rare and therefore no impacts are likely on the backshore. However, combined with routine highwater events at 1.00m higher than present the overall impact will be greater.




Acknowledgement
The inundation mapping for future events is super-imposed over current beach and backshore. The purpose is to illustrate the potential impact of sea level rise. In this location the changes to beach and backshore are likely to be low.

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# 5. Coastal exposure – summary (Cell 2.4)

**Summary**

Cell 2.4

Hallett Cove Cliffs North

Summary

**The Esplanade**

***2020-2050***

Current impact in coastal layout of rocky beach and resistant rock cliffs is low and 0.30m of sea level rise will be unlikely to change this assessment.

***2050-2100***

If seas rise as projected post 2050, then there will be increased impact on the base of the cliff, especially from routine tidal events. The exact impact is unknown, these cliffs are of a resistant type and therefore any undercutting is likely to be slow.

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# 5. Coastal exposure – location map (Cell 2.5)

**Location**

Cell 2.5

Hallett Cove Cliffs North

Location Map

**Kurnabinna Terrace**

**The scenarios modelled are:**

- Routine tidal action is likely to have greater impact on the backshore over time. Routine high-water events are expected to occur a few times per month from April to September.
- 1 in 100-year ARI storm surge event (CPB)

The timing of the scenarios:

- Current
- 2050
- 2100

**Nature Maps (SA) assigns:**

Relative exposure:
Moderate

Wave energy:
Low

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# 5. Coastal exposure – routine high water (2020)

Routine high water

Cell 2.5

Hallett Cove Cliffs North

2020 scenario

Event: Routine high water

**Kurnabinna Terrace**

Routine tidal action is likely to have greater impact on the backshore over time. Routine high-water events are expected to occur a few times per month from April to September.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms in CoM monitoring project (2021, 2022)

The event modelled:

| | |
|---|---|
| Routine highwater | 1.60m AHD |
| Wave set-up | 0.20m |
| Total risk | 1.80m AHD |

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: The modelling is congruent with observations and the current impact on beach and backshore is low.

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# 5. Coastal exposure – routine high water (2050)

**Routine high water**

Cell 2.5

Hallett Cove Cliffs North

2050 scenario

Event: Routine high water

**Kurnabinna Terrace**

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

| | |
|---|---|
| Routine highwater | 1.60m AHD |
| Sea level rise | 0.20m |
| Wave set-up | 0.30m |
| Total risk | 2.10m AHD |

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: The modelling indicates impact on beach and backshore would remain low for 2050 projections.

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Acknowledgement
The inundation mapping for future events is super-imposed over current beach and backshore. The purpose is to illustrate the potential impact of sea level rise. In this location the changes to beach and backshore are likely to be low.

# 5. Coastal exposure – routine high water (2100)

**Routine high water**

Cell 2.5

Hallett Cove Cliffs North

2100 scenario

Event: Routine high water

**Kurnabinna Terrace**

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

| | |
|---|---|
| Routine highwater | 1.60m AHD |
| Sea level rise | 1.00m |
| Wave set-up | 0.20m |
| Total risk | 2.80m AHD |

Wave run-up is an additional 1.00m and depicted in light blue.

Routine highwater events 1.00m higher than present would remove any friable material from the base of these cliffs, potentially increasing their slope.

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Acknowledgement
The inundation mapping for future events is super-imposed over current beach and backshore. The purpose is to illustrate the potential impact of sea level rise. In this location the changes to beach and backshore are likely to be low.

# 5. Coastal exposure – storm surge (2020)

**Storm surge**

Cell 2.5

Hallett Cove Cliffs North

2020 scenario

Event: 1 in 100 sea-flood risk

**Kurnabinna Terrace**

The current 1 in 100-year event risk set by SA Coast Protection Board is:

| | |
|---|---|
| Storm surge | 2.40m AHD. |
| Wave set-up | 0.30m |
| Risk | 2.70m AHD |

Wave run-up is an additional 1.20m and depicted in light blue.

This is a rare event similar to 9 May 2016 and is likely to cause scarping at the base of the sloping cliffs, especially in the location where the slope was mechanically lowered in the 1980s after a landslip. However, there doesn't appear to be any threat to the stability of the slope from this event.

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# 5. Coastal exposure – storm surge (2050)

**Storm surge**

Cell 2.5

Hallett Cove Cliffs North

2050 scenario

Event: 1 in 100 sea-flood risk

**Kurnabinna Terrace**

The current 1 in 100-year event risk set by SA Coast Protection Board is:

| | |
|---|---|
| Storm surge | 2.40m AHD. |
| Sea level rise | 0.30m |
| Wave set-up | 0.30m |
| Risk | 3.00m AHD |

Wave run-up is an additional 1.20m and depicted in light blue.

This would be a rare event and is likely to cause scarping at the base of the sloping cliffs, especially in the location where the slope was mechanically lowered in the 1980s after a landslip.

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# 5. Coastal exposure – storm surge (2100)

**Storm surge**

Cell 2.5

Hallett Cove Cliffs North

2100 scenario

Event: 1 in 100 sea-flood risk

**Kurnabinna Terrace**

The current 1 in 100-year event risk set by SA Coast Protection Board is:

| | |
|---|---|
| Storm surge | 2.40m AHD. |
| Sea level rise | 1.00m |
| Wave set-up | <u>0.30m</u> |
| Risk | 3.70m AHD |

Wave run-up is an additional 1.20m and depicted in light blue.

This would be a rare event and is likely to cause significant scarping and erosion at the base of the sloping cliffs, especially in the location where the slope was mechanically lowered in the 1980s after a landslip.

Combined with routine highwater events higher than present the impact would be significant and recession of the base likely.

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Acknowledgement
The inundation mapping for future events is super-imposed over current beach and backshore. The purpose is to illustrate the potential impact of sea level rise. In this location the changes to beach and backshore are likely to be low.

# 5. Coastal exposure – summary (Cell 2.5)

Summary

Cell 2.5

Hallett Cove Cliffs North

Summary

**Kurnabinna Terrace**

***2020-2050***

Current impact on the base of this cliff is low, but larger events like 9 May 2016 do cause scarping to the friable material at the base of the cliffs. Seas 0.30m than present is likely to cause minor recession to any friable material at the base.

***2050-2100***

If sea levels rise as projected, then routine high-water events combined with storm events will have a significant impact on the base of this cliff. Recession of the base is likely where the material is friable and the rock underneath become more exposed. It is unknown what impact this will have on the upper and lower slopes.

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# 5. Coastal exposure – location map (Cell 2.6)

**Location**

Cell 2.6

Hallett Cove Cliffs North

Location Map

**Clifftop Crescent**

**The scenarios modelled are:**

- Routine tidal action is likely to have greater impact on the backshore over time. Routine high-water events are expected to occur a few times per month from April to September.
- 1 in 100-year ARI storm surge event (CPB)

The timing of the scenarios:

- Current
- 2050
- 2100

**Nature Maps (SA) assigns:**

Relative exposure:
Moderate

Wave energy:
Low

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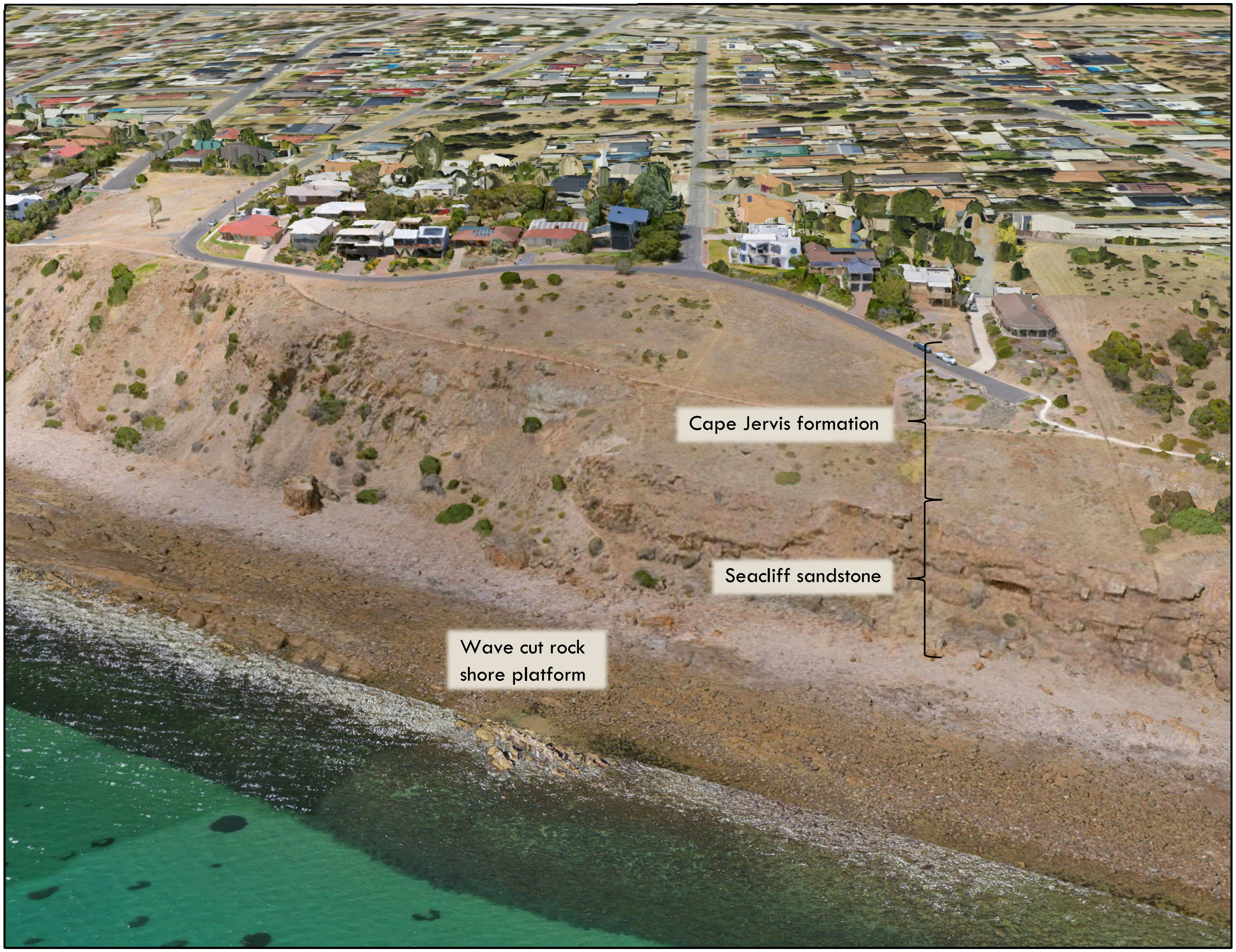

# 5. Coastal exposure – routine high water (2020)

**Routine high water**

Cell 2.6

Hallett Cove Cliffs North

2020 scenario

Event: Routine high water

**Clifftop Terrace**

Routine tidal action is likely to have greater impact on the backshore over time. Routine high-water events are expected to occur a few times per month from April to September.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms in CoM monitoring project (2021, 2022)

The event modelled:

| | |
|---|---|
| Routine monthly tide | 1.60m AHD |
| Wave set-up | 0.20m |
| Total risk | 1.80m AHD |

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: The modelling is congruent with observations and the current impact on beach and backshore is low.

