Kilcunda Foreshore Erosion: Options Assessment

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Executive Summary

Kilcunda is a high energy surf beach in South Gippsland, approximately 120 km SE of Melbourne. The beach is popular among surfers and fishers all year and bathers in the summer months. The Bass Coast Rail Trail is situated directly atop the dune crest with views of Bass Strait and is popular with tourists and locals alike. Walkers, cyclists and horse riders regularly use the trail for recreation.

Erosion occurring at the end of an existing historic seawall structure on the beach has severely impacted the dunes in recent years. This is demonstrated by the loss of multiple beach access stairs in the last decade from the Kilcunda Surf Beach carpark and the cemetery. In the last year, erosion has begun to impact the edge of the Bass Coast Rail Trail with some of the trail eroded off the dune edge (Figure 1).

The Bass Coast Shire Council have contracted BMT to undertake a coastal process study, and to produce this Kilcunda Foreshore Erosion Options Analysis to identify, assess and estimate the cost of options for coastal adaptation at this site. The aim of all adaptation options is to maintain the community and recreational values in the area for current and future generations.

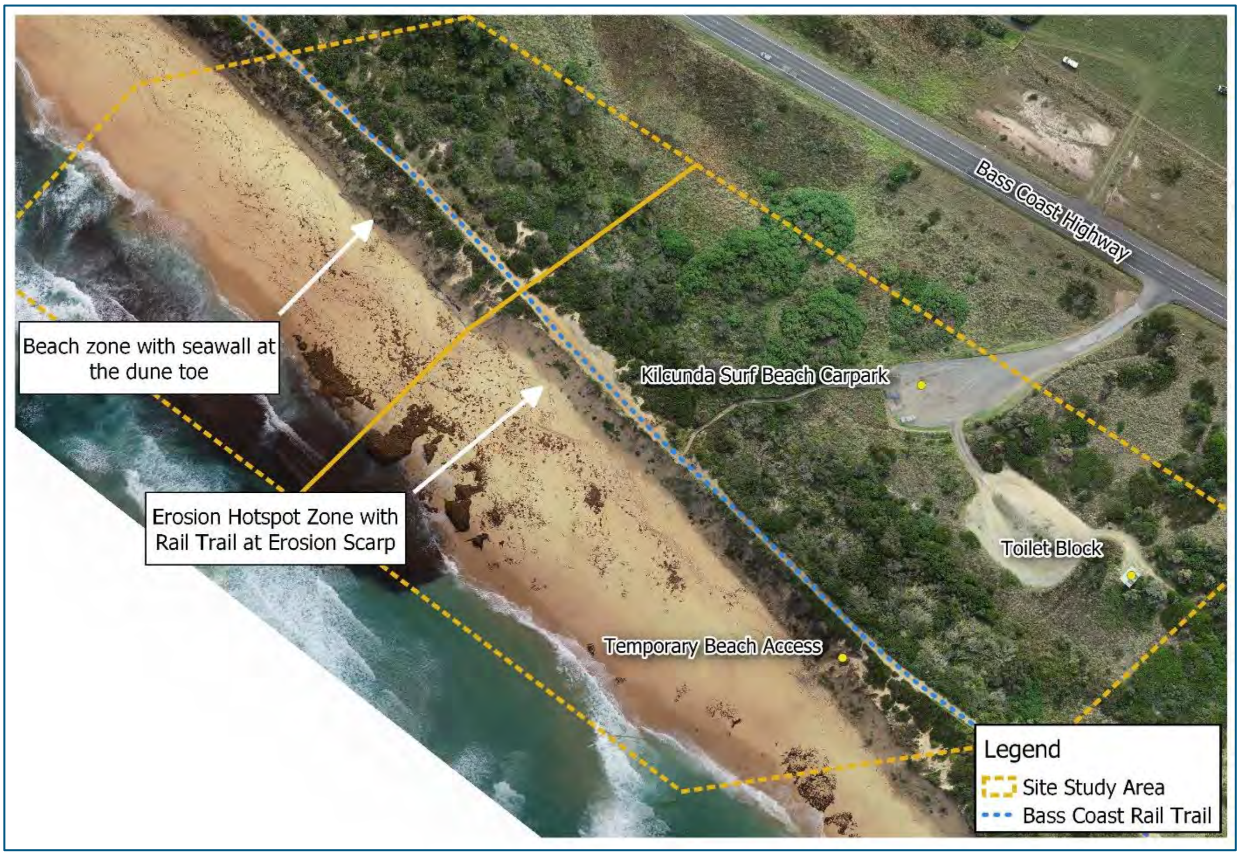

Figure 1 Site Map

The coastal process study and coastal hazard assessment allowed us to identify the major threats and issues facing the Kilcunda site currently and into the future. These are,

- Erosion of the dune in front of the Kilcunda Surf Beach carpark has led to the loss of beach access stairs and to a section of the Bass coast rail trail being at risk of falling from the top of the dune. Because the dune is in the current erosion hazard zone, using the Rail Trail is hazardous (Figure 2). The combination of a net erosion trend and the predicted impacts of sea level rise predict erosion to increase in this region.

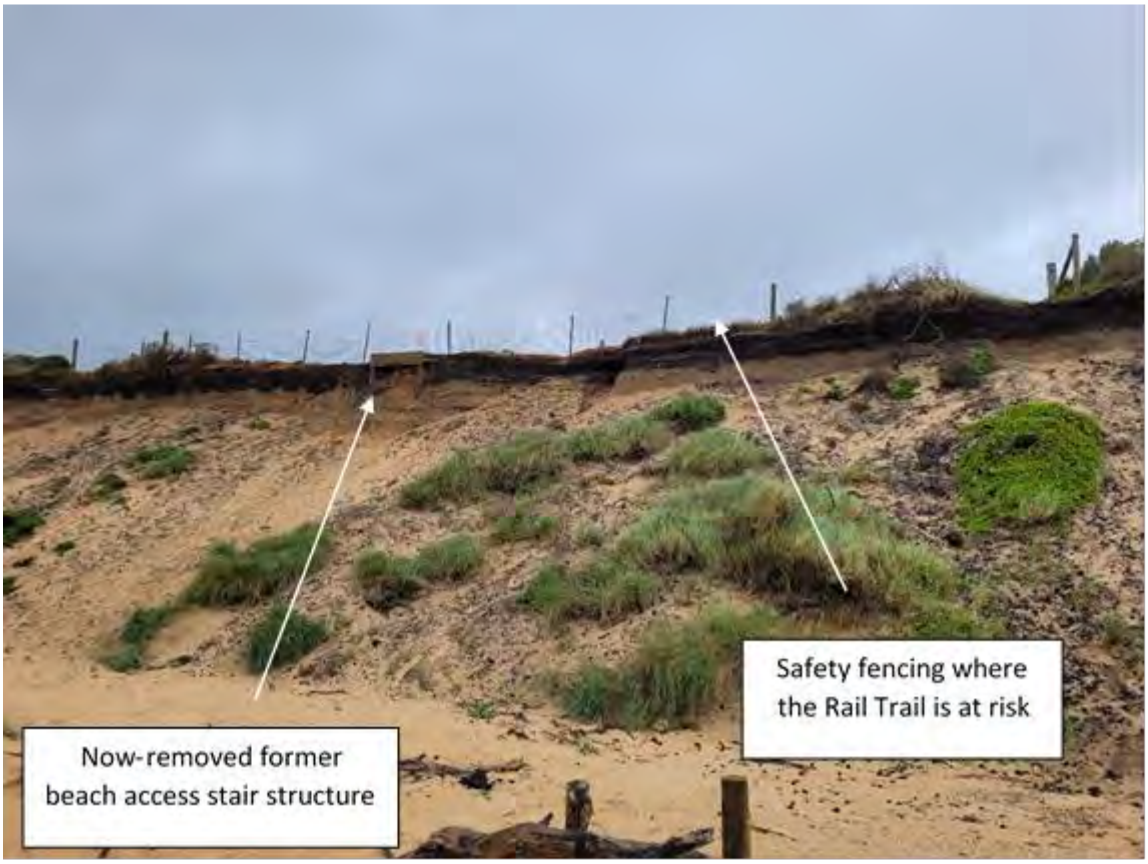

Figure 2 Erosion Hotspot with Fenced Rail Trail at Crest

Five relevant adaptation options were discussed as follows,

- **Non-Intervention/Minimum Intervention Consistent with Public Safety** – The purpose of including this option is to explore how minimal action regarding coastal adaptation would impact the Bass Coast Rail Trail and other assets. The trail would remain in its current alignment with safety fencing installed where necessary. When the trail was at risk of imminent failure, it would be shut indefinitely and allowed to erode. This option does not maintain the values of the site.

- **Retreat the Bass Coast Rail Trail on the Dune Crest** – This option would move the rail trail back from the erosion scarp as much as possible while keeping it on the dune crest. This would maintain the scenic values of the trail and minimise any impact on trail users. This option is only forecast to be effective for 1-10 years (possibly longer) after which further works to adapt the rail trail to coastal erosion would be necessary.

- **Re-Route the Bass Coast Rail Trail Behind the Dune** – This option would re-route the rail trail down off the dune crest, around the erosion hotspot and then back up to the dune crest where erosion no longer puts the trail at risk. This option has a relatively high cost, does not maintain beach access but increases the safety of trail users. This option would likely be effective for many years.
- **Beach/Dune Nourishment** – This option would nourish the beach and re-build the dune in the erosion hotspot area to protect the rail trail from erosion. Sand would ideally be taken from an on-beach borrow area. This may be considerably expensive depending on the ease of transporting sand to the site and may only be effective for weeks – months due to the high wave climate. This option is not recommended for this site because of the high cost and short effective lifetime.
- **Short Term Protection** – This option would use rock bags or geotextile sandbags as emergency protection of the toe of the dune from further erosion. This would stop further erosion of the site, however, by itself, this option would not be sufficient to minimise risk to trail users. If this option were used in combination with retreat of the trail on the dune crest, it may increase the effective lifetime of that option. Walls created using these containers may negatively impact coastal processes.
- **Protection with Revetment and Beach/Dune Nourishment** – This option would nourish the dune and then protect the toe with a rock revetment. This option may effectively protect the Rail Trail in its current alignment for many years, however, would be very expensive and would have significant impacts on coastal processes. This type of adaptation option is designated as an 'option of last resort' in the Victorian Marine and Coastal Policy (VMACP) (DELWP 2020) and thus should not be implemented immediately when other effective, more economical, lower impact options are available.

Possible adaptation pathways have been identified with key trigger values determining current and future adaptation decision points. We recommend immediately shifting the trail back on the dune crest and preparing detailed concept designs for the re-routing of the Bass Coast Rail Trail when erosion again impacts the trail in future.

Contents

List of Figures

List of Tables

1 Introduction

1.1 Background

Kilcunda Surf Beach is situated 1 km SE of the Kilcunda township. The beach is a high energy surf beach with a relatively steep sandy beach profile and high dunes. These dunes have historically been modified significantly to support the historic Nyora – Wonthaggi rail line (servicing the Wonthaggi coal mine) and the current Bass Coast Rail Trail at the dune crest. The 900 m long beach is bounded by rocky headlands at either end, as has the Bourne Creek Intermittently Open/Closed Lagoon (ICOL) entrance in the NW corner.

Since approximately 2005, dune erosion in the eastern half of the beach has caused the loss of the Surf Beach Carpark beach access in 2005, the cemetery beach access stairs in 2010 and most recently the carpark access stairs again in 2019. Since 2019, dune erosion has continued and now threatens an approximate 160 m stretch of the Bass Coast Rail Trail.

The Bass Coast Shire Council (Council) have commissioned BMT to undertake this Foreshore Erosion Options Assessment for Kilcunda to review available options to manage erosion and respond to sea level rise within an 'Adaptation Pathways' framework in accordance with the Victorian Marine and Coastal Policy (VMACP) (DELWP 2020).

The options assessment considers both short- and long-term options and maps their interdependencies. Objectives of this study are to:

- Investigate coastal processes influencing erosion at the Kilcunda project site.
- Assess the risk to built public assets.
- Assess options available for the management of coastal erosion to ensure the viability of built public assets.

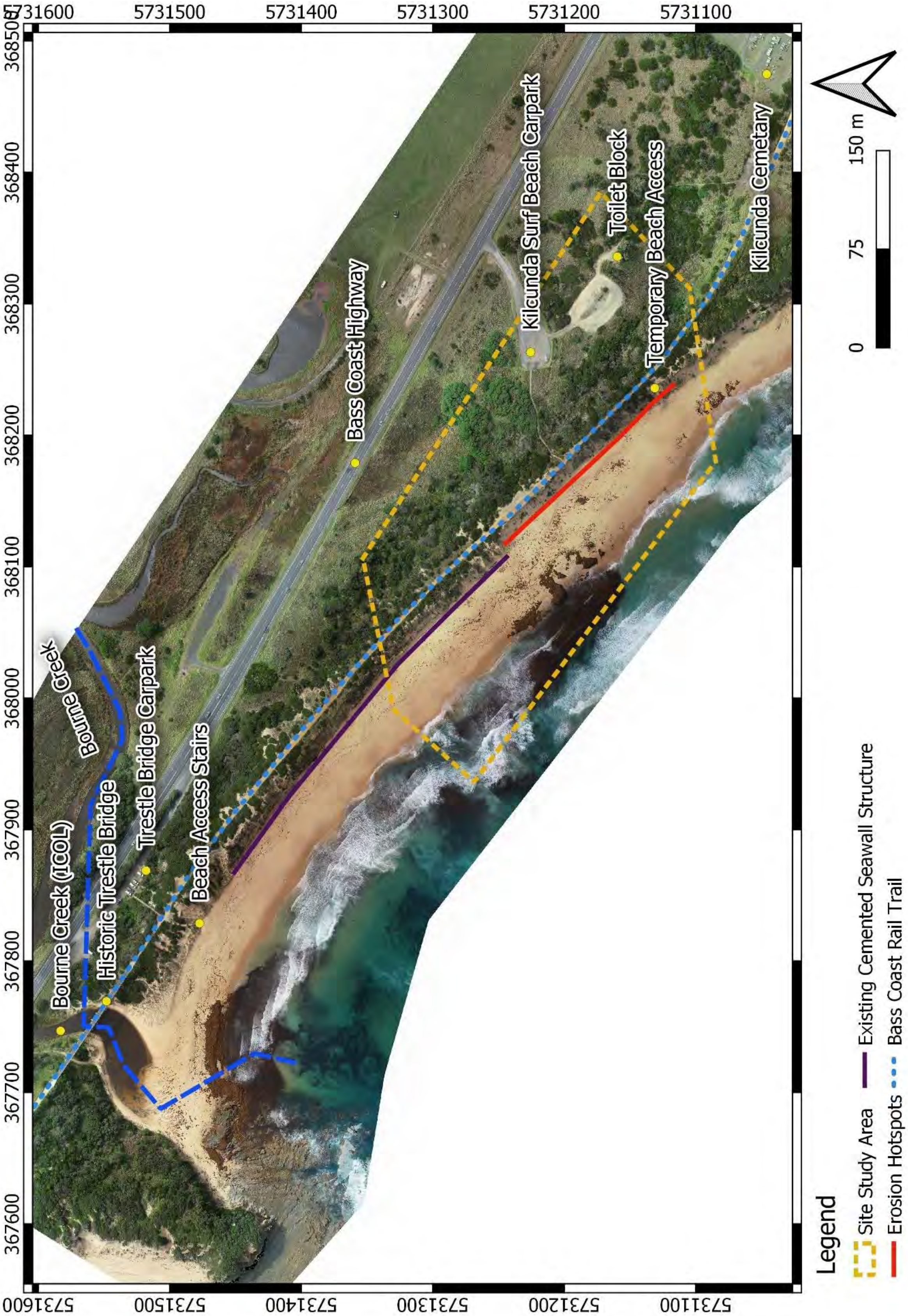

Figure 1-1 Study area site map

1.2 Study Area

1.2.1 Site Description

The Kilcunda site area is located on Kilcunda Surf beach, bounded by Bourne Creek entrance (an intermittently closed/open lagoon (ICOL)) in the NW and a small bluff to the SE, seaward of the Kilcunda Cemetery. The beach is backed by a high (12 – 14 m) dune system with the Bass Coast Rail Trail along the top of the dune crest. The rail trail follows the historic branch railway from Nyora to Wonthaggi which serviced the Wonthaggi Coalmine. The township of Kilcunda is NW of the study site along the Bass Highway, past the historic Bourne Creek Trestle Bridge which spans the creek entrance as part of the rail trail.