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# 5. Coastal exposure – routine high water (2050)

**Routine high water**

Cell 2.6

Hallett Cove Cliffs North

2050 scenario

Event: Routine high water

**Clifftop Terrace**

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

| | |
|---|---|
| Routine highwater | 1.60m AHD |
| Sea level rise | 0.30m |
| Wave set-up | 0.20m |
| Total risk | 2.10m AHD |

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: The modelling indicates impact on beach and backshore would remain low for 2050 projections.

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Acknowledgement
The inundation mapping for future events is super-imposed over current beach and backshore. The purpose is to illustrate the potential impact of sea level rise. In this location the changes to beach and backshore are likely to be low.

# 5. Coastal exposure – routine high water (2100)

**Routine high water**

Cell 2.6

Hallett Cove Cliffs North

2100 scenario

Event: Routine high water

**Clifftop Terrace**

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

| | |
|---|---|
| Routine highwater | 1.60m AHD |
| Sea level rise | 1.00m |
| Wave set-up | 0.20m |
| Total risk | 2.80m AHD |

Wave run-up is an additional 1.00m and depicted in light blue.

The impact of seas 1m higher than present would be significant and would remove any friable material from the base of the cliffs and expose more rock.

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Acknowledgement

The inundation mapping for future events is super-imposed over current beach and backshore. The purpose is to illustrate the potential impact of sea level rise. In this location the changes to beach and backshore are likely to be low.

# 5. Coastal exposure – storm surge (2020)

**Storm surge**

Cell 2.6

Hallett Cove Cliffs North

2020 scenario

Event: 1 in 100 sea-flood risk

**Clifftop Terrace**

The current 1 in 100-year event risk set by SA Coast Protection Board is:

| | |
|---|---|
| Storm surge | 2.40m AHD. |
| Wave set-up | 0.30m |
| Risk | 2.70m AHD |

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. This event is very rare and therefore no impacts are likely on the backshore.

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# 5. Coastal exposure – storm surge (2050)

**Storm surge**

Cell 2.6

Hallett Cove Cliffs North

2050 scenario

Event: 1 in 100 sea-flood risk

**Clifftop Terrace**

The current 1 in 100-year event risk set by SA Coast Protection Board is:

| | |
|---|---|
| Storm surge | 2.40m AHD. |
| Sea level rise | 0.30m |
| Wave set-up | 0.30m |
| Risk | 3.00m AHD |

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. This event is very rare and therefore impacts are likely to be limited to the removal of the friable material at the base of the cliffs.

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Acknowledgement
The inundation mapping for future events is super-imposed over current beach and backshore. The purpose is to illustrate the potential impact of sea level rise. In this location the changes to beach and backshore are likely to be low.

# 5. Coastal exposure – storm surge (2100)

**Storm surge**

Cell 2.6

Hallett Cove Cliffs North

2100 scenario

Event: 1 in 100 sea-flood risk

**Clifftop Terrace**

The current 1 in 100-year event risk set by SA Coast Protection Board is:

| | |
|---|---|
| Storm surge | 2.40m AHD. |
| Sea level rise | 1.00m |
| Wave set-up | 0.30m |
| Risk | 3.70m AHD |

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment: Rocky beach and resistant rock cliffs in backshore. This event is very rare and therefore impacts are likely to be limited to the removal of the friable material at the base of the cliffs. However, combined with routine highwater at sea levels 1.00m higher than present would have a considerable impact on the base of this cliff (effects unknown).

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# 5. Coastal exposure – summary (Cell 2.6)

Summary

Cell 2.6

Hallett Cove Cliffs North

Summary

**Clifftop Terrace**

Current impact in coastal layout of rocky beach and resistant rock cliffs is low and 0.30m of sea level rise will be unlikely to change this assessment.

***2050-2100***

If seas rise as projected post 2050, then there will be increased impact on the base of the cliff, especially from routine tidal events. The exact impact is unknown, these cliffs are of a resistant type and therefore any undercutting is likely to be slow.

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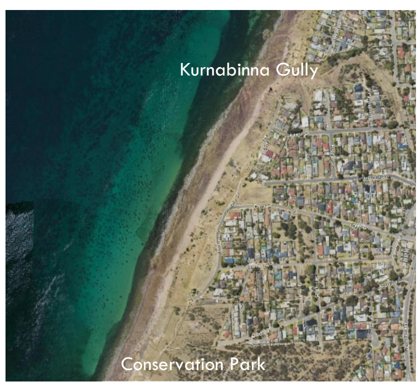
# COASTAL EXPOSURE – Summary table

## Hallett Cove Cliffs North (Cell 2)

| Hallett Cliffs (N) | | Coastal context - natural | | | | Modified | Exposure* | Scenario Modelling | |
|---|---|---|---|---|---|---|---|---|---|
| Cell | Location | Bathymetry | Benthic | Beach | Backshore | Human | Waves | 2020 - 2050 | 2050-2100 |
| 2.1 | Westcliff | Slope: -9m at ~540m offshore (1:60). Steeper slope than Cell 1/3 | Nearshore dominated by low profile reef to 170m offshore, then seaweed beds. | Rocky platform, shingles below the cliffs. | Steeply sloping cliff 34m high. (Resistant Wilmington Fm. with some Pleistocene clay). | Walking trail at cliff crest, development set well back. | Moderate exposure<br><br>Low wave energy | Current impact in coastal layout of rocky beach and resistant rock cliffs is low and 0.30m of sea level rise will be unlikely to change this assessment. | Increased impact on the base of the cliff. However, these cliffs are of a resistant type and therefore any undercutting is likely to be slow. |
| 2.2-4 | Grey Road to Murnado Street | Slope: -9m at ~500m offshore (1:55) | Rock platform, low profile reef to 120m offshore. Bare sand a further 120m offshore. | Narrow rock platform, tide interacts with cliffs. | Vertical cliffs at base (resistant Wilmington or Reynella siltstone) sloping back to 35m high. | Walking trail at cliff crest, development set well back. | Moderate exposure<br><br>Low wave energy | Current impact in coastal layout of rocky beach and resistant rock cliffs is low and 0.30m of sea level rise will be unlikely to change this assessment. | Increased impact on the base of the cliff. However, these cliffs are of a resistant type and therefore any undercutting is likely to be slow. |
| 2.5-6 | The Esplanade and Clifftop Parade | Slope: -9m at ~500m offshore (1:55). | Low profile reef to 120m offshore. Bare sand a further 120m offshore. | Rocky/ shingle beach with thin veneer of sand. | Steeply sleeping cliffs to 34m high (Seacliff sandstone with section of undifferentiated material). | Cliff slope mechanically lowered at Esplanade. | Moderate exposure<br><br>Low wave energy | Larger storm events will cause scarping of friable material at base of the cliffs, but otherwise the impact is expected to be low. | Increased impact on base of the cliffs with recession likely in locations where the material is friable. Unknown as to how this will impact cliff stability. |

***Exposure Rating:** Assigned by SA Nature Maps.


**Hallett Cove Cliffs North – Key Points**

2.1 Rocky beach and resistant cliffs. Impact in the near term (2020-2050) expected to be low. If seas rise as projected, increased impact will occur on these cliffs with unknown consequences (but likely to be low due to their resistant nature).
2.2-3 Rocky beach with resistant cliffs. Seawater frequently interacts with the base of these cliffs and this interaction will increase with sea level rise. In the short term, these cliffs are likely to suffer little impact, the longer term is unknown (but probably low).
2.4-6 Rocky beach with resistant cliffs but overlain by some unconsolidated material. Increases in sea level will cause removal of this material with likely recession.

# 6. Storm water runoff from urban settlement

# 6. Storm water runoff from urban settlement

## Purpose of the study

The purpose of this study is to evaluate the impact of storm water that flows from urban areas to the coast. Large volumes of rainwater can quickly accumulate and flow from the impervious surfaces of urban settlements. Storm water flowing over softer embankments can cause gullying and instability and scouring of dunes and beaches. Over time cliffs, embankments and dunes break down and sand levels are likely to drop on the beach. In the context of sea level rise, the locations where storm water is impacting beaches and backshores may be locations where incursions of seawater occur first. Finally, in some locations the potential exists for a confluence of events where storm water and sea storms combine and produce greater levels of flooding.

Four questions are assessed in this project:

(1) Does Council manage storm water from urban settlement so that it does not flow uncontrolled over backshores and beaches?

(2) What impact is occurring on the backshores and beach due to storm water runoff?