The problem area this study focusses on is SE of the historic seawall structure (See following section and Figure 1-3) where coastal erosion has cut into the dune face creating a steep scarp destroying the beach access stairs and undermining section of the rail trail. The length of trail currently at risk from erosion is estimated at 160 m (refer Section 3.1 and Figure 2).

Figure 1-2 Erosion Hotspot with safety fencing on the crest.

Although the broader sediment compartment between the bounding headlands NW and SE of Kilcunda surf beach will be included in the coastal process analysis, this study is focussed specifically on the erosion hotspot area (Figure 1) between the cemetery and where the cemented seawall structure begins and does not include the creek, the trestle bridge or the sea cliffs at either headland.

Key factors relating to coastal processes at the site include:

- it is a high-energy surf beach facing directly into the SW swell from the Southern Ocean
- significant cyclical onshore – offshore sand movement resulting in fluctuating beach levels and erosion at dune toe,
- unknown net sediment transport direction

Key values/assets at the site are understood to be:

- Bass Coast Rail Trail used for walking, cycling and horse riding
  - Possible cultural values related to the historic rail line
- Beach Access from Kilcunda Surf Beach Carpark
- Beach Amenity
  - Often used for surfing, fishing, swimming, sunbathing.
- Natural Values
  - Coastal dune vegetation seaward and landward of rail trail
  - Hooded Plover breeding area at northern end of beach
- Infrastructure Assets
  - Carpark and toilet block at Surf Beach carpark

1.2.2 Existing Coastal Protection

The barrier dune system backs the beach with a crest height of 12 – 14 m AHD. This dune was significantly modified by humans when the Wonthaggi to Nyora railway line was placed atop it. These alterations included placement of fill to make the dune crest level and placement of ballast rock to support the rail line. This layering can clearly be seen in the dune scarp at the erosion hotspot (Figure 1-4). There has also been placement of a mix of small basalt and sandstone boulders on the dune face in an apparent attempt to limit erosion of the dune. At some point the toe of this rock batter was cemented together to produce a seawall structure which is now in very poor condition with significant subsidence, cracks, and blowouts evident along its length (Figure 1-3). Despite its condition however, this structure is providing some level of protection to the dune and has stabilised the seaward face of the dune over much of the western half of the beach.

The timeframe of construction of these coastal modifications is uncertain, however, it is theorised to have been during the rail line era, (1910 – 1978).

Figure 1-3 Existing Seawall Structure NW of Erosion Hotspot

Figure 1-4 Anthropogenic Modification of Dune

1.3 Previous Studies

There are very limited published reports/studies for Kilcunda Surf Beach and even the Bass Coast more generally. Outlined below are the most relevant data sources available.

CSIRO – 2009 - The Effect of Climate Change on Extreme Sea Levels along Victoria's Coast

This report analyses the effect storm surge and climate change has on total storm tide levels along the Victorian Coast. As well as including sea level rise and its obvious effects on coastal storm tide levels, the authors additionally factor in predictions of wind speed changes in Bass Strait to predicted future storm tide levels. Kilcunda is one of the measured sites in this report with predictions of Storm tide levels under the current (2009) climate, as well as for 2030, 2070 and 2100 climate scenarios.

Eric C. Bird – 2003 – The Coast of Victoria

In this book, Eric Bird describes the geomorphology of the entire Victorian coastline. The section of coastline 'San Remo to Inverloch' briefly describes Kilcunda as a zone where shoreline sandstone cliffs further west decline, and the beach width increases. He notes the beach is backed by grassed dunes. Discussion of the regional sandstones and more general geomorphology informed the geomorphology section in this report.

1.4 Methodology

This study has employed an outcome-centric methodology for rapid assessment of coastal hazards and selection of adaptation measures/options using a pathways approach consistent with the VMACP (2020).

- The first step was a rapid desktop-review of coastal processes and coastal hazards based on a site inspection and available literature.
- This was followed by a first-pass options assessment conducted by BMT to identify a short list of coastal management strategies which may be applied to the site. This list was then taken to an options workshop with expert coastal engineers and representatives from Council to narrow the options shortlist into a limited set of technically feasible options that aligned with Councils strategic objectives.
- The tailored coastal hazard assessment was then undertaken to provide the information needed to support management decisions based on the agreed set of options, i.e. identified the most favourable options and trigger values for the implementation of each option.
- A full options assessment on the technically feasible management options previously identified was then undertaken to determine how effective they are now, and how effective they will be into the future.
- Finally, the favourable measures were assembled into a number of possible adaptation pathways that show how a series of measures can be implemented over time to manage the adaptation of the system to rising sea levels increasing coastal hazards.

The outcome-focused methodology made maximum use of previous studies and available data to inform a strong focus on identifying and developing practical solutions to complex coastal management issues.

2 Coastal Hazards

2.1 First Pass Hazard and Risk Screening

The first-pass assessment of the coastal hazards identifies which hazards will most likely drive both adaptation planning and the foreshore erosion options assessment. It is informed by site visits, stakeholder meetings and background documents.

The long list of coastal hazards shown in Table 2-1 is a combination of those outlined in the Victorian Marine and Coastal Policy (DELWP 2020) and the prescriptive list given in the NSW Coastal Management Act (NSW State Government 2016). Combining these lists enables certainty that all potential coastal hazards for the site are assessed.

Table 2-1 First Pass Hazard Assessment Summary

Coastal Hazard	Importance at Kilcunda
(a) Beach erosion (short term storm erosion)	High
(b) Shoreline recession (long term shoreline retreat)	High
(c) Storm Inundation (short term storm effects including storm surge and wave run-up)	Low (Dunes are 13 m AHD elevation)
(d) Tidal Inundation (reoccurring high tide inundation, sea level rise)	Low (Dunes are 13 m AHD elevation)
(e) Catchment Inundation (catchment flooding in combination with storm surge/high water level events)	Low (Dunes are 13 m AHD elevation)
(f) Coastal cliff or slope instability	Low
(g) Coastal Groundwater Changes	Low
(h) Coastal lake or watercourse entrance instability	Low (too far from site to impact)

This study focusses on the following hazards which will drive adaptation decisions at Kilcunda:

- Beach Erosion (short-term storm erosion),
- Shoreline Recession (long-term shoreline retreat),

2.2 Coastal Processes

2.2.1 Geomorphology

Region Scale Geomorphology

The geomorphology of the Kilcunda region is dominated by the presence of the early cretaceous Wonthaggi formation basement sediments comprised predominantly of fluvial volcaniclastic sandstone (Figure 2-1). These same sediments span much of the South Gippsland region forming the Strzelecki ranges and hilly terrain the region is known for. These sediments outcrop as coastal cliffs from San Remo to Kilcunda along the George Bass Coastal Walk and the Punchbowl Foreshore Reserve. At the coast, these sediments slope approximately 20 degrees landward (Bird 1993).

The northern boundary of the Wonthaggi formation is defined by the Bass Fault, north of which are alluvial and colluvial fans formed as eroded parent cretaceous sediments are carried down-slope towards western port bay. Abutting the Wonthaggi formation at various location along the Bass Fault are also remnant basaltic lava flows from the older volcanics formation, similar to those seen on much of the south Coast of Phillip Island.

The southern edge of the Wonthaggi Formation seen in Figure 2-1 is where the Powlett River (just south of map extents) and its tributaries have excavated channels into the sedimentary formation. These channels have since been filled with alluvial sediment which is gradually moved towards the mouth of the Powlett River. Sediment from this river system may be a source of beach-sand in the region.

During the Holocene Still Stand with sea levels fairly constant for the last 6,000 years, dune barriers have formed between headlands of cretaceous sediments. These can be seen at the Kilcunda Surf Beach study site, as well as further south. These are predominantly at high elevations and between Kilcunda and Cape Patterson are only dissected by the Powlett river and the Bourne Creek.

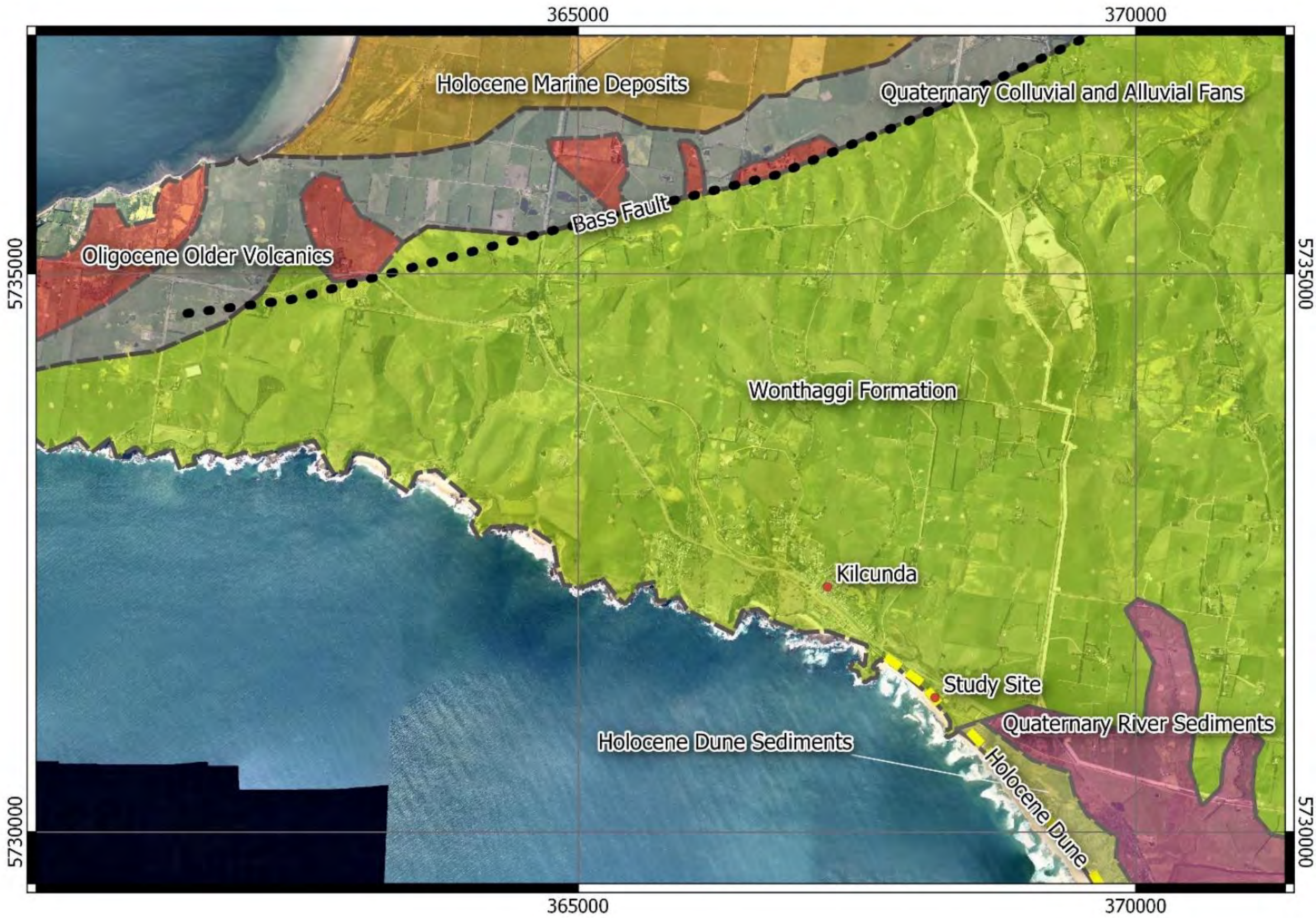

Figure 2-1 Geomorphology Map (Adapted from GeoVic)

Site Specific Geomorphology

The Kilcunda Surf beach Study site is characterised by a wide and relatively steeply sloping high energy surf beach. Seaward of the shoreline, sand is worked into banks and rip-channels by incoming swell waves. The beach is bounded on the NW and SE by two headlands of the Wonthaggi formation cretaceous sediments. These create barriers to sediment moving along the shore with the larger northern headland more effective at this.

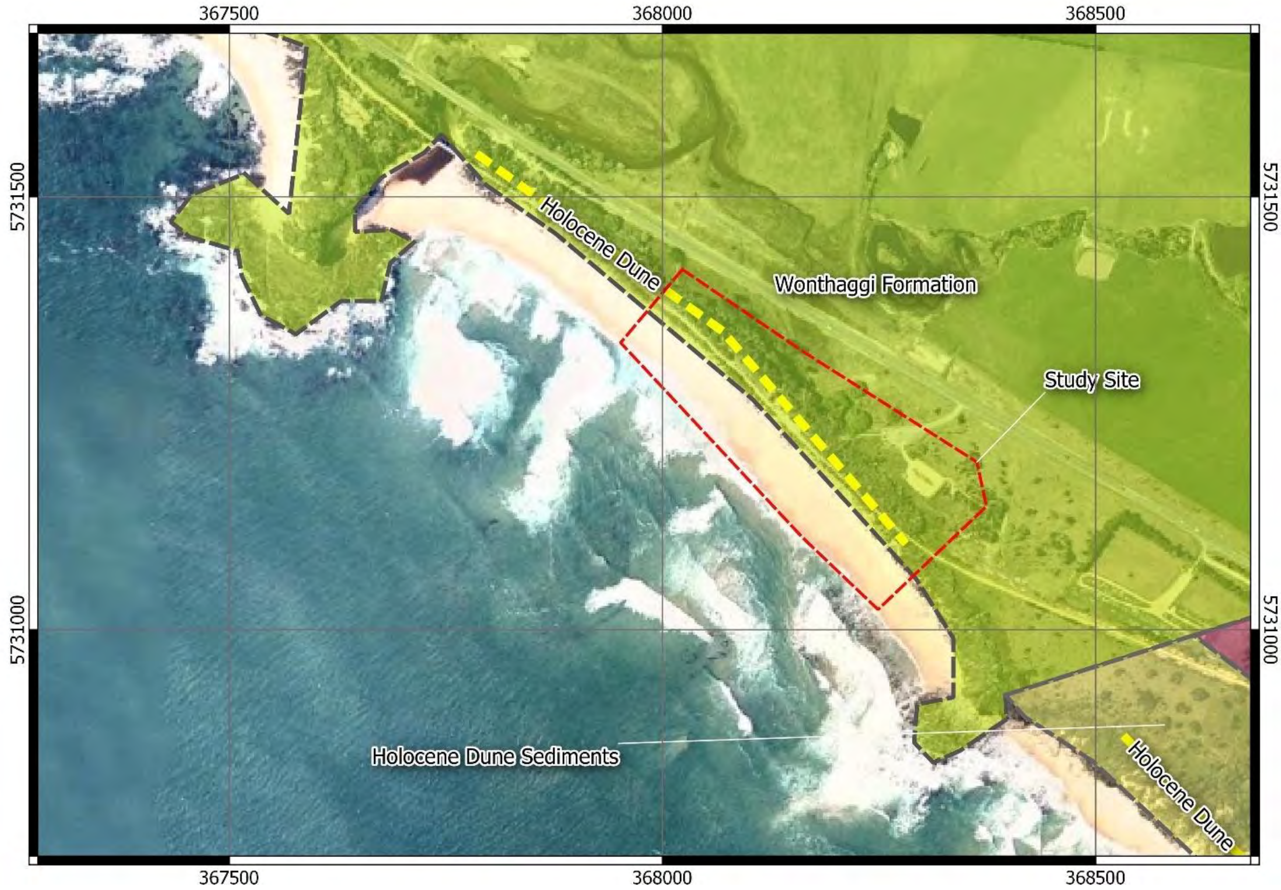

Figure 2-2 Site Specific Geomorphology

Holocene barrier dunes have formed between the headlands with the dunes dissected by the Bourne Creek ICOL entrance adjacent to the NW headland. There is no evidence that this lagoon mouth has significantly changed its configuration since 2007 with only minimal movement of the stream location.

The morphology of the dune system in the erosion hotspot area is specifically relevant to this study. Analysis of historical aerial images shows significant change in the positions of sandbars and rip channels immediately seaward of the erosion hotspot with no evidence of any shallow underlying reef. As such, it is assumed that the dune sands extend to a significant depth with no harder geology underlying which may act to inhibit shoreline erosion. There is equally no evidence in the dune erosion scarp of any erosion-resistant material. It is thus assumed that the cretaceous basement sediments dip to lower elevations in this area between the two headlands and that unconsolidated to loosely consolidated dune sand underlies all built assets in the area.

2.2.2 Water levels

Water levels at a site at any given time are the combination of many fluctuating factors including astronomical tide, storm surge, wave set up and wave run up (Figure 2-3). Because each of these are constantly changing, extreme water levels at a site thus only occur when high water phases of the various constituents of water levels combine.

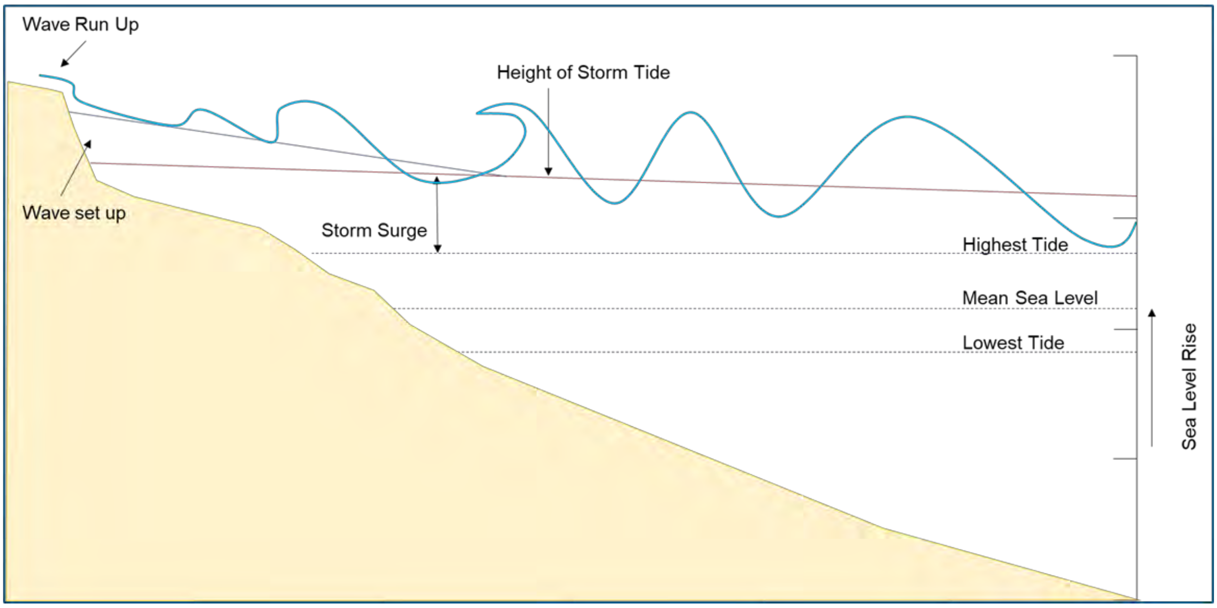

Figure 2-3 Diagram showing the constituents of water level at the coast.

The astronomical tide refers to fluctuations in local water level predominantly due to the gravitational pull of the sun and the moon. At Kilcunda, the tidal signal is a combination of a smaller diurnal component (1 tidal cycle a day) and larger semi diurnal (2 tidal cycles a day) component yielding two tides per day with the amplitude fluctuating over a 28-day cycle. There is no measured tidal gauge at Kilcunda, however, time and tidal height differences are given for various locations along the Victorian coastline including Seal Rocks (VRCA 2019). Seal Rocks is approximately 30 km from Kilcunda thus, this tidal data is adopted as representative of the study site (Table 2-1).

It is important to note that for sites where no tidal gauge is measured, VRCA does not include estimations of highest or lowest astronomical tide (HAT and LAT), nor highest or lowest recorded tides (HRT and LRT).

Table 2-2 Seal Rocks tidal plane (applicable to Kilcunda) (VRCA 2019)

Tidal Plane	Water Level chart Datum (m)	Water Level (m AHD)
Mean High Water Spring	2.5	1.1
Mean High Water Neap	1.8	0.4
Mean Sea Level	*1.4**	0
Mean Low Water Neap	1.1	-0.3
Mean Low Water Spring	0.4	-1.0

**Interpolated*

'Storm tide' refers to the combination of astronomical tide level, and storm surge which often occurs when low pressure systems with cold fronts cross Bass Strait causing sharp drops in atmospheric pressure, winds from the SW and high sea waves (McInnes et al. 2005) (Figure 2-3). Storm tide (exclusive of wave set up and wave runup) levels along the Victorian coastline have previously been calculated by McInnes et al. (2009) for ARI 10, 20, 50- and 100-year events under current conditions, and under various possible future climate change conditions. The storm tide heights for these events under current conditions are given in Table 2-3 below.

Table 2-3 Estimated Storm Tide Levels at Kilcunda (CSIRO 2009)

Annual Recurrence Interval ARI (Years)	Average Exceedance Probability AEP (%)	Storm Tide Levels (m AHD)
10	10	1.54
20	5	1.70
50	2	1.85
100	1	1.94

As well as astronomical tides and storm surge, water levels at the coast are increased by wave set up and wave run up, both of which are locally dependant on the shore profile (Figure 2-3). Wave setup is caused by breaking waves pushing water towards the land. Wave run up is where broken waves flow up the local beach surface towards land. In storm conditions, these processes can cause overtopping of coastal protection structures and dunes.

Generally, wave set up can increase coastal water levels by approximately 20% of the incoming offshore significant wave height. Wave runup has been estimated for the NSW coast as between 3 – 6 m on top of the highest coastal water level elevation (Hughes 2016). Calculation of more accurate estimations of wave set up and wave runup are out of the scope of this report due to inundation hazard being assessed as of low-importance in the first pass hazard assessment (See section 2.1).

2.2.3 Climate Change and Sea Level Rise

Climate change currently affects and is forecast to increasingly affect many varying global processes (IPCC, 2019). This is especially true for mean sea level and the various coastal processes which act to shape the coastline many of us inhabit (IPCC 2014).

The projected sea level rise (SLR) in the Bass Strait has been derived from data provided by the Intergovernmental Panel on Climate Change (IPCC) in their most recent Special Report on the Oceans and Cryosphere released in September 2019 (IPCC, 2019). The projected SLR is displayed below in Figure 2-4. The SLR is quoted relative to the average mean sea level from 1990-2005.

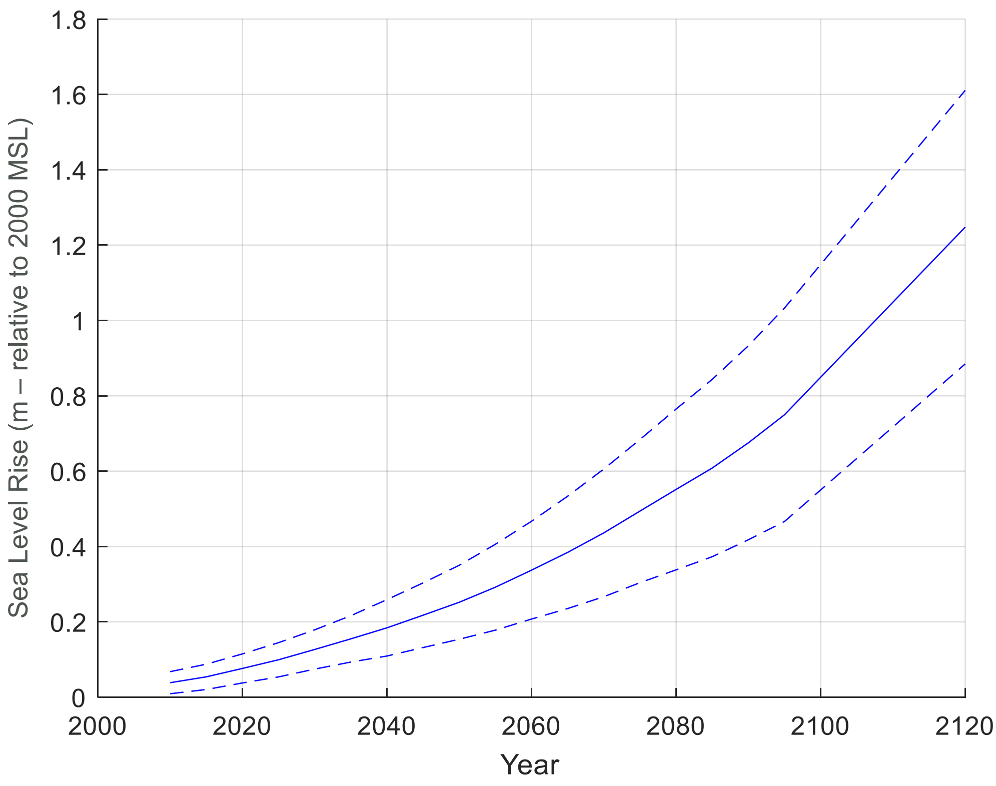

Figure 2-4 Project sea level rise in the Bass Strait derived from the IPCC Special Report on the Oceans and Cryosphere under RCP8.5 emission scenario.

From the most recent IPCC data, SLR relative to 2021 MSL has been calculated as shown in Table 2-4. The Victorian Marine and Coastal Policy (VMACP) has set a benchmark of 0.8 m of SLR by 2100 for coastal adaptation planning (Victorian State Government 2020). This is more conservative than the IPCC estimates, thus, for adoption into this adaptation options assessment, the IPCC estimations are scaled up to match the 2100 VMACP benchmark (Table 2-4).

Table 2-4 Sea level rise adopted values

Year	Sea Level Rise (m – relative to 2021 MSL) (IPCC 2019)	Adopted Sea Level Rise (m – relative to 2021)
2021	0 (Current MSL)	0 (Current MSL)
2031	0.05	0.1
2041	0.13	0.18
2071	0.38	0.43
2091	0.62	0.67
2101	0.75	0.80

2.2.4 Wave Climate

We used an existing BMT Bass Strait SWAN model to characterise the wave climate at Kilcunda as shown in Figure 2-5. This model incorporates swell waves entering Bass Strait from the east and west (from global wave models), wind wave generation, wave interaction, refraction and shoaling within Bass Strait. The model was used to hindcast 12 years of wave conditions and results were reported from the point between 1987 and 1999. An extreme value analysis of this data was also conducted for significant wave height to determine the magnitude of various return interval events. The model was previously calibrated using Apollo Bay wave measurements.

Note that modelled wave conditions were extracted at nearshore location, seaward of the surfzone, with a mean depth of approximately 8m. Long period swell waves will have undergone significant shoaling and refraction before they reach this point, which means that the reported waves are lower height and more shore-normal in direction than the deep water wave climate further offshore.

Results from this model show that:

- The dominant waves at the site are swell waves from the Great Australian Bite and Southern Ocean with periods of 8 – 21 s which approach the sire from 200 to 260 degrees (Figure 2-6).
- Smaller wind waves formed in Bass Strait with periods of 1 – 8 s which approach the site from directions between 180 – 210 degrees (Figure 2-6).

These wave characteristics are summarized in visually in Figure 2-7.

Extreme value analysis results for significant wave height and peak period are given in Table 2-5 for ARI 1, 10, 25, 50 and 100-year events.