(3) Is there any potential for increased flooding due to confluence of rain events with sea storm events?

(4) Do any storm water outlets require review[12]?

[12] In this cell, Question 4 was not relevant due to the elevated nature of backshores.

## Methodology

A drone was utilised to capture photography of the City of Marion coastline after rain events to check for scouring of backshores and beaches, or debris deposits on beaches. Two captures were achieved, one in 2021 and one in 2022.

Storm water monitoring (2021)

In the last two weeks of July, rain fell on 11 out of 14 days. The rain fall for July was ~50% above the 20-year mean. Specifically, 14mm of rain fell on 31st July. No evidence of scouring or slides within cliff escarpments, nor sediment transfer to the beach was observed apart from some moderate mud staining on the beach at Hallett Cove from storm water runoff from the Conservation Park[13].

Storm water monitoring (2022)

Significant rain events occurred in early June 2022, but these have not been evaluated at the time of writing this report[14]. For example, 52mm rain fell on 5 June 2022 and 15.4mm on 6th June (Happy Valley gauge). The drone photographic capture of the whole coast was undertaken on 9th June 2022. The findings were similar to those of 2021 (see above).

[13] See Cells 1-4, Coastal Monitoring program for City of Marion, year 2021.

Storm water outlet review

On 9 and 10 June 2022 (after significant rain events), every storm water outlet that could be located was reviewed, photographed, and assessed within the GIS environment. In particular, the following items were catalogued and assessed:

1. Location of outlet (e.g. top of cliff)
2. Outlet type (e.g. 300mm pipe)
3. End control (e.g. Headwall)
4. Condition of infrastructure
5. Vegetation cover (e.g. overgrown)
6. Nature of backshore (e.g. cliff, embankment)
7. Nature of beach (e.g. rocky, sandy)
8. Impact on backshore (e.g. scouring, gullying)
9. Impact on beach (e.g. scouring, gullying)
10. Comments and recommendations.

Outputs from the study

Two main outputs are generated from this study:

- A digital file (GIS) with locations, photographs, and an attribute table for each of the storm water outlets.
- This report which provides a summary of the findings on the following pages.

[14] See Cells 1-4, Coastal Monitoring Program for City of Marion, year 2022 (not completed at date of writing).

# 6. Storm water runoff from urban settlement

## Previous studies and plans

*Hallett Cove Creeks Storm Water Management Plan, Southfront, 2012.*

Overview of the study

The Hallett Cove Creeks Stormwater Management Plan (2012) produced by Southfront is a thorough investigation of the current storm water system for three catchment areas located in Cell 2 and 3, and a suggested improved management strategy.

The report concluded that stormwater infrastructure was assessed as meeting performance standards in line with current day expectations (with a few exceptions). The study used a 1 in 10 ARI rainfall event which it considers the standard to use in evaluating the effectiveness of stormwater infrastructure capacity. Coincidently, such an event did occur within the study period and the effectiveness of the system was evaluated in that context.

The key issues flagged for improvement were:

- Erosion of Waterfall Creek channel, along most of its length,
- Lack of stormwater quality improvement measures,
- Lack of stormwater harvesting and reuse.

Coastal Outlets

The report lists numerous recommended upgrades and strategies, but none of these appear to relate to ocean outfalls (apart for GPT at Heron Reserve). However, the study did review coastal outlets and concluded the following.

While the significant majority of the study area is drained to water courses or gullies that ultimately discharge into the Gulf, there are a number of underground stormwater drainage systems that also discharge directly to the Gulf.... There had previously been concern regarding the erosion of cliffs and beaches due to many of these outfalls discharging well above beach level, with little or no erosion control, or pollutant interception measures in place. AWE reviewed these outfalls in 2005 and developed concept designs to address the issues identified. Six outfalls were identified in the study area (Cell 2 and 3) and summarised in the table on this page.

It is understood that some of these upgrades have been completed (e.g. Grand Central Ave) but this has not been reviewed as part of this project.

In the context of coastal adaptation

In some coastal locations there is the potential for a confluence of a rain event with a sea storm event which may increase the likelihood of flooding of urban settlement. However, in the City of Marion coastal area which is predominantly cliff area, storm water is usually discharged well above high water levels of the ocean. However, as noted in the Southfront report, the issue within City of Marion relates to potential erosion of backshores (cliffs and slopes) and the containment of pollution and debris in the storm water runoff.

| Location | AWE Ref | AWE Recommendation | Status |
|---|---|---|---|
| Westcliff Ct | 11 | No work required | - |
| Nungamoora St | 13 | Install GPT | Outstanding |
| Peera St | 14 | No work required | - |
| Fryer Street | 16 | Install GPT | Outstanding |
| Clifftop Cr | 18 | Install rock-lined overflow swale | Completed (refer photo below) |
| Grand Central Ave | 21 | Install GPT | Outstanding |

**Table: 4.3 from Southfront Report**

# 6. Storm water runoff from urban settlement

**Storm water**

Cell 2.1
Hallett Cove Cliffs (North)
Storm Water
2022

**Storm water outlet assessment Westcliff**

1. Is storm water managed appropriately?

Storm water from urban environments drains to Westcliff Gully

2. What impact is occurring on the backshores and beach due to storm water runoff (if any)?

No impacts were observed on the beach after rain events in June 2022.

3. Outlets requiring review.

Not inspected as these were at the top of the gully.

Integrated Coasts
markwestern@integratedcoasts.com
www.integratedcoasts.com

# 6. Storm water runoff from urban settlement

**Storm water**

Cell 2.2

Hallett Cove Cliffs (North)

Storm Water

2022

**Storm water outlet assessment**
**Grey Road**

1. Is storm water managed appropriately?

Pipe and riprap end generally controls storm water flows (but see below).

2. What impact is occurring on the backshores and beach due to storm water runoff (if any)?

Water flows from the riprap and erodes the path below, and the base of footbridge.

3. Outlets requiring review.

2.8 to assess impact of erosion on path and footbridge.

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# 6. Storm water runoff from urban settlement

**Storm water**

Cell 2.3

Hallett Cove Cliffs (North)

Storm Water

2022

**Storm water outlet assessment**
**Pindee Street**

1. Is storm water managed appropriately?

These are both open channels (but outlet not located for Cell 2.9).

2. What impact is occurring on the backshores and beach due to storm water runoff (if any)?

None observed on cliffs and beaches, nor higher up the slopes.

3. Outlets requiring review.

None in relation to impacts on backshores.

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# 6. Storm water runoff from urban settlement

**Storm water**

Cell 2.4

Hallett Cove Cliffs (North)

Storm Water

Current design

**Storm water outlet assessment
The Esplanade**

1. Is storm water managed appropriately?

Review required of all outlets.

2. What impact is occurring on the backshores and beach due to storm water runoff (if any)?

2.11 Evidence of channel bank collapse.

3. Outlets requiring review.

2.11 Review volume of water and nature of controls higher up (if any).
2.15 Further drone inspection recommended. Possible gully in cliff.
2.16 End control recommended – soft cliff (but minimal impact as yet)

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# 6. Storm water runoff from urban settlement

**Storm water**

Cell 2.5

Hallett Cove Cliffs (North)

Storm Water

Current design

**Storm water outlet assessment Kurnabinna Terrace**

1. Is storm water managed appropriately?

Storm water from urban environments drains to the top of the cliffs.

2. What impact is occurring on the backshores and beach due to storm water runoff (if any)?

Minor scouring but overall impact is low.

3. Outlets requiring review.

2.19 Condition of infrastructure may need review (going from memory).

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# 6. Storm water runoff from urban settlement

**Storm water**

Cell 2.6

Hallett Cove Cliffs (North)

Storm Water

Current design

**Storm water outlet assessment Clifftop Crescent**

1. Is storm water managed appropriately?

Storm water from urban environments to the top of cliffs.

2. What impact is occurring on the backshores and beach due to storm water runoff (if any)?

Minimal impacts were observed after rain events (minor scour).

3. Outlets requiring review.

2.19 Condition of end control (?)
2.21 Consider litter control.

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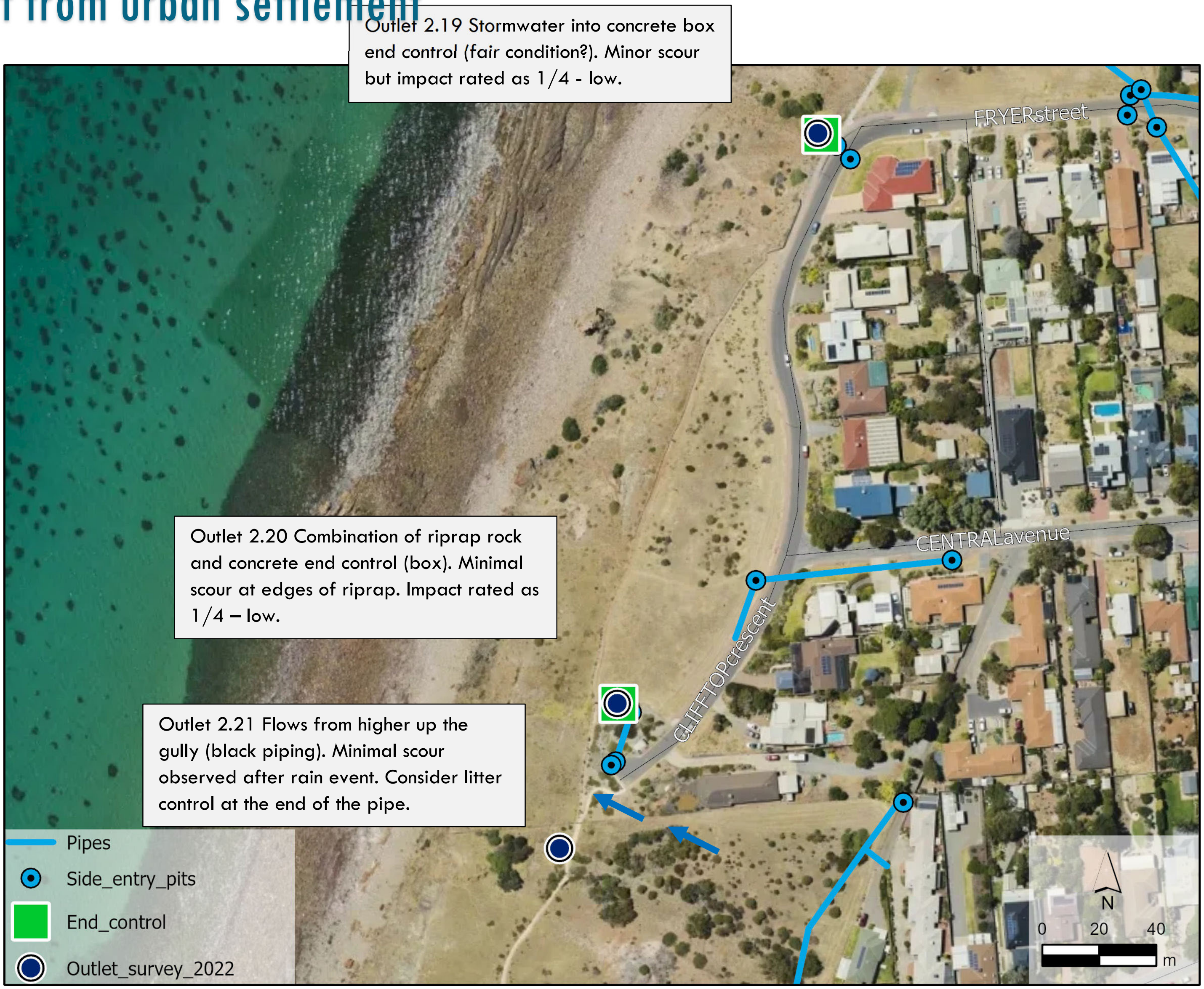