Table 2-5 Inshore wave heights – Extreme Value Analysis

			Significant Wave Height (m)				
	LON	LAT	ARI-1	ARI-10	ARI-25	ARI-50	ARI-100
Kilcunda	145.4850	-38.560	2.28	2.58	2.7	2.79	2.88

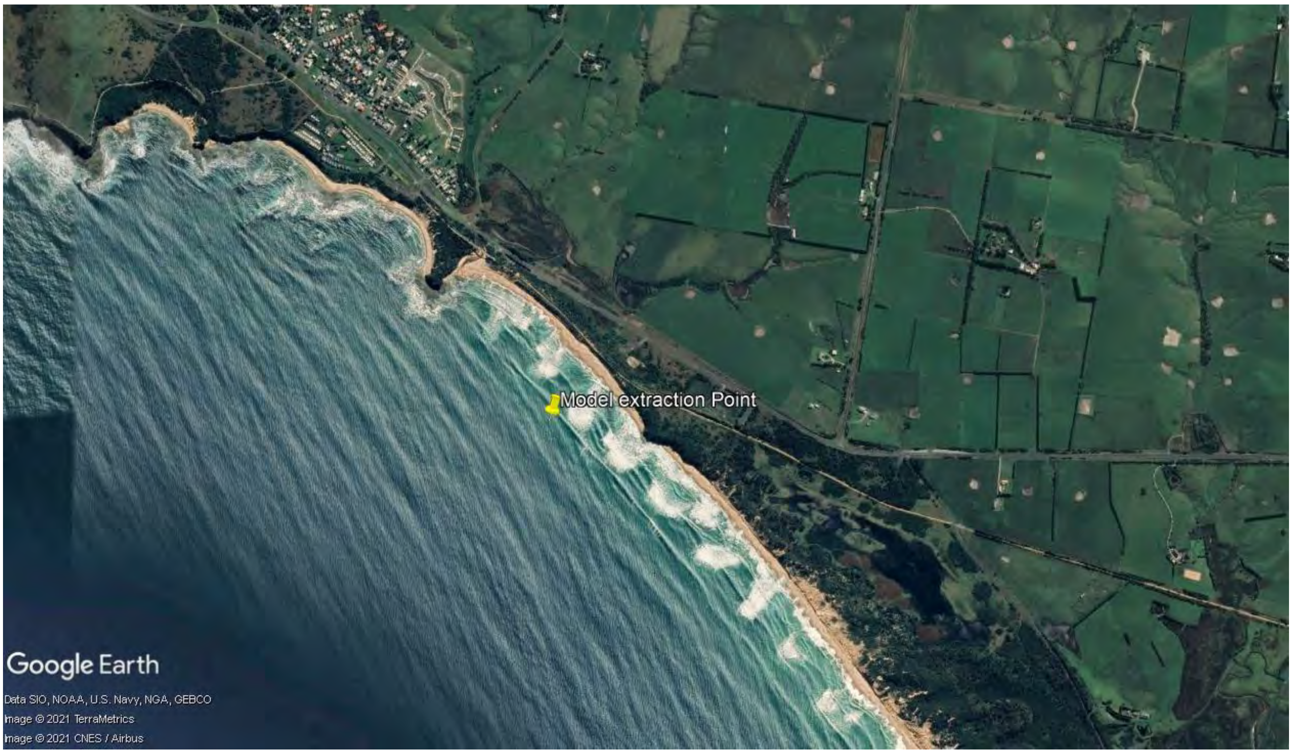

Figure 2-5 SWAN model extraction point

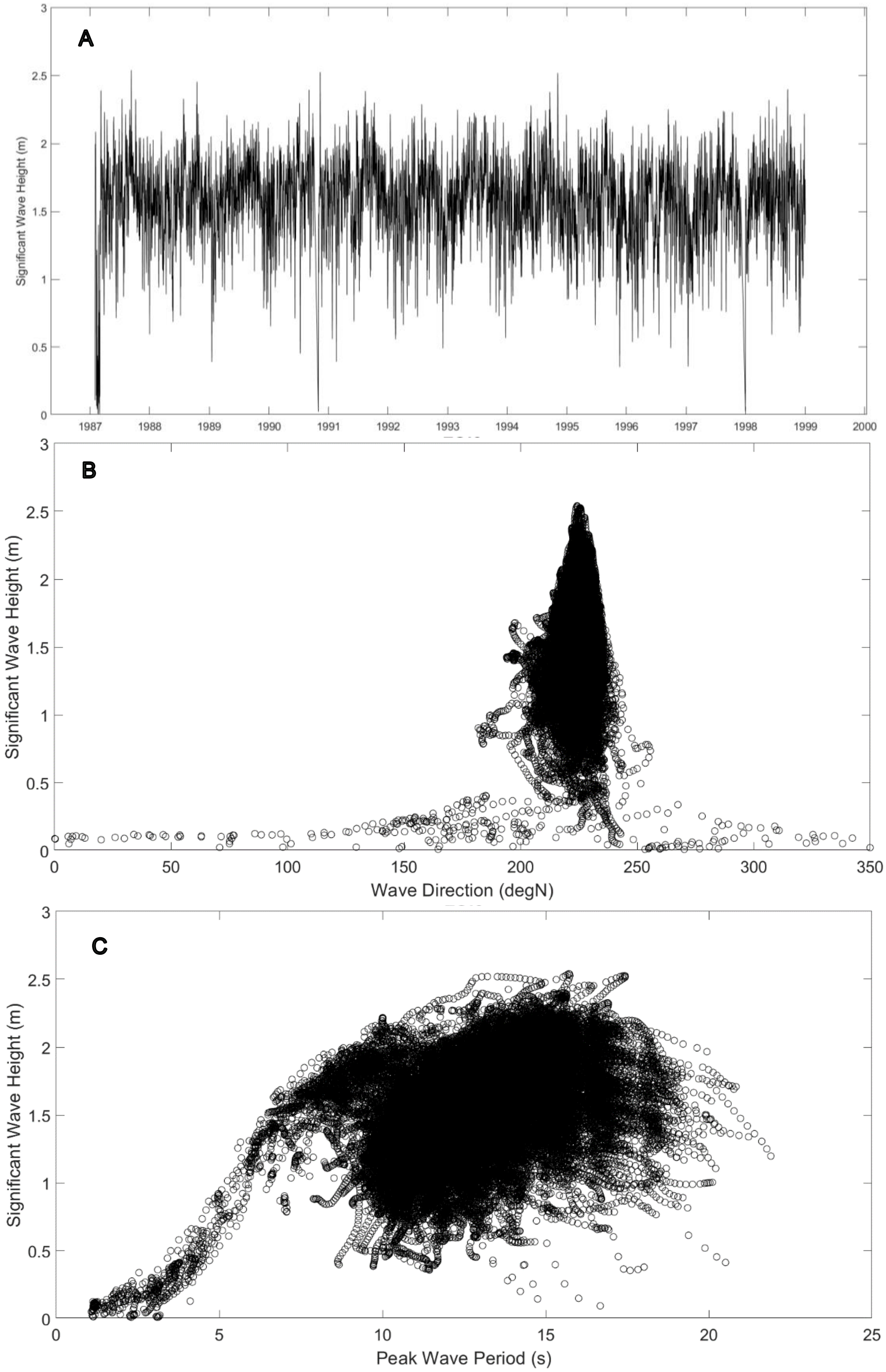

Figure 2-6 Bass Strait SWAN model results

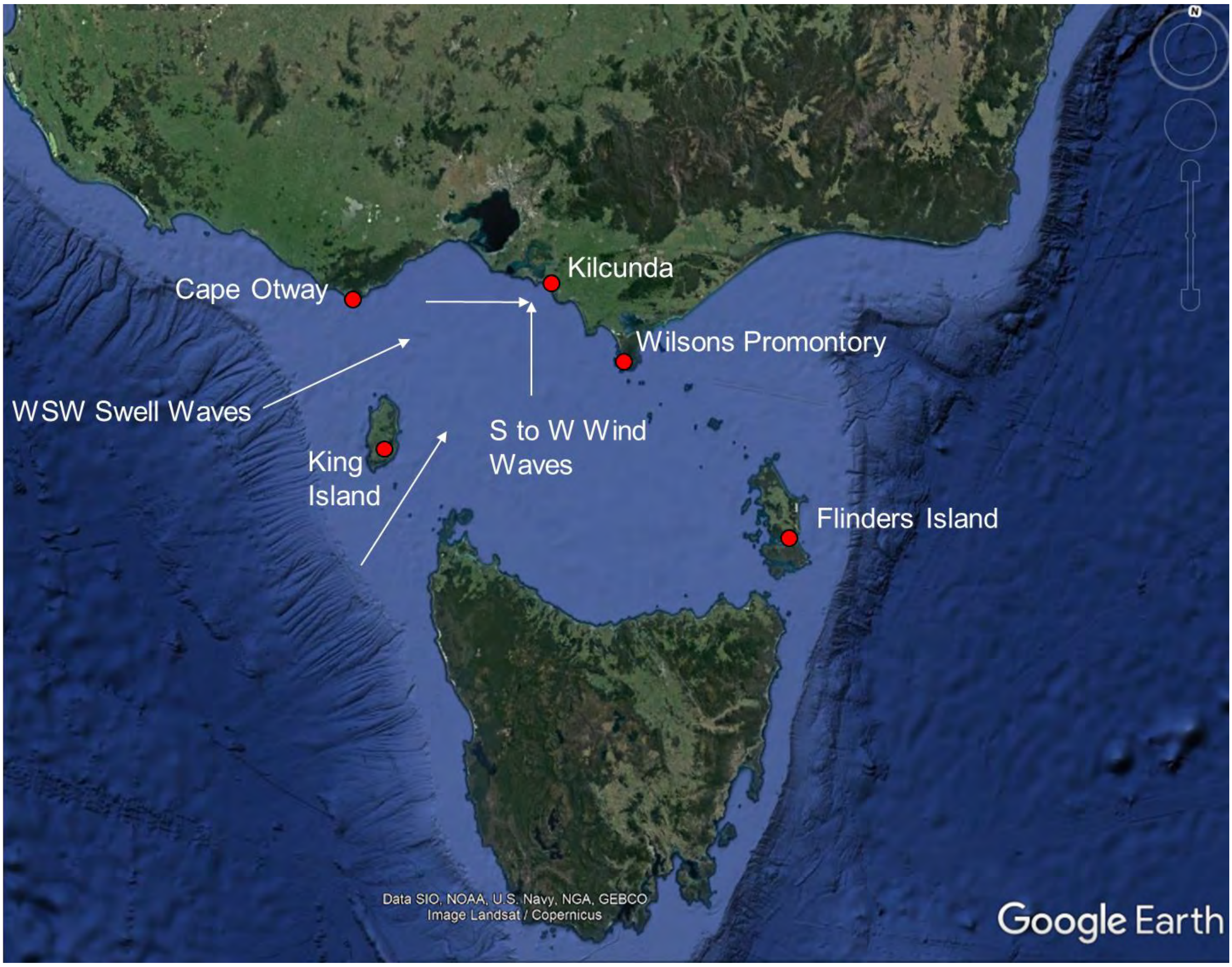

Figure 2-7 Diagram Showing the different wave sources for Kilcunda

2.2.5 Storm Demand

Storms with elevated water levels and large waves typically erode sand from the beach and dune and deposit it in nearshore sandbars. 'Storm demand' is defined as the volume of sediment removed from a shore profile per meter of shoreline above 0 m AHD elevation (Mariani et al. 2012). Storm demand values can be calculated for individual beaches if survey is available pre- and post-storm. These can vary substantially both along a beach and between beaches with differing shoreline characteristics.

Mariani et al. (2012) calculated representative storm demand values for different coastal compartments around Australia using XBEACH and SBEACH models. In the absence of site specific data, the values calculated by Mariani et al. for South Gippsland have been adopted for Kilcunda in this study (Table 2-6).

Table 2-6 Adopted Storm Demand Values (Mariani et al. 2012)

Storm Return Interval	Storm Demand (m^3/m)
ARI1	72
ARI10	95
ARI100	138
2 x ARI100	211

A separate analysis of dune erosion was also undertaken via comparison of the limited aerial imagery available on Google Earth from the previous 14 years (2007 – 2021). The dune crest line (top of erosion scarp) in the erosion hotspot zone was compared visually between consecutive images to find the time period with the greatest horizontal storm recession of the dune crest.

The results of this analysis are summarized in Table 2-7 and Figure 2-8, showing the greatest horizontal erosion of the dune crest during the previous decade was seen between 2010 and 2014, up to a horizontal distance of 5 m.

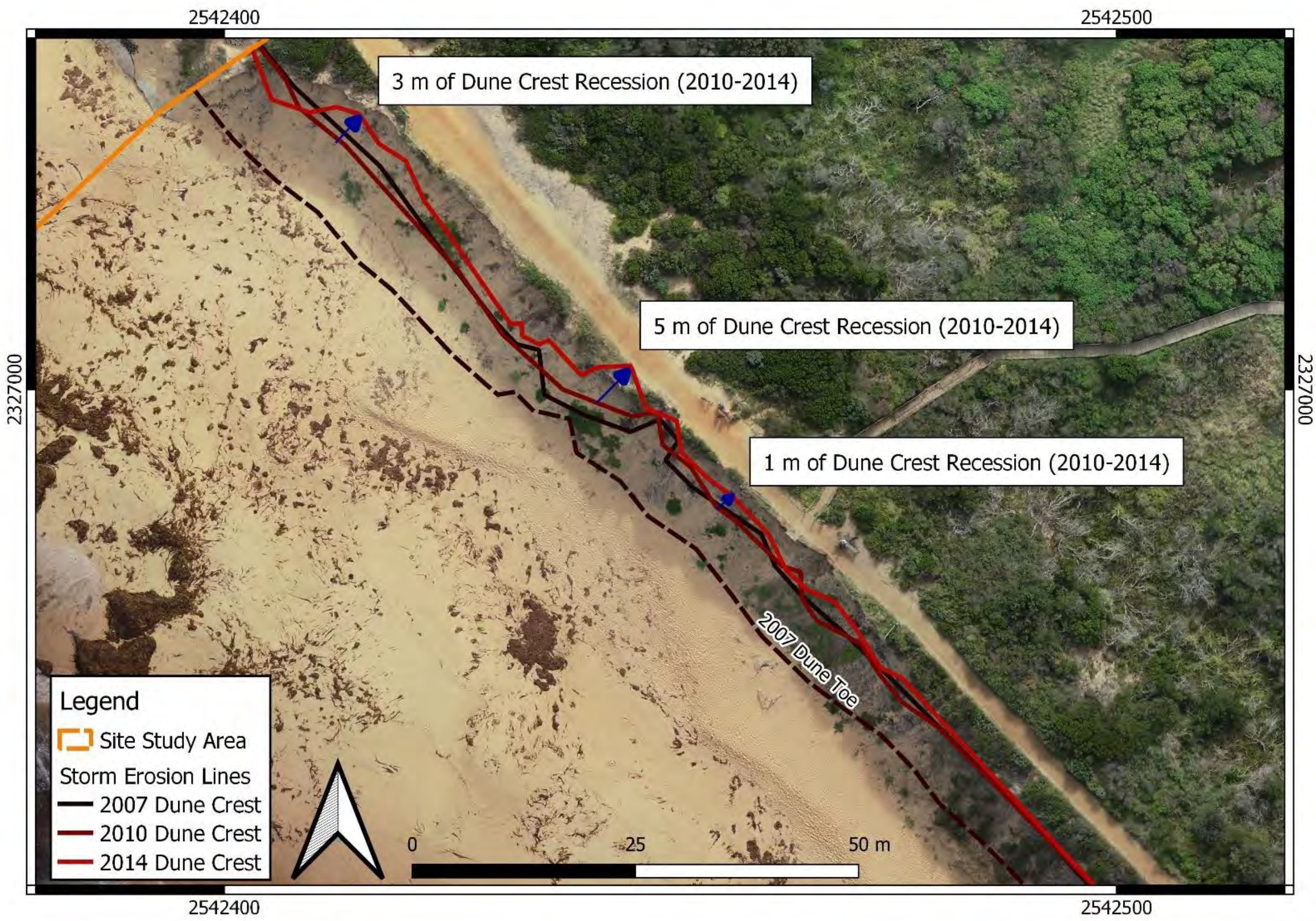

Figure 2-8 Comparison of Dune Crest Erosion 2007 – 2021.

Both the storm demand values reported by Mariani et al. (2012) and the dune crest erosion distance found through aerial imagery comparison are used in the following section to inform the assessment of the erosion hazard at Kilcunda.

2.3 Erosion Hazard

2.3.1 Storm Erosion

The extent of storm erosion along a beach under storm conditions shows considerable spatial variability depending on beach gradient, sediment size, the presence of single or multiple sand bars, rips, low tide beach terraces, deep troughs and a variety of other beach morphological features (Mariani et al. 2012).