# 6. Storm water runoff from urban settlement

**Summary of findings**[15]:

**1. Does Council manage the flow of storm water from urban settlement so that it does not flow uncontrolled over coastal backshores and dunes?**

In a location such as Hallett Cove Cliffs North it is inevitable that storm water will need to drain to the coast. The key issue to consider is what impact storm water is having on cliff environments. Storm water can erode softer cliff environments but also will break down rock over time as water flows through fissures and crevices. The cliff slump that occurred in Cell 2.5 was attributed to uncontrolled storm water.

Personal comment: The inspection occurred after significant rain events in June 2022, and we were surprised at how little impact was observed in most locations.

**2. What impact is occurring on the beach or backshore due to storm water runoff?**

The storm water outlets were reviewed after significant rains in June 2022, and only minor gullying was observed in backshores (cliffs) and no impact to the beach. Litter was observed on the beach (Cell 2.5) and on top of the cliff (Cell 2.6).

**3. Do any storm water outlets require review?**

2.8 to assess impact of erosion on path and footbridge (Cell 2.2).
2.11 Review volume of water and nature of controls higher up (if any) (Cell 2.4).
2.15 Further drone inspection recommended. Possible gully in cliff (Cell 2.4).
2.16 End control recommended – soft cliff (but minimal impact as yet) (Cell 2.5).
2.19 Condition of end control (?) (Cell 2.5).
2.21 Consider litter control (Cell 2.6).

Figures (a) It is recommended that further drone review establish whether appropriate end control has been installed and what impact is occurring on this cliff.

Figures (b) Litter on the beach (consider litter end control if viable)

[15] In some coastal locations whether a confluence of rain events and sea storm events could create potential for increased flooding would be considered. This cell is elevated above any risk of confluence of events.

# 7. HAZARD IMPACTS AND RISKS

The purpose of this section of work is to consider the inputs from the first part of the study and undertake an assessment of hazard impacts and risks within this cell. We undertake this in two steps:

1. Assign an inherent hazard rating,
2. Conduct a risk assessment utilising the risk framework of City of Marion.

# 7. Hazard impacts and risks

## Methodology

South Australian Coast Protection Board considers three main coastal hazards: inundation, erosion, and sand drift. Only the first two are under consideration in this project as there are no assets at risk from sand drift. The assessment of hazard impacts and risks is undertaken in two main steps.

### 1. Assign an inherent hazard rating

It is the combination of the characteristics of the coastal fabric and the nature of the exposure that determines the degree of hazard risk. This reality is most simply understood when considering inundation risk. Whether a coast is at risk from inundation depends entirely on the topography of the coast. If we explain this another way, a low-lying coast is inherently more at risk from flooding whereas an elevated coast is inherently not at risk from flooding.

The assessment of the erosion hazard is more complex, but it is still the relationship of fabric to exposure that determines whether a coast is inherently more at risk from erosion or less at risk. A coastal fabric of granite is less at risk from erosion than a coast backed by sand dunes. In some locations the natural fabric of the coast has been altered by human intervention. For example, the Adelaide metropolitan beaches were once backed by sand dunes, but installation of rock revetment has changed the nature of the fabric to rock.

The application of an inherent risk rating does not suggest that areas rated as 'low' are entirely free from vulnerability, nor conversely that areas rated more highly are necessarily vulnerable now. The aim is to assess the underlying inherent vulnerability of the fabric of the coastal location. This assessment takes into consideration the following elements and has meaning (context) in relation to all South Australian coasts:

- The geological layout
- Sediment supply/ balance
- The erodibility of beach and backshores
- The historical analysis as to how the coastline has performed over time
- The exposure (set by Nature Maps)
- Whether any human intervention has altered the nature of the coastline.

The risk assignments range from 'low' to 'very high' and may include a 'no risk' category. For example, coastal land that is elevated above any inundation risk will be assigned 'no risk'. A dotted circle to the right of the main assignment indicates that the risk assignment requires intensifying due to unique factors, or to indicate a higher risk that does not qualify for an overall higher rating (Example, Figure a).

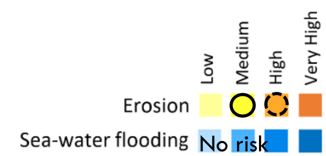



Figure a. Example of inherent risk output

# 7. Hazard impacts and risks

**2. Conduct a risk assessment using the risk framework of City of Marion.**

In this study we are primarily concerned with the way that coastal hazards may impact urban settlements over the coming century. How inundation and erosion impact human settlement will vary according to location. For example, at Hallett Cove Beach public assets are positioned in the immediate backshore, whereas at Field River some private assets directly adjoin the beach. Additionally, if seas rise as projected then seawater may flow further inland in low-lying areas and change the ecology. To evaluate public safety, how easily people may be able to retreat to a safe place is considered.

Direct impacts

In summary, while the impact of sea level rise may be somewhat uniform on a coastal region, the impact will be felt differently in the context of human experience. To bring appropriate focus, hazard impacts are described within four main receiving environments:

- Public infrastructure (assets)
- Private assets
- Public safety
- Ecosystem disruption

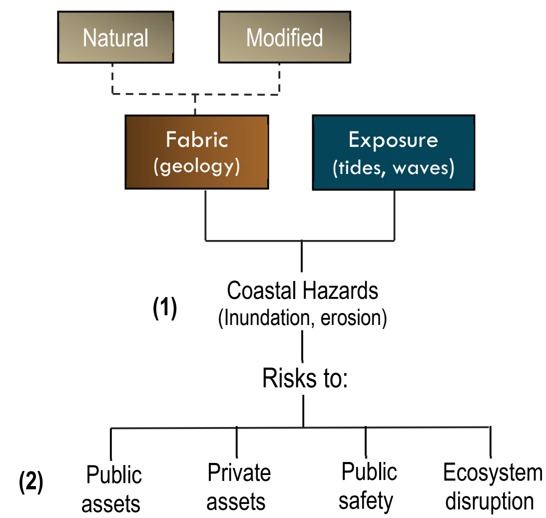
Note, the term ecosystem disruption is used to describe the situation where changes in a coastal region might bring about larger scale changes that may threaten to disrupt the entire ecological system, for example seawater flooding into freshwater ecologies.

Indirect impacts

To provide focus and contain variables, this risk assessment is confined to direct impacts upon physical receiving environments. Indirect impacts may arise because of these direct impacts. For example, the loss of a beach in some coastal locations may cause indirect impacts – loss of tourism resulting in a declining economy, and may also diminish social well-being and community pride.

This assessment utilises the Council's risk assessment framework and assessment is provided for two eras: the current era, and the 'future outlook'. In this study, future outlook means the end of this current century. This is a long-term frame, but infrastructure such as houses and roads, have long lifespans.

The overall risk assessment strategy is summarised in the diagram below (Figure a).



# 7-1 Inherent hazard risk assessment (SA)

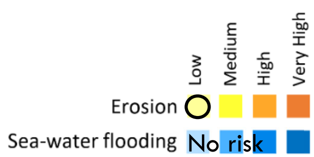
**Inherent risk assessment:**

Inherent risk assessments are established using set criteria outlined above that apply to the whole State of South Australia[1].

**West Cliff (Cell 2.1)**

Erodibility is low. Resistant cliffs covered in some friable at the base.

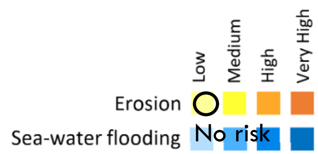
Predominantly elevated backshore is at no risk from inundation. The Esplanade overtopped in 2016 and therefore rated as medium to high risk from sea-water flooding.




**Grey Road to Murnado Street (Cell 2.2-3)**

Erodibility low. Seawater does interact with the base of the cliffs, but these are resistant to erosion, and therefore 'low' is assigned.

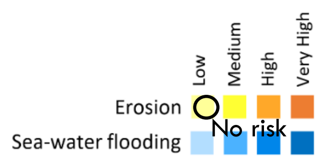
The elevated backshore is at no risk from inundation.




**Kurnabinna Gully (Cell 2.4)**

Erodibility low. Seawater does interact with the base of the cliffs, but these are resistant to erosion, and therefore 'low' is assigned.

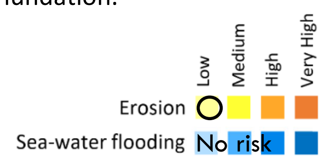
The elevated backshore is at no risk from inundation.




**The Esplanade (Cell 2.5)**

A land slip occurred here in the 1996 but this was in the upper cliff and probably related to uncontrolled water. There is some friable material at the base of this cliff but remains assigned as low erodibility.

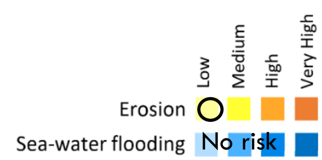
The elevated backshore is at no risk from inundation.




**Clifftop Parade (Cell 2.6)**

Resistant sloping rock cliffs (with some unconsolidated material at the base in Cell 1.5). Dominated by low profile offshore reef and rocky beach platform, and therefore assessed as low erodibility.

The elevated backshore is at no risk from inundation.




[1] Worksheets that underpin the evaluation are available from Integrated Coasts.

# 7-2 Risk assessment using Council's risk framework

**Risk assessment on receiving environments:**

The following pages contain the risk assessments for Hallett Cove Cliffs North:

- Westcliff (Cell 2.1)
- Grey Road to Murnado Street (Cell 2.2-4)
- The Esplanade (Cell 2.5)
- Clifftop Parade (Cell 2.6)

The risk assessment template draws on City of Marion risk framework, Policy RM-PRO-1.01 (v8.0) dated 25/02/2020.

**Location: Westcliff (2.1)** Erosion **Risk assessment using Council's risk framework**

| | |
|---|---|
| **Coastal setting Westcliff** | Rock platform beach with shingles below the cliffs. Nearshore dominated by low profile reef to 170m offshore, then seaweed beds. Steeply sloping cliff 34m high. (Resistant Wilmington Fm. with some Pleistocene clay). Walking trail along cliff crest, urban development set well back.Moderate exposure, Low wave energy Current impact in coastal layout of rocky beach and resistant rock cliffs is low and 0.30m of sea level rise will be unlikely to change this assessment. Seas 1.00m higher than present will substantially increase the impact to the base of the cliff, but these cliffs are resistant and undercutting is likely to be slow. Storm water discharges through Westcliff Gully. |

**Risk identification:** No current risk. Future risk exists as a result of impact of sea level rise on the base of the cliff.

**Current risk mitigation:** Nil

| Receiving environment | Risk description | Time | Likelihood | Consequence | Risk |
|---|---|---|---|---|---|
| Public infrastructure | Walking trail set well back from the coast and at no risk from actions of the sea. Uncontrolled storm water make impact the walking trail. | 2020 | *unlikely* | *insignifcant* | low |
| | | 2100 | *unlikely* | *insignifcant* | low |
| Private assets* | Private properties are set well back from the coast. There are no erosion risks from actions of the sea or increases in sea level rise. Impacts from storm water have not been assessed on private dwellings. | 2020 | *no risk* | *no risk* | no risk |
| | | 2100 | *no risk* | *no risk* | no risk |
| Public safety | The public use the footpaths, roads and walking trails. This assessment assumes that people remain on these surfaces. This assessment relates to erosion risk and does not relate to the structural stability of the walking trail. Stormwater may increase erosion. | 2020 | *unlikely* | *minor* | Low |
| | | 2100 | *unlikely* | *minor* | low |
| Ecosystem disruption | The coastal setting is rocky beach and predominantly hard rock cliff backshores. Ecosystem disruption is not anticipated from rising sea levels. | 2020 | *no risk* | *no risk* | no risk |
| | | 2100 | *no risk* | *no risk* | no risk |

**Inherent hazard rating**

Inherent vulnerability

| | low | medium | high | very high |
|---|---|---|---|---|
| Erosion | ○ | | | |
| Sea flooding | no risk | | | |

**Erosion hazard rating**

Current Outlook 2022

| | low | Medium | high | extreme |
|---|---|---|---|---|
| Public infrastructure | ○ | | | |
| Private assets | no risk | | | |
| Safety of people | ○ | | | |
| Eco-system disruption | no risk | | | |

**Erosion hazard rating**

Future Outlook 2100

| | low | Medium | high | extreme |
|---|---|---|---|---|
| Public infrastructure | ○ | | | |
| Private assets | no risk | | | |
| Safety of people | ○ | | | |
| Eco-system disruption | no risk | | | |

**Assumptions**

Rain water events have not been assessed in this project.

The assignment of future risks assumes that seas rise as projected and that no adaptation responses are employed.

*Governments are not necessarily liable for private assets.

**Location: Grey St to Murnada Rd (2.2-3)**

## Erosion

**Risk assessment using Council's risk framework**

| | |
|---|---|
| **Coastal setting**<br>**Grey St - Murnada Rd** | Narrow rock beach platform, tide interacts with cliffs. Vertical cliffs at base (resistant Wilmington or Reynella siltstone) sloping back to 35m high. Low profile reef to 120m offshore. Bare sand a further 120m offshore. Moderate exposure, Low wave energy. Current impact in coastal layout of rocky beach and resistant rock cliffs is low and 0.30m of sea level rise will be unlikely to change this assessment. Seas 1.00m higher than present will increased impact on the base of the cliff. However, these cliffs are of a resistant type and therefore any undercutting is likely to be slow. |

**Risk identification:** No current risks. Sea level rise will increase interactions of the sea with the base of the cliff.

**Current risk mitigation:** Nil

| Receiving environment | Risk description | Time | Likelihood | Consequence | Risk |
|---|---|---|---|---|---|
| Public infrastructure | Walking trail set well back from the top of the cliff. No risk from rising sea levels, but uncontrolled storm water may undermine / destabalise the walking trail. | 2020 | *unlikely* | *insignifcant* | low |
| | | 2100 | *unlikely* | *insignifcant* | low |
| Private assets* | Private properties are set well back from the coast. There are no erosion risks from actions of the sea or increases in sea level rise. Impacts from storm water have not been assessed on private dwellings. | 2020 | *no risk* | *no risk* | no risk |
| | | 2100 | *rare* | *major* | no risk |
| Public safety | The public use the footpaths, roads and walking trails. This assessment assumes that people remain on these surfaces. This assessment relates to erosion risk and does not relate to the structural stability of the walking trail. Storm water may erode the trail. | 2020 | *unlikely* | *minor* | Low |
| | | 2100 | *unlikely* | *minor* | low |
| Ecosystem disruption | The coastal setting is rocky beach and predominantly hard rock cliff backshores. Ecosystem disruption is not anticipated from rising sea levels. | 2020 | *no risk* | *no risk* | no risk |
| | | 2100 | *no risk* | *no risk* | no risk |

**Inherent hazard rating**

Inherent vulnerability

| | low | medium | high | very high |
|---|---|---|---|---|
| Erosion | O | | | |
| Sea flooding | no risk | | | |

**Erosion hazard rating**

Current Outlook 2022

| | low | Medium | high | extreme |
|---|---|---|---|---|
| Public infrastructure | O | | | |
| Private assets | no risk | | | |
| Safety of people | O | | | |
| Eco-system disruption | no risk | | | |

**Erosion hazard rating**

Future Outlook 2100

| | low | Medium | high | extreme |
|---|---|---|---|---|
| Public infrastructure | O | | | |
| Private assets | no risk | | | |
| Safety of people | O | | | |
| Eco-system disruption | no risk | | | |

**Assumptions**

Rain water events have not been assessed in this project.

The assignment of future risks assumes that seas rise as projected and that no adaptation responses are employed.

*Governments are not necessarily liable for private assets.

**Location: Kurnabinna Gully (2.4)** — Erosion — **Risk assessment using Council's risk framework**

| | |
|---|---|
| **Coastal setting Kurnabinna Gully** | Beach is narrow rock platform, tide interacts with cliffs. Vertical cliffs at base (resistant Wilmington or Reynella siltstone) sloping back to 35m high. Walking trail along cliff crest, urban development set well back (but portion Esplande is set close, reviewed in Cell 2.5). Beach access stairs positioned within Kurnabinna Gully. Moderate exposure, Low wave energy. Current impact in coastal layout of rocky beach and resistant rock cliffs is low and 0.30m of sea level rise will be unlikely to change this assessment. Seas 1.00m higher than present will have increased impact at base of cliff, but these cliffs are resistant to erosion. Storm water drains through the gully, and over clifftop. |

**Risk identification:** Actions of the sea interact with the base of these cliffs and sea level rise will increase the impact. Storm water flows not all contained.

**Current risk mitigation:** Nil.

| Receiving environment | Risk description | Time | Likelihood | Consequence | Risk |
|---|---|---|---|---|---|
| Public infrastructure | Walking trail, beach access stairs. The Esplanade is set as close as 2m from the top of the cliff. The difficulty of assessing risk in this location is that the cliffs are rated as resistant to erosion, but infrastructure is set near the cliff top. | 2020 | *rare* | *severe* | medium |
| | | 2100 | *rare* | *severe* | medium |
| Private assets* | Private properties are situated landward of The Esplanade. It is unlikely that private properties would be directly impacted but could be impacted by secondary issue of road access. While the risk is rare, a cliff slump occurred in Cell 2.5. | 2020 | *rare* | *major* | medium |
| | | 2100 | *rare* | *major* | medium |
| Public safety | This assessment assumes that people remain on official walking surfaces. While not strictly an erosion risk, rising sea levels will mean that people will be more prone to be 'caught' by tides at the base of the cliff if they use the access stairs. | 2020 | *unlikely* | *minor* | low |
| | | 2100 | *unlikely* | *moderate* | medium |
| Ecosystem disruption | The coastal setting is rocky beach and predominantly hard rock cliff backshores. Ecosystem disruption is not anticipated from rising sea levels. | 2020 | *no risk* | *no risk* | no risk |
| | | 2100 | *no risk* | *no risk* | no risk |

**Inherent hazard rating**
Inherent vulnerability

| | low | medium | high | very high |
|---|---|---|---|---|
| Erosion | ○ | | | |
| Sea flooding | no risk | | | |

**Erosion hazard rating**
Current Outlook 2022

| | low | Medium | high | extreme |
|---|---|---|---|---|
| Public infrastructure | | ○ | | |
| Private assets | | ○ | | |
| Safety of people | ○ | | | |
| Eco-system disruption | no risk | | | |

**Erosion hazard rating**
Future Outlook 2100

| | low | Medium | high | extreme |
|---|---|---|---|---|
| Public infrastructure | | ○ | | |
| Private assets | | ○ | | |
| Safety of people | ○ | | | |
| Eco-system disruption | no risk | | | |

**Assumptions**

Rain water events have not been assessed in this project.