The processes occurring during and after storm erosion events have been described by Nielsen et al. (1992) (Figure 2-9). When storm erosion occurs on sandy beaches, a vertical scarp typically forms in the foredune as sand is removed offshore by waves. In the days – weeks after a storm, this vertical scarp begins to slump to the natural angle of repose of dry sand (34 degrees), resulting in the top of the erosion scarp receding slightly further (Nielsen et al. 1992). The area seaward of the top of the scarp at this point is defined as the Immediate Hazard Area (Figure 2-9).

In this state, the dune sand is stable under its own weight, however any additional weight behind the immediate hazard area (e.g. a building or other infrastructure) may cause the dune to slip further. These slips could cause failure of significant dune crest infrastructure and hazards to infrastructure users. This zone is called the Zone of Reduced Foundation Capacity (Nielsen et al. 1992), within which zone a building or other infrastructure may be at risk (Figure 2-9).

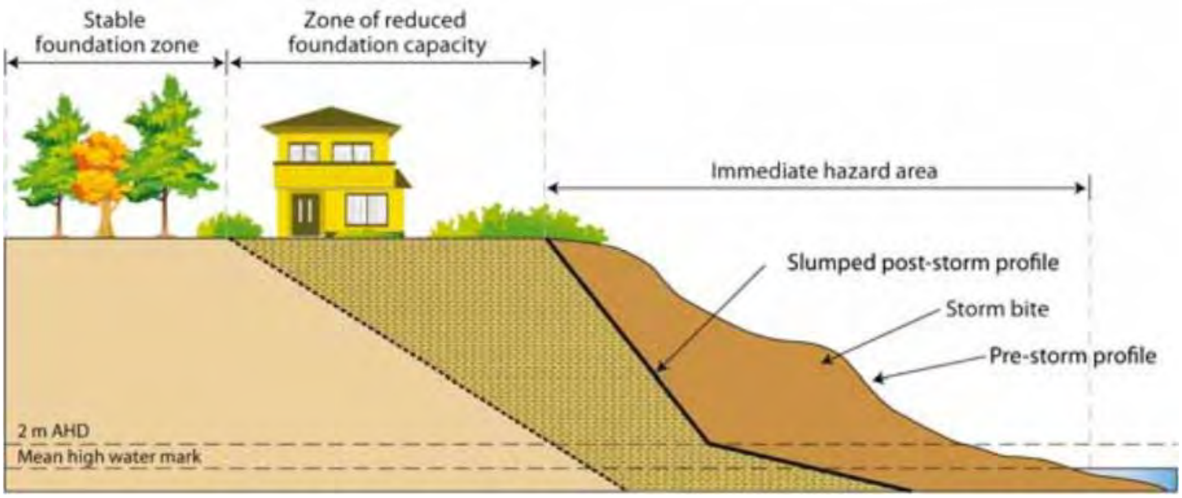

Figure 2-9 Storm Erosion Hazard Zones as defined by Nielsen et al. (1992). (Image: NSW Coastal Management Manual)

The Kilcunda site was surveyed using photogrammetry collected on 6 May 2021 at low tide by Aus AUV. Where this data had captured the tops of vegetation, it was replaced with LiDAR data from the Future Coasts data set (taken between 2007 – 2011) to produce a combined Digital Elevation Model (DEM) of the ground surface.

Storm erosion potential at Kilcunda was assessed via the Nielsen Hazard Zone method using the adopted Storm Demand values (Table 2-6) to calculate the setback distances for the immediate hazard area and the Zone of Reduced Foundation Capacity behind the current dune crest vegetation line (identified through site survey) for ARI1, 10 and 100-year events. These results are summarized below in Table 2-7.

When survey data was collected for Kilcunda, the beach was relatively ‘full’ (had a relatively high volume) of sand. Because of this, the adopted storm demand values (Table 2-6) used in combination with the Nielsen method for estimating storm erosion predict that storms would largely cut sand from the beach without impacting the dune (Figure 2-10). With the current beach profile, the Nielsen method predicts two consecutive ARI100 year storms would only erode the dune crest back 3 m from its current position.

Table 2-7 Potential Storm Erosion Setback Distances.

Return Interval	Hazard Zone	Setback Distance Landward of Current Vegetation Line (m)*
ARI1	Immediate Hazard Area	-25
	Zone of Reduced Foundation Capacity	-15
ARI10	Immediate Hazard Area	-20
	Zone of Reduced Foundation Capacity	-10
ARI100	Immediate Hazard Area	-10
	Zone of Reduced Foundation Capacity	0
2 x ARI100	Immediate Hazard Area	3
	Zone of Reduced Foundation Capacity	20

**Note that negative values refer to situations where calculated zone boundaries lie on the beach side of the dune crest. See* Figure 2-9 *for reference.*

Comparison of these empirical results to the actual erosion seen during the last decade at the site (Section 2.2.5) shows that the Nielsen approach with the adopted storm demand values may substantially underestimate the erosive potential of storms on this coast. For example, between 2010 – and 2014, the maximum dune crest recession distance was 5 m, greater than the predicted effect of two consecutive ARI100 storms.

As such, we nominally adopt the maximum dune crest erosion value of 5 m during the last decade (2010 – 2021) as the storm erosion potential for an ARI10 year storm.

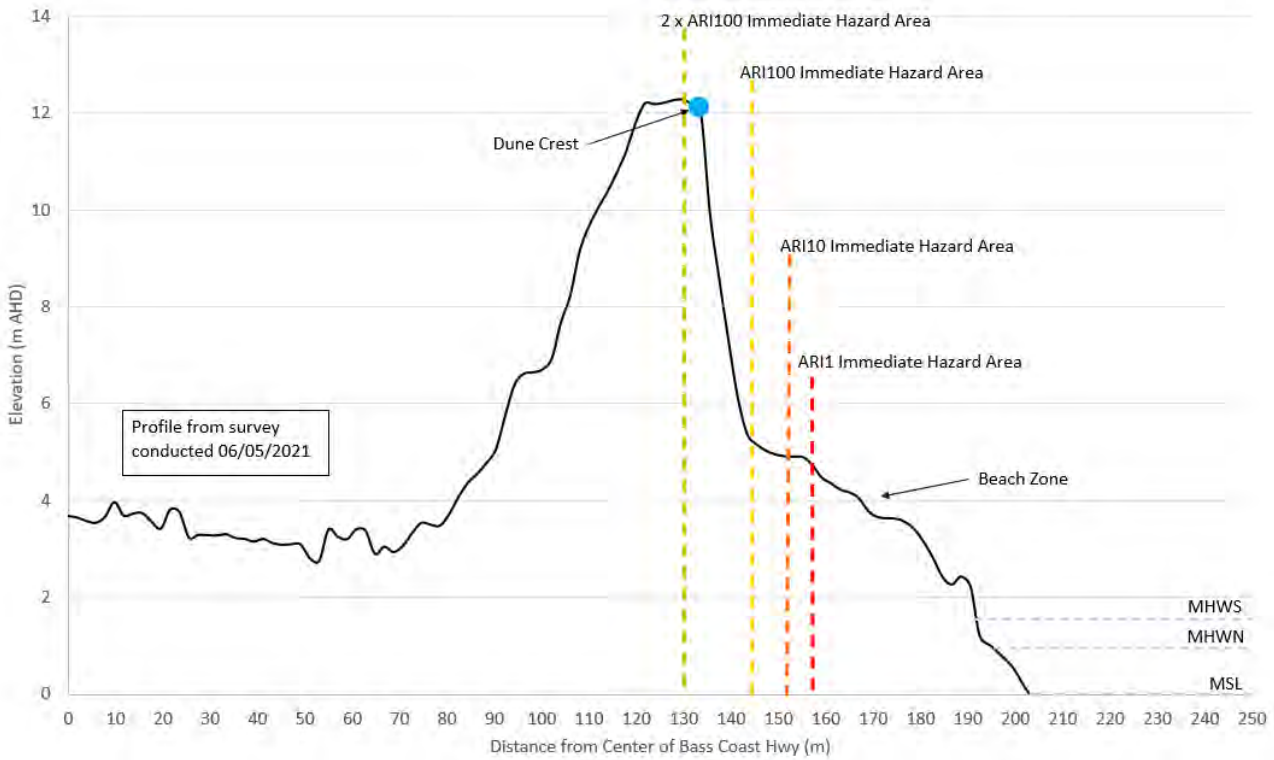

Figure 2-10 Hazard Zones Calculated according to Nielsen et al. (1992) method.

2.3.2 Coastal Recession due to Sediment Loss

Long-term coastal recession can occur for a number of reasons including sea level rise and sediment deficit. A sediment deficit occurs on a beach when there is more sand being removed from the area than is being returned (e.g. through long-shore drift or cross shore transport). Although shoreline position often fluctuates on shorter time scales (e.g. seasonally), a sediment deficit can be identified through comparison of yearly aerial photographs from previous years. Coastal recession due to sediment loss is here defined as the long-term recession rate (m/year) of the beach.

To calculate this, we utilised the recently released Digital Earth Australia Coastlines data set (Geoscience Australia 2021). This data includes the median position of the coastline at approximately 0 m AHD on sandy beaches around Australia each year from 1988 – 2019. From this, we calculated the distance from the coastline to the centre of the Bass Coast Hwy along two cross sections through both the erosion hotspot zone, and the seawall beach zone, for each year. General coastal recession rates were identified as summarized in Table 2-10.

The results of this analysis are summarized below in Table 2-8 and Figure 2-12.

This analysis seemingly shows a slightly lower recession rate for the seawall section than for the erosion hotspot. Interestingly however, the seawall and the dune toe has been in the same position since the wall's construction (between 1910 and 1978). This thus infers that the Digital Earth Australia model may have an error of ±0.2 m and recession at the erosion hotspot may be between 0.1 and 0.5 m/year.

As previously mentioned, the seawall is in very poor condition with significant subsidence, cracks, dislodged armour and blowouts evident along its length. As sea levels rise, increased water depth at the wall toe will cause larger waves to break on the structure causing more damage. For our estimate of current and future erosion hazard zones at the site (Section 2.3.4) we therefore assume the wall has failed and the dune will recede landward from its present position as the same rate as the unprotected area. As such, we adopt a recession rate due to sediment loss of 0.3 m/year for both beach zones for further calculations (Table 2-10).

Table 2-8 Coastline Recession Rates from Digital Earth Australia: 1988 – 2021

Beach Section	Calculated Beach Recession Rate (m/year)
Erosion Hotspot	0.3
Seawall Beach Zone	0.2

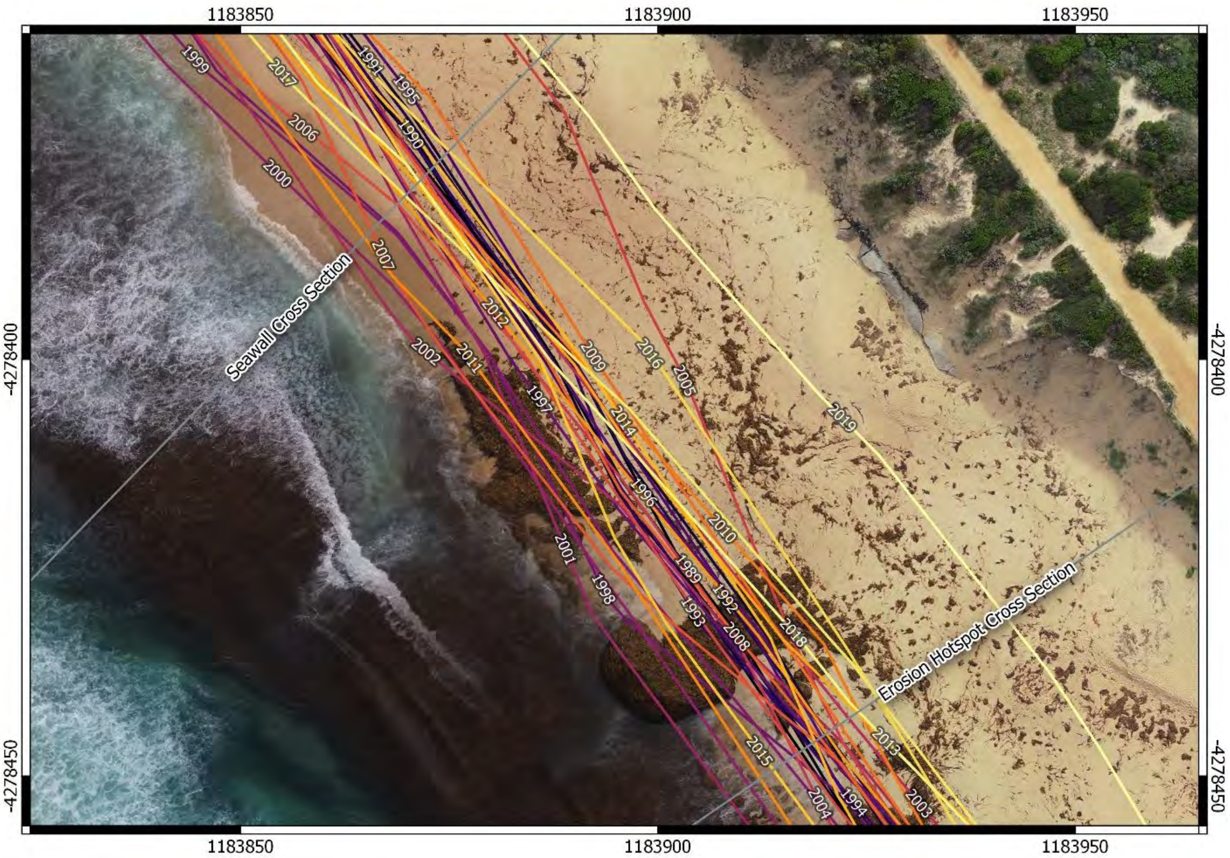

Figure 2-11 Map Showing the DEA Coastline Positions at Kilcunda.

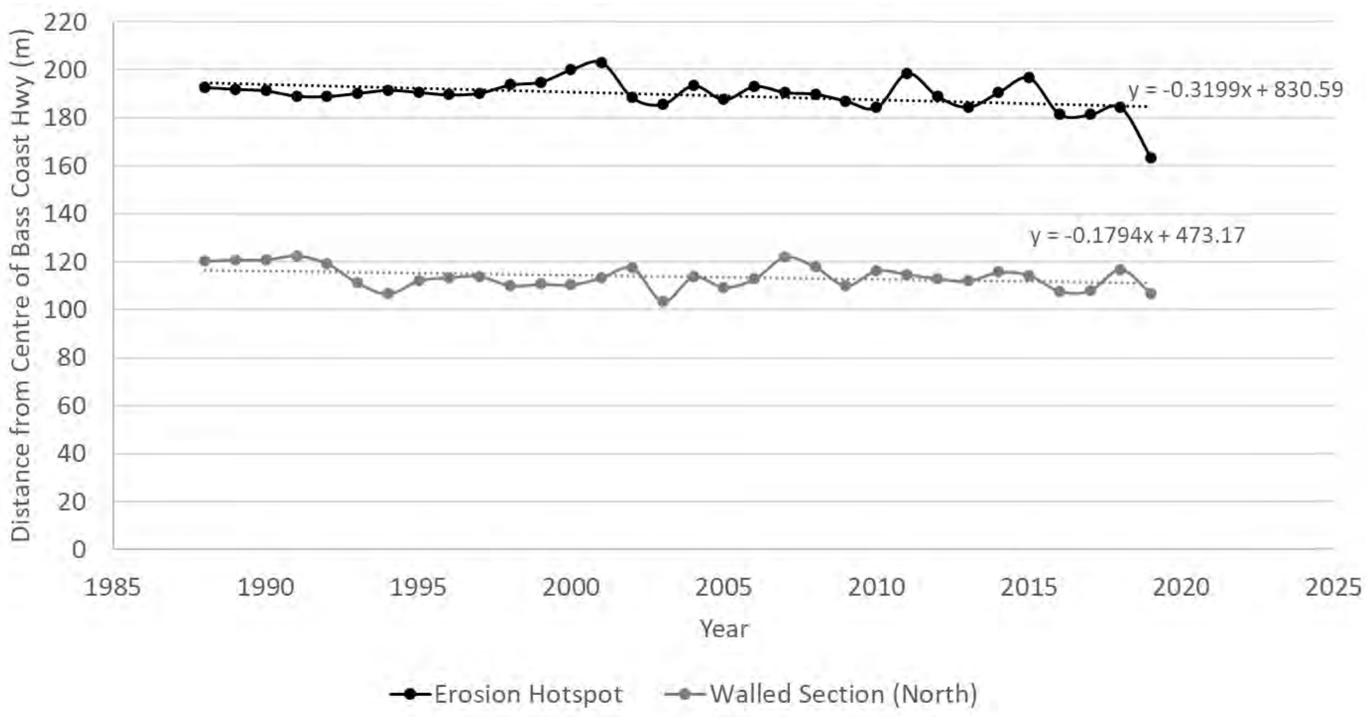

Figure 2-12 Coastal Recession Trends (1988 – 2019).