The assignment of future risks assumes that seas rise as projected and that no adaptation responses are employed.

*Governments are not necessarily liable for private assets.

**Location: The Esplanade (2.5)** — Erosion — **Risk assessment using Council's risk framework**

| | |
|---|---|
| **Coastal setting The Esplanade** | Rocky/ shingle beach with thin veneer of sand. Steeply sleeping cliffs to 34m high (Seacliff sandstone with section of undifferentiated material). Low profile reef to 120m offshore. Bare sand a further 120m offshore. Moderate exposure, Low wave energy. Larger storm events will cause scarping of friable material at base of the cliffs, but otherwise the impact is expected to be low. Increased impact on base of the cliffs with recession likely in locations where the material is friable. Unknown as to how this will impact cliff stability. |

**Risk identification:** Actions of the sea interact with the base of these cliffs and sea level rise will increase the impact.

**Current risk mitigation:** Nil.

| Receiving environment | Risk description | Time | Likelihood | Consequence | Risk |
|---|---|---|---|---|---|
| Public infrastructure | Walking trail set near the top of the cliff slope. The Esplanade is set as close as 2m from the top of the cliff. | 2020 | *rare* | *severe* | medium |
| | | 2100 | *rare* | *severe* | medium |
| Private assets* | Private dwellings are set further back from the cliff on this portion of The Esplanade. However, a slump did occur in the upper cliff in 1996 and therefore the risk requires assessment. | 2020 | *rare* | *major* | medium |
| | | 2100 | *rare* | *major* | medium |
| Public safety | The public use the footpaths, roads and walking trails. This assessment assumes that people remain on these surfaces. This assessment relates to erosion risk and does not relate to the structural stability of the walking trail. Storm water may erode the trail. | 2020 | *unlikely* | *minor* | low |
| | | 2100 | *unlikely* | *minor* | low |
| Ecosystem disruption | The coastal setting is rocky beach and predominantly hard rock cliff backshores. Ecosystem disruption is not anticipated from rising sea levels. | 2020 | *no risk* | *no risk* | no risk |
| | | 2100 | *no risk* | *no risk* | no risk |

**Inherent hazard rating**

Inherent vulnerability

| | low | medium | high | very high |
|---|---|---|---|---|
| Erosion | ○ | | | |
| Sea flooding | no risk | | | |

**Erosion hazard rating**

Current Outlook 2022

| | low | Medium | high | extreme |
|---|---|---|---|---|
| Public infrastructure | | ○ | | |
| Private assets | | ○ | | |
| Safety of people | ○ | | | |
| Eco-system disruption | no risk | | | |

**Erosion hazard rating**

Future Outlook 2100

| | low | Medium | high | extreme |
|---|---|---|---|---|
| Public infrastructure | | ○ | | |
| Private assets | | ○ | | |
| Safety of people | ○ | | | |
| Eco-system disruption | no risk | | | |

**Assumptions**

Rain water events have not been assessed in this project.

The assignment of future risks assumes that seas rise as projected and that no adaptation responses are employed.

*Governments are not necessarily liable for private assets.

**Location: Clifftop Parade (2.6)** | Erosion | **Risk assessment using Council's risk framework**

| | |
|---|---|
| **Coastal setting Clifftop Parade** | Rocky/ shingle beach with thin veneer of sand. Steeply sleeping cliffs to 34m high (Seacliff sandstone with section of undifferentiated material). Low profile reef to 120m offshore. Bare sand a further 120m offshore. Moderate exposure, Low wave energy. Larger storm events will cause scarping of friable material at base of the cliffs, but otherwise the impact is expected to be low. Increased impact on base of the cliffs with recession likely in locations where the material is friable. Unknown as to how this will impact cliff stability. |

**Risk identification:** Actions of the sea currently have low interaction with the backshore. This interaction will increase if seas rise as projected.

**Current risk mitigation:** Nil.

| Receiving environment | Risk description | Time | Likelihood | Consequence | Risk |
|---|---|---|---|---|---|
| Public infrastructure | Walking trail set near the top of the cliff slope. Clifftop Parade close to cliff top at the corner. Increasing impact at the base of the cliff may destabilise the top of the cliff if seas rise as projected by 2100. | 2020 | *rare* | *minor* | low |
| | | 2100 | *unlikely* | *major* | medium |
| Private assets* | Private dwellings are set well back from the cliff (20 to 40m). | 2020 | *no risk* | *no risk* | no risk |
| | | 2100 | *no risk* | *no risk* | no risk |
| Public safety | The public use the footpaths, roads and walking trails. This assessment assumes that people remain on these surfaces. This assessment relates to erosion risk and does not relate to the structural stability of the walking trail. Storm water may erode the trail. | 2020 | *unlikely* | *minor* | low |
| | | 2100 | *unlikely* | *minor* | low |
| Ecosystem disruption | The coastal setting is rocky beach and predominantly hard rock cliff backshores. Ecosystem disruption is not anticipated from rising sea levels. | 2020 | *no risk* | *no risk* | no risk |
| | | 2100 | *no risk* | *no risk* | no risk |

**Inherent hazard rating**

Inherent vulnerability

| | low | medium | high | very high |
|---|---|---|---|---|
| Erosion | O | | | |
| Sea flooding | no risk | | | |

**Erosion hazard rating**

Current Outlook 2022

| | low | Medium | high | extreme |
|---|---|---|---|---|
| Public infrastructure | O | | | |
| Private assets | no risk | | | |
| Safety of people | O | | | |
| Eco-system disruption | no risk | | | |

**Erosion hazard rating**

Future Outlook 2100

| | low | Medium | high | extreme |
|---|---|---|---|---|
| Public infrastructure | | O | | |
| Private assets | no risk | | | |
| Safety of people | O | | | |
| Eco-system disruption | no risk | | | |

**Assumptions**

Rain water events have not been assessed in this project.

The assignment of future risks assumes that seas rise as projected and that no adaptation responses are employed.

*Governments are not necessarily liable for private assets.

# 8. Cell summary and recommendations

This cell report is designed to be reviewed and updated over time so that the baseline data is continually brought forward and modified to reflect any changes in the coastal system. This part of the report contains three main parts:

- Summary – a snapshot of the state of the coastal system at the date of writing.
- Overview of adaptation options and strategies.
- Recommendations – a review of recommendations from the prior study and a list of amended recommendations for the future.

# 8.1 Summary – Hallett Cove Cliffs North (Cell 2.1)

**Westcliff**
**Coastal setting**

The beach is rocky platform with shingles below cliffs. Steeply sloping cliff 34m high (resistant Wilmington Fm. overlaid with some friable Pleistocene clay between the two gullies). Nearshore dominated by low profile reef to 170m offshore, then seaweed beds. The cell is rated as moderate exposure and low wave energy. Walking trail along cliff crest with stairs and platforms across gullies. Residential development set well-back from the shore.


### Coastal fabric – changes to beaches and backshores

Land based and aerial photography indicate that there have been minimal changes to the beach and backshores since the 1940s due to the rocky nature of the coast. No new rock falls were observed.

### Coastal exposure – sea level rise, storms, and projections.

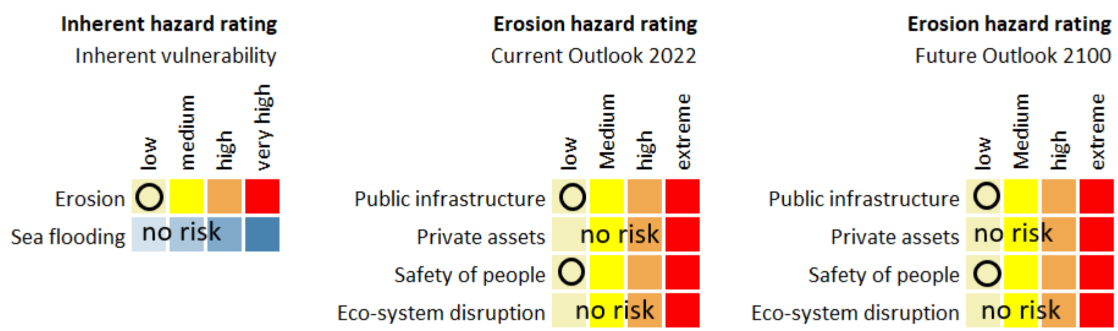
The rate of sea level rise remains relatively low at 3-4mm in this region. Storm monitoring shows that actions of the sea interact less with these cliffs than those either side. Sea levels 0.30m higher than present (2050) are unlikely to cause instability, but seas 1.00m higher than present may (2100). In reality the impact is unknown.

### Storm water runoff – impacts in the coastal zone

Stormwater is generally collected within the road reserves and piped to Westcliff Gully. These outlets were not inspected as part of this study. Inspection of the beach and backshore after significant rain events in June 2022 found no adverse impacts on coastal backshores or the beach.

### Overview of Impacts and risk assessment

Current impact on the coast by actions of the sea is low due to the rocky nature of this location. Routine actions of the sea do not appear to be impacting the base of the cliffs, and seas 0.30m higher are unlikely to have significant impact. Seas at 1.00m higher would impact the base, and friable material will be removed and the cliff slope steepen. Storm water from natural terrain may erode the friable section of upper cliff.



# 8.1 Summary – Hallett Cove Cliffs North (Cell 2.2-3)

**Grey Street to Murnado Road**

**Coastal setting**

Predominantly hard rock vertical cliffs that are resistant to erosion, dominated by low profile offshore reef and rocky beach platform, and therefore assessed as low erodibility. Sea flood modelling demonstrates that seas are routinely interacting with the base of the cliffs which will increase if seas rise as projected. However, these cliffs are resistant to erosion. The walking trail is set on the crest of the cliff. Residential development is set well-back from the cliff tops.


### Coastal fabric – changes to beaches and backshores

Land based and aerial photography indicate that there have been minimal changes to the beach and backshores since the 1940s due to the rocky nature of the coast. Only one minor rock fall was identified since 1979 for this entire cell, occurring in 2007.

### Coastal exposure – sea level rise, storms, and projections.

The rate of sea level rise remains relatively low at 3-4mm in this region. Actions of the sea regularly interact with these cliffs, but they are resistant to erosion and seas 0.30m higher are unlikely to change this outlook. The impact of seas 1.00m higher than present will be significant at the cliff base, but the effect unknown.

### Storm water runoff – impacts in the coastal zone

Stormwater is generally collected within the road reserves and piped to the top of cliffs. Minimal impacts were observed on the cliff tops and beach after significant rain events.

### Overview of Impacts and risk assessment

Current impact on the coast by actions of the sea is low due to the rocky nature of this location. Routine actions of the sea interact with the base of the cliffs, but these cliffs are resistant to erosion, and seas 0.30m higher are unlikely to have adverse impact. Seas at 1.00m higher would have higher impact but the effect of this is unknown.

**Inherent hazard rating**
Inherent vulnerability

| | low | medium | high | very high |
|---|---|---|---|---|
| Erosion | O | | | |
| Sea flooding | no risk | | | |

**Erosion hazard rating**
Current Outlook 2022

| | low | Medium | high | extreme |
|---|---|---|---|---|
| Public infrastructure | O | | | |
| Private assets | no risk | | | |
| Safety of people | O | | | |
| Eco-system disruption | no risk | | | |

**Erosion hazard rating**
Future Outlook 2100

| | low | Medium | high | extreme |
|---|---|---|---|---|
| Public infrastructure | O | | | |
| Private assets | no risk | | | |
| Safety of people | O | | | |
| Eco-system disruption | no risk | | | |

# 8.1 Summary – Hallett Cove Cliffs North (Cell 2.4)

**Kurnabinna Gully**

**Coastal setting**

Hard rock vertical cliffs that are resistant to erosion (Reynella Siltstone), dominated by low profile offshore reef and rocky beach platform. Seas are routinely interacting with the base of the cliffs which will increase if seas rise as projected. However, these cliffs are resistant to erosion. The walking trail is set back from the top of the cliff and beach access is provided to the beach via stairs. The Esplanade is set as close to the top of the cliff (as close as 2m in places).


### Coastal fabric – changes to beaches and backshores

Land based and aerial photography indicate that there have been minimal changes to the beach and backshores since the 1940s due to the rocky nature of the coast. No new rock falls were observed.

### Coastal exposure – sea level rise, storms, and projections.

The rate of sea level rise remains relatively low at 3-4mm in this region. Actions of the sea regularly interact with these cliffs, but they are resistant to erosion and seas 0.30m higher are unlikely to change this outlook. The impact of seas 1.00m higher than present will be significant at the cliff base, but the effect unknown.

### Storm water runoff – impacts in the coastal zone

Stormwater is generally collected within the road reserves and either piped into Kurnabinna Gully or flows from the top of the cliffs. There are several stormwater issues for review: the volume and impact of storm water flowing down Kurnabinna Gully, storm water flowing down softer section of a cliff, and litter control.

### Overview of Impacts and risk assessment

Current impact on the coast by actions of the sea is low due to the rocky nature of this location. Seas 0.30m higher than present are unlikely to cause instability, but seas 1.00m higher may (but this is unknown). Seas at higher levels may see more people 'caught' at the base of the cliff in rising tides. The Esplanade is set as close as 2m to the top of the stable cliff, risk assignment is difficult, but a slumping event did occur in 1996 (Cell 2.5).

**Inherent hazard rating**
Inherent vulnerability

| | low | medium | high | very high |
|---|---|---|---|---|
| Erosion | O | | | |
| Sea flooding | no risk | | | |

**Erosion hazard rating**
Current Outlook 2022

| | low | Medium | high | extreme |
|---|---|---|---|---|
| Public infrastructure | | O | | |
| Private assets | | O | | |
| Safety of people | O | | | |
| Eco-system disruption | no risk | | | |

**Erosion hazard rating**
Future Outlook 2100

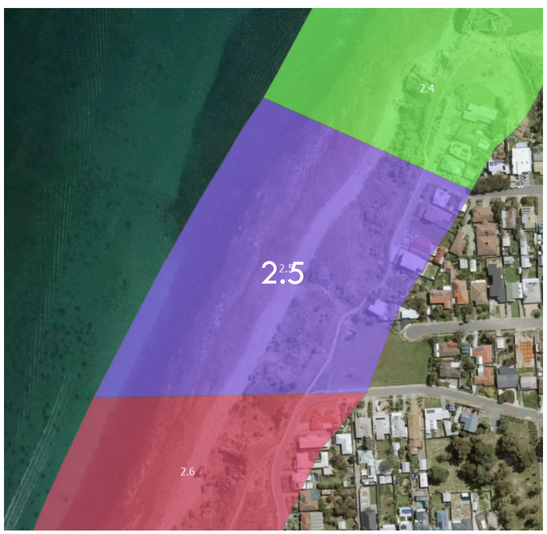
| | low | Medium | high | extreme |
|---|---|---|---|---|
| Public infrastructure | | O | | |
| Private assets | | O | | |
| Safety of people | O | | | |
| Eco-system disruption | no risk | | | |

# 8.1 Summary – Hallett Cove Cliffs North (Cell 2.5)

**The Esplanade**

**Coastal setting**

Predominantly hard rock vertical cliffs that are resistant to erosion (Wilmington Formation, but contains some friable material), dominated by low profile offshore reef and rocky beach platform with thin layer of sand. Larger events impact the base of the cliffs, but routine tides do not. The Esplanade or the walking trail is set at the top of the cliff. In 1996, a slump occurred in the upper cliff and the cliff slope was mechanically lowered. The slump may have been caused by uncontrolled water.




### Coastal fabric – changes to beaches and backshores

Land based and aerial photography indicate that there have been minimal changes to the beach and backshores since the 1940s due to the rocky nature of the coast. A slump in a portion of the upper cliff occurred in 1996 and the cliff slope was mechanically lowered.

### Coastal exposure – sea level rise, storms, and projections.

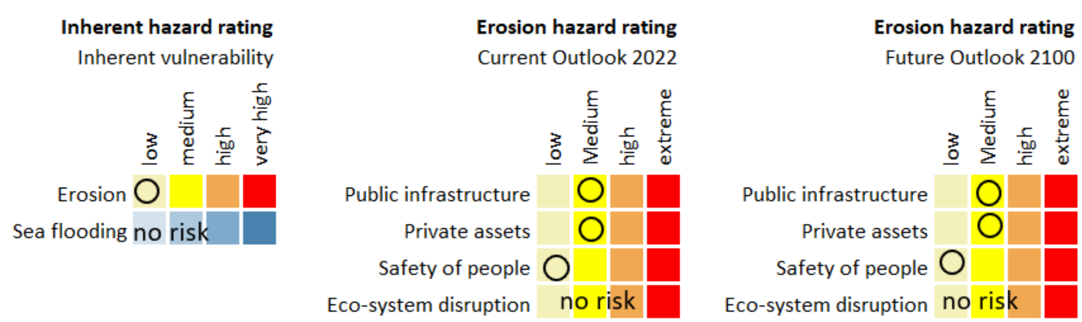
The rate of sea level rise remains relatively low at 3-4mm in this region. Larger storm events impact the base of the cliff, but routine tides interact less frequently. Sea levels 0.30m higher than present are unlikely to cause instability, but seas 1.00m higher projected for 2100 may cause instability. In reality the impact is unknown.

### Storm water runoff – impacts in the coastal zone

Stormwater is generally collected in the road reserve and piped to the top of the cliff where it flows down a gully to the beach. Some minor scouring was observed in the softer soil in this location.

### Overview of Impacts and risk assessment

Current impact on the coast by actions of the sea is low due to the rocky nature of this location. Seas 0.30m higher than present is unlikely to cause instability, but seas 1.00m higher may (but this is unknown). The Esplanade and walking trail are set a little further inland than in Cell 2.4. A slump occurred in the upper cliff in 1996 and the cliff slope was mechanically lowered. The most likely cause was uncontrolled water flows.

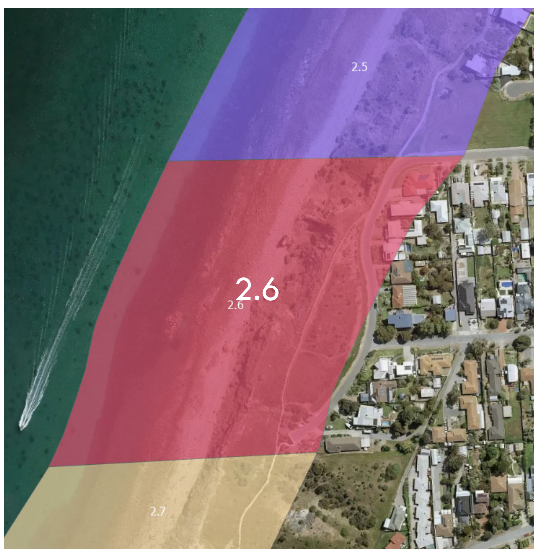


# 8.1 Summary – Hallett Cove Cliffs North (Cell 2.6)

**Clifftop Parade**

**Coastal setting**

Predominantly hard rock vertical cliffs that are resistant to erosion (Seacliff Sandstone with Cape Jervois formation on top). Beach is a rocky platform with a thin layer of sand. Offshore is dominated by low profile reef. Larger events impact the base of the cliffs, but routine tides do not. The walking trail is set at the top of most of the cliff with a small section of Clifftop Parade situated on the northern side and close to the top of the cliff.