2.3.3 Coastal Recession Due to Sea Level Rise

As mentioned previously, coastal recession can also occur due to sea level rise (SLR). This recession is inherently difficult to predict due to the impacts of constantly changing local shorelines. As such, any prediction of shoreline retreat due to SLR has a high degree of uncertainty.

To assess the likely extent of shoreline retreat due to SLR, we use the Brunn rule to calculate a recession rate (m recession/ m of SLR). The Brunn rule assumes the beach profile is in equilibrium with the water level and will rise as the sea level rises. For this to occur, the beach profile must also shift landward as sea levels rise. The Brunn rule relies heavily on the value of shoreline slope. In this study, this slope was calculated using the approximate top of the active beach profile at 6 m AHD and a depth of closure of -20 m AHD. Results of this analysis are given in Table 2-9.

As previously mentioned, there is a high level of uncertainty in these predictions. Regarding the following erosion options analysis, this uncertainty will have little impact on the use of any short-term measures. For long-term options, the time frame is indicative only and may differ from estimated values by decades.

Table 2-9 Coastal Recession rate due to Sea Level Rise

Coastal Recession Constituent	Value
Coast Recession due to Sea Level Rise	40 m/m Sea Level Rise

2.3.4 Predicted Erosion Hazard Zones

The maximum erosion hazard zones for Kilcunda were calculated by combining the estimates of storm erosion, coastal recession due to sediment loss and recession due to sea level rise as summarized in Table 2-10. This enabled estimation and mapping of the possible location of the shoreline under various SLR scenarios.

Table 2-10 Components of Erosion Hazard Calculation

Erosion Type	Erosion Hotspot	Walled Section
Storm Dune Recession for ARI10 year Hs event (m)	5	5
Long Term Coastal Recession due to sediment loss (m/year)	0.3	0.3
Coastal Recession due to SLR (m recession/m SLR)	40	40

Erosion hazard lines have been calculated and mapped in terms of a slumped storm erosion escarpment in the seaward face of the dune, i.e. the 'Immediate Hazard Area' defined in Figure 2-9.

Shoreline position setback distances behind the current dune crest are calculated for the years 2031, 2071 and 2101, and summarized in Table 2-11. These are also mapped across the study site area in Figure 2-13. As mentioned previously (Section 1.2) the existing seawall was constructed many years ago and is in poor condition with cracks, subsidence and blowouts along its length. As such, in calculating the future erosion hazard line setback values for this walled beach section we have assumed that the wall will fail with sea level rise and future wave impact. In line with this, we assume the coastline in this area will recede with minimal protection of the dune. The recession values for the walled section may be considerably conservative if the wall does not fail.

Table 2-11 Erosion Hazard Line Setback Distances Behind 2021 Dune Crest

Erosion Hazard Line	Setback Behind 2021 Dune Crest (m)	
	Erosion Hotspot	Walled Section*
Current Erosion Hazard Line	5	5
2031 Erosion Hazard Line (0.1 m SLR)	10	10
2071 Erosion Hazard Map (0.43 m SLR)	35	35
2101 Erosion Hazard Line (0.8 m SLR)	60	60

**Recession values for walled section assume wall failure and thus may be considerably conservative.*

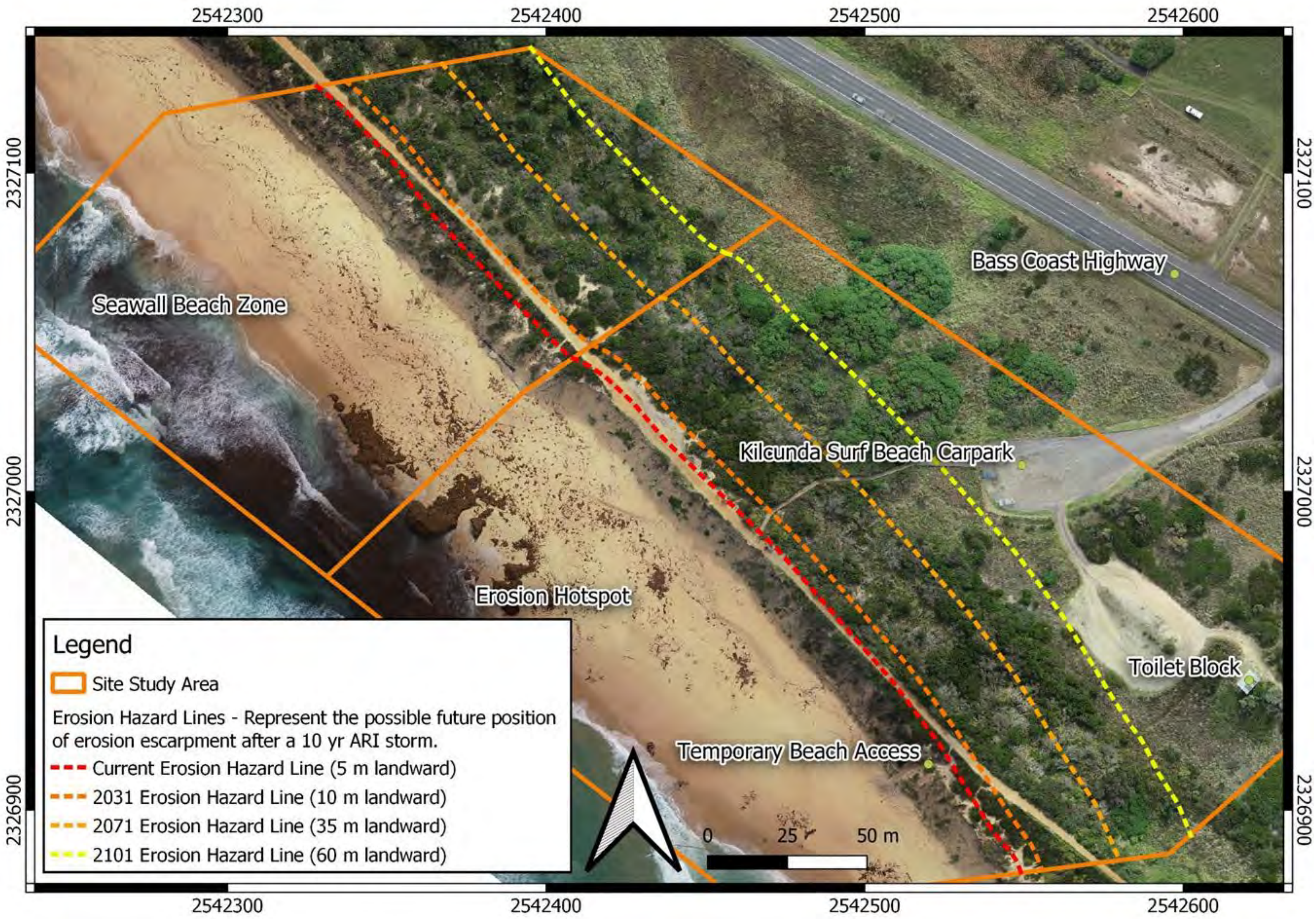

Figure 2-13 Erosion Hazard Line Map – Kilcunda

3 Asset Vulnerability

3.1 Bass Coast Rail Trail

The Bass Coast Rail Trail is the only asset at risk from erosion in the Kilcunda study site area (Figure 2-13). Inspection of the results of the erosion hazard map above shows that in the Erosion Hotspot Beach Zone, much of the trail is seaward of the current erosion hazard line. In short, this means that approximately 160 m of the trail (from the south eastern extent of the existing seawall almost to the current temporary beach access path) is currently at risk of failure in a significant storm or series of storms.

Currently the beach has a large quantity of sand on it. As such, from the current beach state, there would likely need to be multiple consecutive storms to lower the beach level before a storm would cause significant erosion of the dune scarp.

The erosion hazard map (Figure 2-13) also shows approximately 115 m of the rail trail is seaward of the 10-year erosion hazard line. This section of the trail is behind the existing seawall and, as mentioned previously, the hazard lines for this section of beach were calculated assuming the seawall (already in poor condition with cracks, subsidence and blowouts seen along its length) has failed. If the seawall remains largely intact in the coming years, the erosion hazard may be lower than predicted.

Although outside of the study site of the current project, it should also be noted that between approximately 110 - 140 m SE of the Bourne Creek mouth, there is a dune blowout section at the north end of the existing dune protection which may also pose increased erosion risk to the rail trail.

Table 3-1 Summary of Bass Coast Rail Trail Vulnerability to Erosion Hazard

Beach Section	Bass Coast Rail Trail Vulnerability	Possible Lifetime of Current Configuration
Erosion Hotspot	Extremely Vulnerable	0 – 10 years
Seawall Beach Section	Moderately Vulnerable	10 –? (pending seawall failure)

4 Adaptation Options Assessment

4.1 First Pass Options Analysis

The first pass options assessment was undertaken collaboratively between coastal engineers at BMT and members of the Bass Coast Shire Council. It was undertaken to short list the adaptation measures/options to be investigated further and rule out those which are not feasible/desirable at the site.

Table 4-1 below, outlines a long list of potential coastal adaptation measures identified by coastal engineers at BMT. These are arranged according to the Marine and Coastal Policy hierarchy (DELWP 2020) in order of:

(1) Non – Intervention,

(2) Avoid,

(3) Nature-Based Methods,

(4) Accommodation,

(5) Retreat,

(6) Protect.

A short comment on each option is also given describing the adaptation measure and giving reasons why, or why not the measure is recommended for further assessment. Following this are assessments of the possible options of individual (utilising one adaptation option) and hybrid (utilising multiple adaptation options) coastal adaptation strategies available for Kilcunda.

Table 4-1 Summary of potential coastal adaptation measures. Green highlighted cells signify the option will be assessed further while red highlighted cells signify the measure will not.

Coastal Adaptation Measure	Comment	Shortlist for Further Consideration (Y/N)
1.0 Non – Intervention		
Minimum intervention consistent with public safety	E.g. If beach accesses are undermined, remove them; if the rail trail erodes, fence then close it. This option will be assed further as a baseline from which to compare the outcomes of other adaptation measures.	Y (Base Case)
2.0 Avoid		
Not Applicable	This type of action relates to planning for new uses, development and re-development seeking to avoid placing them in at-risk areas. This project focusses on beach access (cannot be moved landward) and other pre-existing infrastructure, thus this type of action is not relevant.	N

Coastal Adaptation Measure	Comment	Shortlist for Further Consideration (Y/N)
3.0 Nature Based Methods		
Beach Nourishment or Scraping	Beach/dune nourishment involves placing additional sand on the beach sourced from elsewhere (either on the coast or inland). This has recently been used at other (albeit lower wave energy) Victorian sites (e.g. Apollo Bay) where foredune erosion put walking paths, roads and carparks at risk. Beach Scraping involves moving sand from low on the beach to higher up towards the dune base for short term protection.	Y
Wet Sand Fencing	Wet Sand fencing as used recently at Inverloch is of limited effectiveness in high wave-energy environments. At Kilcunda, this measure would be of limited effectiveness and we do not consider that it would prevent further erosion of the Bass Coast Rail Trail.	N
Dune Management	E.g. Safety fencing at toe of dune and re-vegetation of foredune for stability. This measure may be used in concert with other measures such as beach nourishment. Due to the high scarps and continued erosion, this measure on its own however, would not likely be sufficiently effective to manage dune erosion at Kilcunda.	Y
4.0 Accommodate		
Construct or modify beach access structures for increased footing stability.	E.g. Pile any new access structure footings deeper and use more stable footing technology (e.g. screw piles). This measure would allow access stair structures to withstand shoreline erosion cycles and still be present when returning sand again increases beach level.	Y
Construct a piled platform for the rail trail	A piled structure could accommodate some erosion beneath the trail. If the dune continued to recede this could lead to an elevated walking trail 10m or more above the beach and would require a large and complex structure. This is may not considered a practical adaptation option due to the likely cost.	N
5.0 Retreat		

Coastal Adaptation Measure	Comment	Shortlist for Further Consideration (Y/N)
Continued landward retreat of rail trail atop the dune crest	This measure would continue the current management method of incrementally shifting the rail trail landward on the dune crest until it could retreat no further. This is likely a good immediate – short-term option.	Y
Re-Routing the Rail trail behind the dune	When there is no longer room to maintain the rail trail on the dune crest this option would re-route the trail from a point NW of the erosion hotspot zone, down behind the dune system, around the hotspot area and then join back up with the existing trail alignment where it turns landward from the coast in the SE.	Y
6.0 Protect **Immediate – Mid Term Protection**		
Rock Bags (temporary)	This measure would use rock bags to temporarily armour the toe of the dune scarp while more long-term options are investigated.	Y
Geo Bag Revetment	Geotextile sand containers have been used in diverse erosion situations along many Australia beaches as temporary revetment protection structures.	Y
Longer Term Protection		
Engineered Revetment/seawall	Long term engineered coastal protection could take the form of a revetment or seawall. This would protect the coast for a period of time from storm erosion and shoreline recession under future sea level rise scenarios and could extend from the end of the existing structure to the SE end of the beach. A revetment structure could be a 2-layered structure, or rock armouring with less attention to rock placement.	Y
Groynes and Beach Nourishment	This option would effectively create headlands to capture sand on the beach. Although this option has been implemented at various other sites on the Victorian coast because there is no clear net sediment transport direction of any appreciable volume, there is a low certainty that any groyne structure would have an appreciable impact on beach width. It would also be very expensive and would significantly impact the local coastal processes, potentially leading to erosion in other areas.	N

Coastal Adaptation Measure	Comment	Shortlist for Further Consideration (Y/N)
Offshore Breakwaters	This option would create offshore rock breakwaters to attenuate wave energy before it impacts the Kilcunda Surf Beach site. This option would be extremely expensive and would have a large impact on the local coastal processes, potentially causing significant erosion in other areas.	N

4.2 Coastal Adaptation Strategy Options Assessment

4.2.1 Option 1 – Non-Intervention/Minimal Intervention Consistent with Public Safety

This option is essentially the 'Do Nothing' approach and is included as a comparison to the effectiveness of the other options. This approach uses a risk management approach which would decommission assets when they become dangerous.

At Kilcunda, the key asset at risk is the Bass Coast Rail Trail. It is currently at risk over a length of 150 m (Figure 2-13) and has safety fencing along the dune crest in this area. As the erosion advances, the safety fencing should be moved back, at least 2 m from the edge of the erosion escarpment. This would require closure of the rail trail in the near future.

Figure 4-1 Fencing of the Bass Coast Rail Trail at the Dune Crest.

Table 4-2 Assessment of Option 1 – Minimal Intervention Consistent with Public Safety

Technical feasibility/effectiveness	Strongly Negative: This option would not be effective at protecting the Rail Trail. Although it is technically feasible, it is not advised to protect the values of the area.
Timeframe	Strongly Negative: the rail trail is currently at risk of failure and would need to close in the short term
Relative cost	Strongly Positive – minimal cost
Social/economic impact	Strongly Negative: the loss of the rail trail would have a considerable negative impact on recreational opportunities and visitation. Loss of tourists may also negatively impact local businesses in the area.
Impact on coastal processes and environment	Positive: This option would have no impact on coastal processes or on the local environment.
Governance, alignment with VMACP	Positive: Non-Intervention is in line with the VMACP.

This option is not recommended because it fails to maintain the continuity of the rail trail, the most important recreational asset in the study area. Although there is no official management plan for the site, it is our understanding that maintenance of the trail is a priority for Council.

Because this option is not recommended for Kilcunda, a detailed cost analysis is not undertaken here. Nominally however, this option would include regular (e.g. monthly) evaluations of the site by council workers to identify at-risk areas and/or asset failure. Where necessary, fencing should also be installed. This could cost approximately $10,000 - $20,000 per year.

4.2.2 Option 2 – Retreat the Bass Coast Rail Trail on the Dune Crest

This option involves moving 160m of the Bass Coast Rail Trail a short distance landward on the dune crest. The dune crest is narrow and there is only room to move the trail approximately 6m landward before encountering the back slope of the dune. This allows the coastline position to naturally fluctuate while the Bass Coast Rail Trail is modified to accommodate a limited degree of erosion. This would position the trail outside of the current erosion hazard zone, but it would still be inside the 2031 erosion hazard zone (Figure 4-2). This option does not include replacing beach access stairs from the carpark as the dune is expected to experience continued erosion making construction and maintenance of stairs difficult. This option may be effective for 5-10 years, after which time dune erosion will likely make it necessary to take further action.

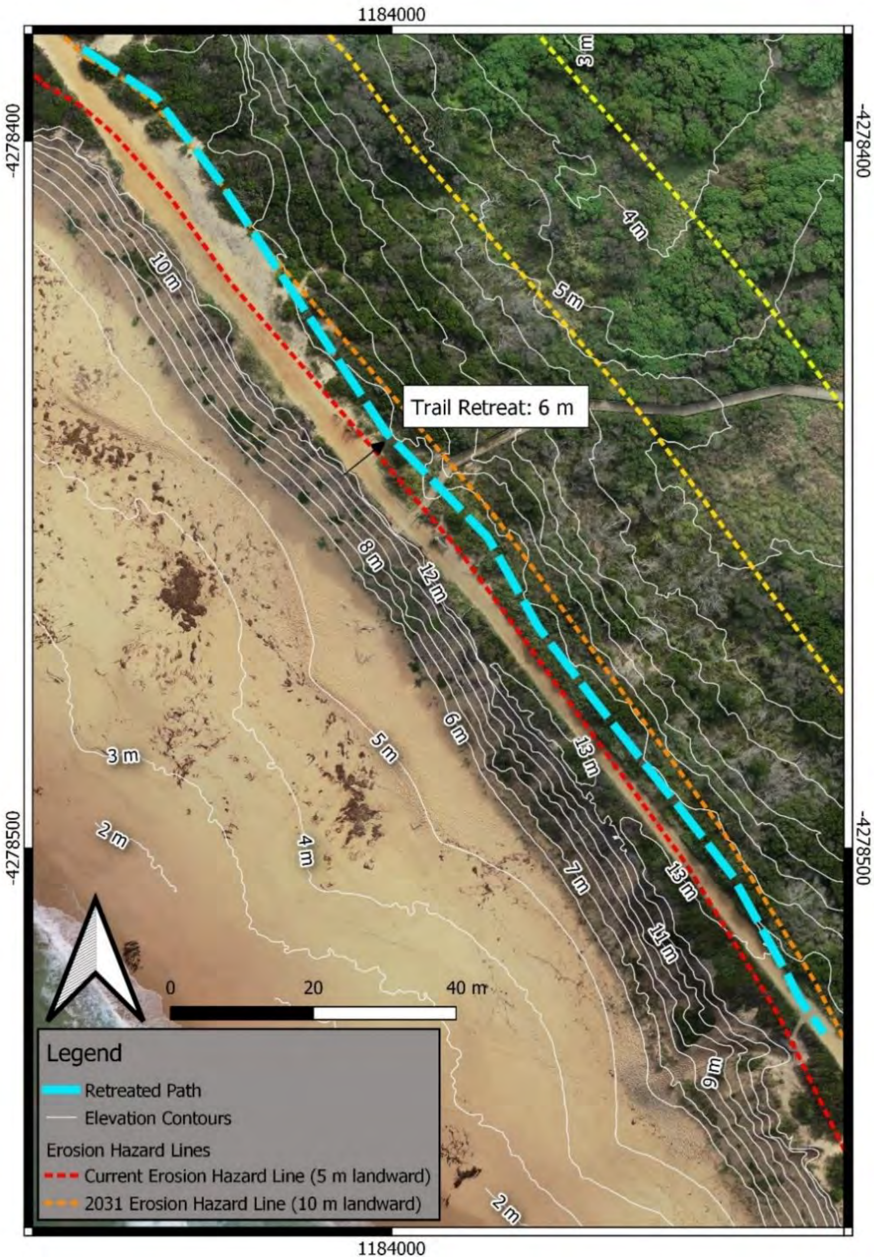

Figure 4-2 Map of Possible Retreated Rail Trail Orientation

Table 4-3 Assessment of Option 2 – Retreat of the Bass Coast Rail Trail on Dune Crest.

Technical feasibility/effectiveness	Positive: medium level of intervention required to move the trail out of the zone of immediate risk.
Timeframe	Positive: short: medium term solution. This option may be effective for 5-10 years. However, after this time the trail may be threatened by erosion again.
Relative cost	Positive: relatively minor cost
Social/economic impact	Positive: this would maintain access along the trail and minimise risk to trail users in the short term, but does not reinstate the beach access.
Impact on coastal processes and environment	Neutral: This option would have no impact on coastal processes. Some clearing of dune crest vegetation required the new trail route, however there is no known sensitive vegetation in this area – should be confirmed by vegetation assessment.
Governance, alignment with VMACP	Positive: Retreat of assets where possible is in line with the VMACP.

Table 4-4 Cost Estimate for Option 2

	Item	Unit	Qty	Rate	Total
1.0	**Site establishment**				
	Site establishment	Item	1	$5,000 - $10,000	$5,000 - $10,000
2.0	**Works**				
	Construct Path	m	160	$350 - $450	$56,000 - $72,000
	Fencing	m	160	$50 - $100	$8,000 - $16,000
3.0	**Allowances**				
	Approvals and permits	%	10%	-	$6,900 - $9,800
	Design fees	%	10%	-	$6,900 - $9,800
	Engineering and supervision	%	3%	-	$2,070 - $2,940
	Contractor overhead	%	5%	-	$3,450 - $4,900
	Contingency	%	15%	-	$10,350 - $14,700
	Total Costs (excluding GST)				$98,500 - $140,000

Trigger Point – The point in time this option should be considered is when the dune erosion escarpment is within 5 m (ARI 10-year potential storm erosion) of the Rail Trail edge. This trigger point has already been reached.

4.2.3 Option 3 – Re-Route the Bass Coast Rail Trail Behind the Dune

This option re-routes the Bass Coast Rail Trail off the dune crest, behind the dune and around the erosion hotspot. After heading past both the toilet block and carpark, the trail would then join back up with the existing trail alignment on either side of the erosion hotspot (Figure 4-3). This would move the trail landward of the 2071 erosion hazard line and increase the safety of trail users. No beach access directly from the carpark is included in this option, however new beach access is provided 150m to the NW at the point where the re-routed trail joins to the current trail alignment. This option may be effective for 50 years or more.

If the existing seawall fails along the beach section to the north, the rail trail may quickly become threatened by erosion. If this occurs, this option may only represent 'phase 1', with subsequent phases required to shift the Rail Trail off the dune crest along the northern part of the beach.

Further assessment of this option against key criteria is summarized below in Table 4-3 and Table 4-6.

Figure 4-3 Map of possible re-routed rail trail configuration.

Table 4-5 Assessment of Option 3 – Retreat of the Bass Coast Rail Trail behind Dune

Technical feasibility/effectiveness	Strongly Positive: medium level of intervention required to move the trail behind the dune. This option will be effective at moving the rail trail out of the zone of immediate and medium-term risk.
Timeframe	Strongly Positive: medium – long term solution. This option may be effective for more than 50 years, depending on the new trail configuration and rate of erosion.
Relative cost	Neutral – Moderate Cost
Social/economic impact	Positive: this would maintain all current values of the area and minimise risk to trail users in the short term.
Impact on coastal processes and environment	Neutral: This option would have no impact on coastal processes. Some clearing of dune crest vegetation required the new trail route, however there is no known sensitive vegetation in this area – should be confirmed by vegetation assessment.
Governance, alignment with VMACP	Positive: Retreat of assets where possible is in line with the VMACP.

Table 4-6 Cost Estimate for Option 3

	Item	Unit	Qty	Rate	Total
1.0	**Site establishment**				
	Site establishment	Item	1	$5,000 - $10,000	$5,000 - $10,000
2.0	**Works**				
	Path	m	425	$350 - $450	$148,750 - $191,250
	Fence	m	50	$50 - $100	$2,500 - $5,000
	Beach Access Stairs	Item	1	$10,000 - $14,000	$10,000 - $14,000
3.0	**Allowances**				
	Approvals and permits	%	10%	-	$16,625 - $22,025
	Design fees	%	10%	-	$16,625 - $22,025
	Engineering and supervision	%	3%	-	$4,988 - $6,608
	Contractor overhead	%	5%	-	$8,313 - $11,013
	Contingency	%	15%	-	$24,938 - $33,038
	Total Costs (excluding GST)				$237,500 - $315,000

Trigger Point – The point in time this option should be considered is when the dune erosion escarpment is within 5 m (ARI 10-year potential storm erosion) of the edge of the then-current trail alignment. This trigger point has already been reached.

4.2.4 Option 4 – Nature-Based Beach and Dune Nourishment

This option would place sand on the beach and dune in areas suffering from erosion (Figure 4-4). This re-builds the beach and dune and protects assets from further erosion. At Kilcunda, this sand would likely be sourced from a 'borrow area' elsewhere on the beach (e.g. at the bar between the Bourne Creek Entrance and the ocean). By itself, sand nourishment may only last for weeks – months, depending on how sand is naturally transported through the system. At Kilcunda, due to the high exposure to the large wave climate, sand nourishment may only be effective for a very short time frame and would need to be repeated regularly. By maintaining the dune position, this option allows for the reinstatement of beach access stairs from the carpark.

Dune management, such as fencing, planting and matting, is often used to increase the stability of nourished material against wave attack. This would not likely be effective at Kilcunda due to the high wave climate (Morris et al. 2021), thus it is not suggested in this option.

Further assessment of this option against key criteria is summarized below in Table 4-7 and Table 4-8.

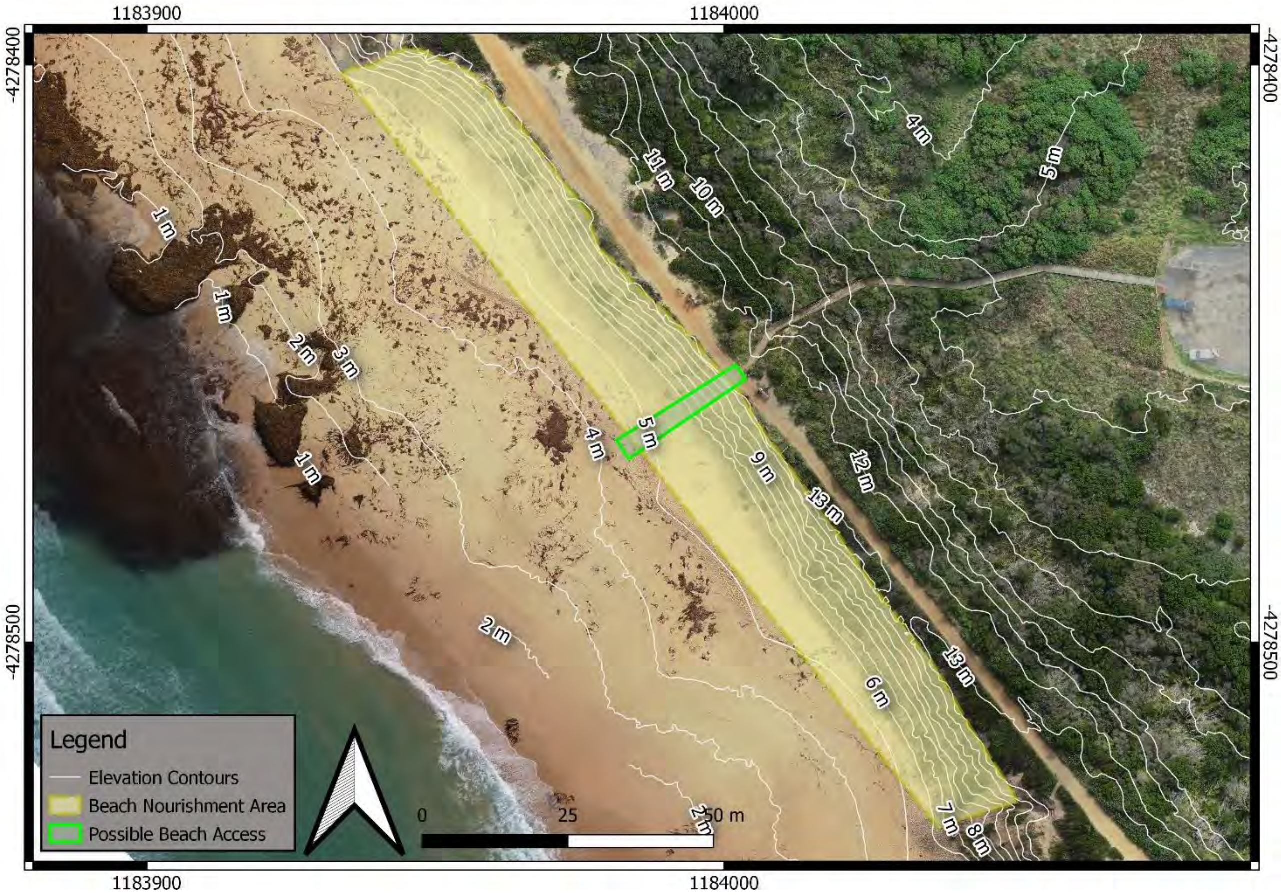

Figure 4-4 Possible Beach Nourishment - Kilcunda

Table 4-7 Assessment of Option 4 – Beach/Dune Nourishment

Technical feasibility/effectiveness	Negative: Although technically feasible, this option would require ongoing nourishment to be effective at protecting the Rail Trail from storm erosion or coastal recession.
Timeframe	Strongly Negative: According to current estimates (5 m of dune crest recession in an ARI10 year storm – Section 0) all nourishment material may be swept away in one storm.
Relative cost	Negative – on-going cost of repeating nourishment approximately annually
Social/economic impact	Strongly Positive: this would maintain all current values of the area and improve access to beach.
Impact on coastal processes and environment	Negative: This option takes sand from a 'borrow area' on the beach, disrupting the natural sediment flow and potentially causing other erosion issues.
Governance, alignment with VMACP	Neutral: Sand nourishment is in middle of the VMACP hierarchy as a soft engineered protection/nature-based solution.