### Coastal fabric – changes to beaches and backshores

Land based and aerial photography indicate that there have been minimal changes to the beach and backshores since the 1940s due to the rocky nature of the coast. No new rock falls were observed.

### Coastal exposure – sea level rise, storms, and projections.

The rate of sea level rise remains relatively low at 3-4mm in this region. Storm monitoring shows that actions of the sea interact less with these cliffs than those to the north. Sea levels 0.30m higher than present (2050) are unlikely to cause instability, but seas 1.00m higher than present may (2100). In reality the impact is unknown.

### Storm water runoff – impacts in the coastal zone

Stormwater is collected within the road reserve and flows to the top of the cliff in two locations or flows from a gully higher up before flowing over the cliffs. End controls have been installed in two places and minimal impact was observed after significant rain events in June 2022.

### Overview of Impacts and risk assessment

Current impact on the coast by actions of the sea is low due to the rocky nature of this location. Seas 0.30m higher than present is unlikely to cause instability, but seas 1.00m higher may (but this is unknown). Public assets are not currently at risk and only a portion of Clifftop Parade may be at risk later in this century.

**Inherent hazard rating**
Inherent vulnerability

| | low | medium | high | very high |
|---|---|---|---|---|
| Erosion | O | | | |
| Sea flooding | no risk | | | |

**Erosion hazard rating**
Current Outlook 2022

| | low | Medium | high | extreme |
|---|---|---|---|---|
| Public infrastructure | O | | | |
| Private assets | no risk | | | |
| Safety of people | O | | | |
| Eco-system disruption | no risk | | | |

**Erosion hazard rating**
Future Outlook 2100

| | low | Medium | high | extreme |
|---|---|---|---|---|
| Public infrastructure | | O | | |
| Private assets | no risk | | | |
| Safety of people | O | | | |
| Eco-system disruption | no risk | | | |

# 8-2 Overview of adaptation options and strategies

**Adaptation options and strategies**

An overview of adaptation approaches is provided on this page to provide context to the recommendations. There are generally six categories of adaptation options:

1. **Avoidance** – Avoid the impacts of coastal hazards by ensuring that assets are not placed in vulnerable locations.
2. **Hold the line** – Install protection infrastructure that reduces the impact of coastal hazards or use environmental practices to strengthen natural protective forms such as dunes.
3. **Accommodate** – Accept some degree of hazard and conduct limited intervention to manage the hazard (for example, in areas that may be subject to inundation, raise houses on poles).
4. **Managed retreat** – Progressively move assets or services away from areas that could be impacted by coastal hazards now or in the future.
5. **Monitor** – monitor the coast and use the data to form future strategies.
6. **Loss acceptance** - Accept that coastal hazards will cause negative impacts on assets and services and when this occurs, they will not be replaced.

**Adaptation responses**

Within the adaptation options there are a range of potential adaptation responses.

Planning

Planning responses are options that use planning legislation and regulations to reduce vulnerability and increase resilience to climate change and sea-level rise. For example, dwellings and sites required to be positioned at higher elevation or set back from the coastline.

Engineering

In the context of climate change adaptation ‘engineering’ has come to describe adaptation options that make use of capital works such as seawalls and levees. Such projects are ‘engineered’ to solve a particular challenge such as to protect coastal infrastructure from erosion and inundation.

Environmental management

Environmental management includes habitat restoration and enhancement through activities such as revegetation of coastal dunes or building structures to support growth of habitat such as seagrasses. It may also include sand nourishment to replace sand that has been lost from the beach system.

**Adaptation timing**

There are two broad ways in which adaptation can occur in relation to timing.

Incremental approach

A series of relatively small actions and adjustments aimed at continuing to meet the existing goals and expectations of the community in the face of the impacts of climate change.

Transformative approach

In some locations, incremental changes will not be sufficient. The risks created by climate change may be so significant that they can only be addressed through more dramatic action. Transformational adaptation involves a paradigm shift: a system-wide change with a focus on the longer term. A transformative approach may be triggered by an extreme event or a political window when it is recognised the significant change could occur.

**Adaptation strategy (Cell 4)**

Due to the elevated and rocky nature of this section of coastline, the adaptation strategy will fall into options ***(1) Avoid*** and ***(5) Monitor*** with an incremental approach over time.

# 8-3 Recommendations – Hallett Cove Cliffs North

**Recommended actions from 2018**

The recommendations from the Coastal Adaptation Study of 2018 are listed below with reviews in the right-hand column.

| | Action | Comments | Time Frame | Review 2022 |
|---|---|---|---|---|
| 1 | Review nature of storm water outflows and assess impacts | Storm water drains into gullies. Undertake routine inspections of the outfall areas. Recommend that staff incorporate review of scouring impacts (use photography). | 1-2 years | A two-year monitoring program was completed 2021-2022. Storm water impacts were reviewed using drone photography (2 rain events) and onsite inspection after rain events in June 2022. The findings of these studies are included in this report. |
| 2 | Quantify more accurately the nature of routine and storm surge interaction with cliff base. | Monitor tidal regime for period of three months (winter). Monitor impact of storm surge events (if, and when they occur) | 1-2 years | A two-year monitoring program (2021-2022) monitored 5 storm events along the coast. Seaweed strands observed using drone photography and surveyed in Cells 1.1,2. In the context of a review of the tide gauge data from Outer Harbor, these inputs were used to generate routine tidal monitoring to a higher degree of accuracy and included in this report. This has quantified the nature of routine and storm surge interaction with the base of the cliff as of low impact. |
| 3 | Recapture digital model as basis for comparison. | Use appropriate software to quantify changes in the coastal environment. | 3-5 years | This action is recommended for 2023. |
| 5 | Conduct a further geological review of the cliff at Kurnabinna Gully. | The close proximity of The Esplanade to the cliff top warranted further investigation. | 3-5 years | Preliminary enquiries were made, and it was found that only limited avenues were available (e.g. ground penetrating radar). Furthermore, we reviewed this location using historical photography and found no changes and no rock falls (a general finding for the whole coast). t is likely that any further investigation would be so heavily qualified that any progress would be very limited. The recommendation is not to bring this recommendation forward. |

# 8-3 Recommendations – Hallett Cove Cliffs North

**Recommended actions 2022 to 2027 (five years)**

This review and upgrade to the Coastal Adaptation Study (2018) and the City of Marion Coastal Monitoring Project provide the basis for the following recommendations in Cell 1. The summary at 8.1 above provides the immediate context for the recommendations.

| | **Action** | **Methodology/ rationale** | **Time Frame** |
|---|---|---|---|
| 1 | Incorporate the findings of the CoM coastal monitoring program (2021-2022) into this report. | This report represents an upgrade from the Coastal Adaptation Study (2018) by including tasks that were not included in the 2018 project and an upgrade to the format. This has coincided with the conclusion of the first two years of the CoM coastal monitoring project. Some of the findings from the monitoring project inform this upgrade, but they have not been formally integrated with this report. | 2023 |
| 2 | Recapture the digital model as a basis for comparison with 2018 capture. | Use appropriate software to quantify changes in the coastal environment. This is likely to be the most effective way to assess changes in cliff environments. | 2023 |
| 3 | Monitor changes in beaches and backshores. | Use aerial photography obtained every three months by City of Marion to assess changes to beaches and backshores. This could be done as an annual operation using 4 captures. In particular, identify locations of any new rock falls, slumps or landslides. | Annual (ongoing) (2023-2027) |
| 4 | Monitor the impact of moderate storm events, either rain or sea storm (2-3 per year). | Use the Coast Snap photo point to photograph storm events at the base of the Marino Rocks carpark. Use drone photography after storm events. For sea-storm events, monitor the location of seaweed strands in relation to the base of cliffs and any impacts to backshores. For rain events, monitor for any scouring of the backshores and beaches. For both events monitor for slumps, slides and falls in cliff environments. (Note, no survey). | Annual (ongoing) (2023-2027) |
| 5 | Assess the impact of any major sea storm. | Identify a suitable tidal benchmark at Outer Harbor to qualify as a major sea storm (for example, 1 in 2 year event). Inspect and survey the seaweed strands and update modelling parameters if required. Note, the proposals for task (4) and (5) simplify some of the current storm monitoring and therefore reduce cost, but still maintains the ability to track more significant storms which will be required in the context of rising sea levels. | As required (likely 3-5 in a five-year period). |
| 6 | Review the findings of this project in relation to the storm water scheme. | This project reviewed storm water outlets in this cell after significant rain events in June 2022. Overall there was minimal impact, but this project identified several items for review and upgrade (if deemed necessary). | 1-2 years |

| | | | |
|---|---|---|---|
| 7 | Monitor the rate of sea level rise in Gulf St Vincent. | It is recognised that this action is not within the direct scope of City of Marion. However, periodic reviews are being done by others (e.g. Watson, 2020) and simple tools now exist at www.sealevel.info. It is recommended that when opportunities exist, City of Marion lobby for improved sea level monitoring in Gulf St Vincent (e.g. additional gauges, tracking vertical land movement). The reason for this action is that currently the rate of sea level rise is relatively low (3-4mm per year) whereas projections for the latter half of the century are high (10-15mm per year). An escalation in the rate at tide gauges will provide an early warning that these projections are being realised. | 2023-2027 |