Table 4-8 Cost Estimate Option 4

	Item	Unit	Qty	Rate	Total
1.0	**Site establishment**				
	Site establishment	Item	1	$5,000 - $10,000	$5,000 - $10,000
2.0	**Nourishment**				
	Sand	m^3	6000	$15 - $30	$90,000 - $180,000
	Access Structures	Item	1	$10,000 - $14,000	$10,000 - $14,000
3.0	**Allowances**				
	Approvals and permits	%	10%	-	$10,500 - $20,400
	Design fees	%	10%	-	$10,500 - $20,400
	Engineering and supervision	%	3%	-	$3,150 - $6,120
	Contractor overhead	%	5%	-	$5,250 - $10,200
	Contingency	%	15%	-	$15,750 - $30,600

Trigger Point – The point in time this option should be considered is when the dune erosion escarpment is within 5 m (ARI 10-year potential storm erosion) of the edge of the then-current trail alignment. This trigger point has already been reached.

4.2.5 Option 5 – Short-Term Protection of Dune

This would use short term protection methods (e.g. geotextile sandbags or rock bags) along the 160 m of dune toe where the Rail Trail is within the immediate hazard zone. This is an emergency option to minimise erosion of the dune and protect the rail trail (Figure 4-6). These protection options are only intended to be short term, intermediate measures before longer term solutions (e.g. protection or retreat) can be designed and implemented.

Rock Bags are made from polyester mesh, are filled on site and then placed using a crane. This option is not advised due to the lack of access to the dune crest and toe for filling and placement processes.

Geotextile sandbags would be more favourable compared to rock bags here. Sandbags are made from woven geotextile fabric and come in 0.75 m^3 and 2.5 m^3 (larger bags would likely be used here due to the high wave climate). They would be filled with beach sand and then stacked in layers to construct a tired wall at the dune toe in the erosion hotspot. Sandbags can shift slightly under wave impact because of their flexibility and still maintain the structural integrity of the wall (Hornsey et al. 2011). Sandbags walls can be expensive to construct (similar to a rock revetment per m), but with correct design may last up to 10 years at Kilcunda. This option may be used in concert with retreating the Rail Trail on the dune crest to potentially increase the lifetime of that option, or it could be used while more permanent protection is designed. Beach access stairs could be constructed from the carpark over the short-term protection, depending on the desired deployment timeframe. Short-term protection would not likely lower the risk to trail users by itself due to the existing vertical erosion scarp still at risk of slumping and eroding the path.

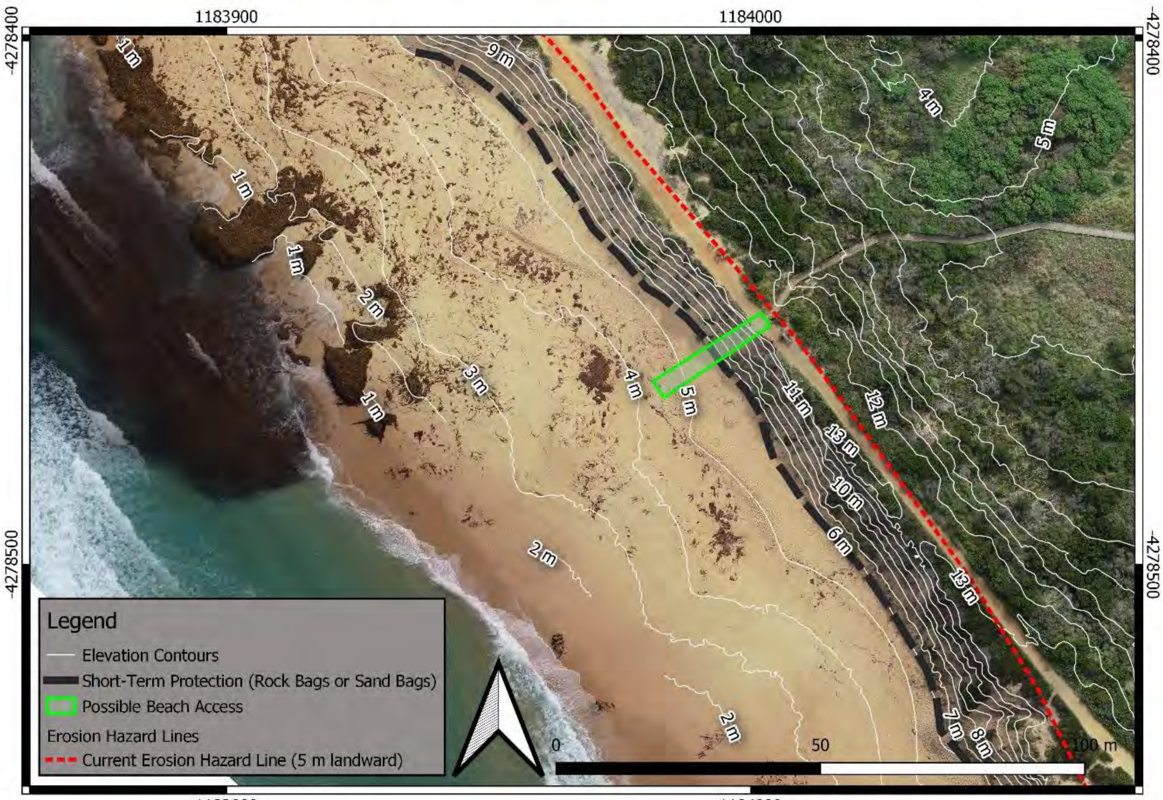

Figure 4-5 Short Term Protection Placement

Table 4-9 Assessment of Option 5 – Short Term Protection

Technical feasibility/effectiveness	Neutral: This option is technically feasible but complex with construction required on the intertidal beach
Timeframe	Negative: A sand bag construction may be effective for the immediate term while other options are made ready.
Relative cost	Negative: Relatively expensive for a short erm measure
Social/economic impact	Neutral: Would maintain current values of the rail trail and minimise risk to trail users in the short term while other options are planned. However a sandbag revetement could cause beach scour, lowering the beach level and reducing the available beach area.
Impact on coastal processes and environment	Negative: A sandbag wall would have a considerable impact on local coastal processes, causing sediment lockup and potential beach lowering and end scour.
Governance, alignment with VMACP	Negative: Protection is only in line with the VMACP when it can be demonstrated that other options are not feasible

Table 4-10 Cost Estimate Option 4

	Item	Unit	Qty	Rate	Total
1.0	**Site establishment**				
	Site establishment	Item	1	$5,000 - $10,000	$5,000 - $10,000
2.0	**Works**				
	Protection Installation	m	160	$7,000 - $10,000	$1,120,000 - $1,600,000
	Access Construction	Item	1	$10,000 - $14,000	$10,000 - $14,000
3.0	**Allowances**				
	Approvals and permits	%	10%	-	$113,500 - $162,400
	Design fees	%	10%	-	$113,500 - $162,400
	Engineering and supervision	%	3%	-	$34,050 - $48,720
	Contractor overhead	%	5%	-	$56,750 - $81,200
	Contingency	%	15%	-	$170,250 - $243,600
	Total Costs (excluding GST)				$1,623,000 - $2,322,500

Trigger Point **–** The point in time this option should be considered is when the dune erosion escarpment is within 5 m (ARI 10-year potential storm erosion) of the edge of the Rail Trail. This trigger point has already been reached.

4.2.6 Option 6 – Protection with Dune Nourishment

This option would construct a rock revetment structure at the toe of the dune to protect it from further erosion and maintain the values surrounding the Bass Coast Rail Trail. Initially, the dune in the erosion hotspot would be nourished, moving the dune toe seaward until it matches the dunes to the NW. A rock revetment structure would then be constructed at the base of this nourished dune as a continuation of the existing seawall structure to the NW. The new protection would extend SE past the end of the erosion hotspot and finish in an area where the rail trail is a sufficient distance inland and would be out of the potential end scour hazard zone (Figure 4-6). The nourished dune would be planted with native plants to minimise wind-erosion of the area. Beach access stairs could be constructed over the dune and revetment to maintain formal beach access.

This sort of protection strategy is designated as an 'option of last resort' in the Victorian Marine and Coastal Policy (DELWP 2020) because it is inherently expensive, may shift the erosion issue to other areas and would have considerable impact on coastal processes. It also may have negative impacts on coastal processes with lowering of the beach level in front of the revetment and end scour.

It is not likely that this option will be needed soon at Kilcunda due to the relative ease of retreating the Bass Coast Rail Trail. This option is, however, a valid way of defending the coastline from erosion and, in a future case where erosion may threaten more valuable assets, this may become the best option. With good design, this strategy may protect coastal assets for many years into the future.

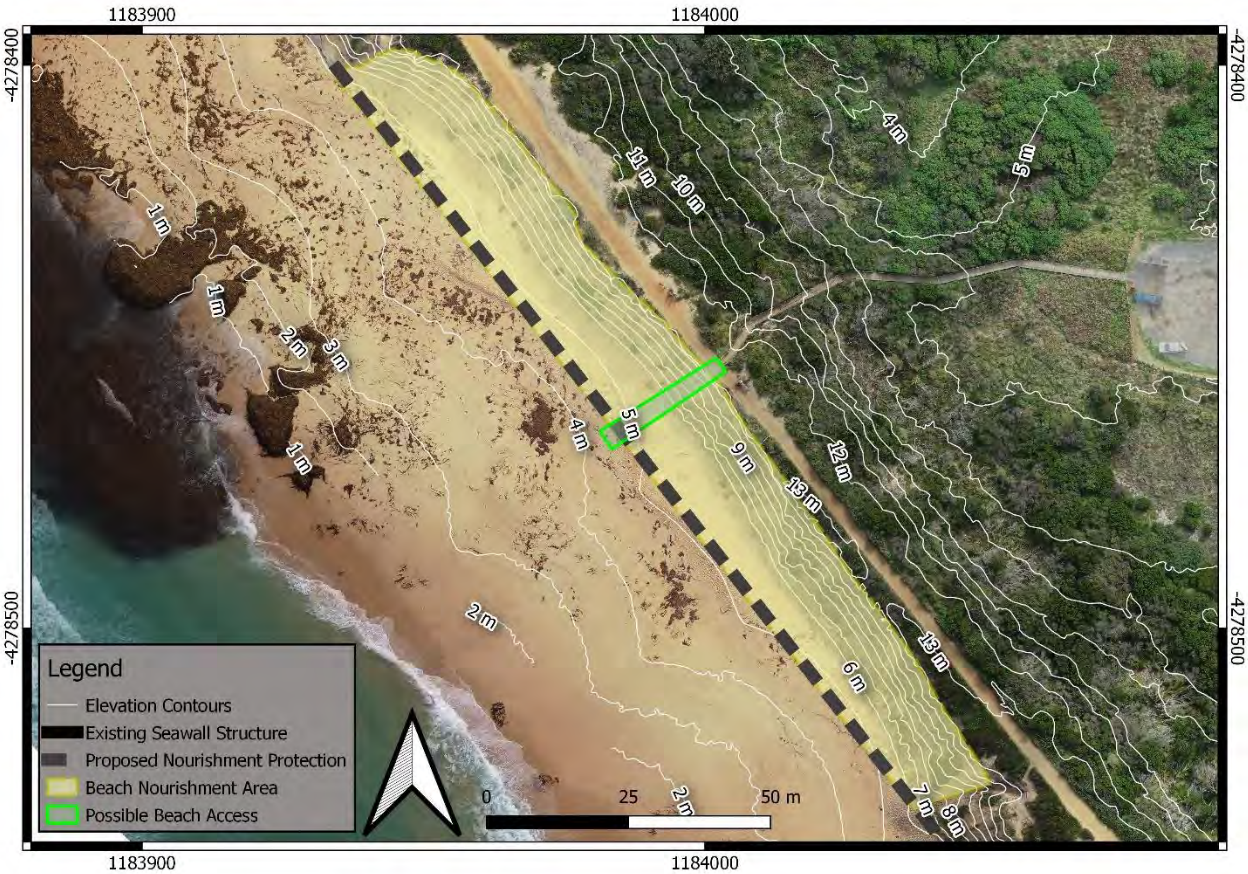

Figure 4-6 Dune Protection with Nourishment

Table 4-11 Assessment of Option 5 – Beach/Dune Nourishment and Protect

Technical feasibility/effectiveness	Positive: This option is technically feasible with many recent similar projects on the Great Ocean Road and throughout Australia, but construction is complex and disruptive
Timeframe	Strongly Positive: Good design could see this strategy remain effective for more than 50 years.
Relative cost	Strongly Negative: Very expensive
Social/economic impact	Neutral: Would maintain current values of the rail trail and minimise risk to trail users in the short term while other options are planned. However a revetement could cause beach scour, lowering the beach level and reducing the available beach area
Impact on coastal processes and environment	Negative: A rock revetment would have a considerable impact on local coastal processes, causing sediment lockup and potential beach lowering and end scour.
Governance, alignment with VMACP	Negative: The VMACP includes protect options but only as an ‘option of last resort’. At Kilcunda, there are effective options which should be used before protection.

Table 4-12 Cost Estimate for Option 6

	Item	Unit	Qty	Rate	Total
1.0	**Site establishment**				
	Site establishment	Item	1	$5,000 - $10,000	$5,000 - $10,000
2.0	**Works**				
	Nourishment	m^3	6000	$15 - $30	$90,000 - $180,000
	Revetment	m^3	225	$6,000 - $10,000	$1,350,000 - $2,250,000
	Access Structures	Item	1	$10,000 - $14,000	$10,000 - $14,000
3.0	**Dune Management**				
	Plants	item	11720	$1 - $2	$11,720 - $23,440
	Coir Logs	m	160	$30 - $35	$4,800 - $5,600
3.0	**Allowances**				
	Approvals and permits	%	10%	-	$147,152 - $248,304
	Design fees	%	10%	-	$147,152 - $248,304
	Engineering and supervision	%	3%	-	$44,146 - $74,491
	Contractor overhead	%	5%	-	$73,576 - $124,152
	Contingency	%	15%	-	$220,728 - $372,456
	Total Costs (excluding GST)				$2,104,500 - $3,550,500

Trigger Point – The point in time this option should be considered is when either available retreat option (Option 2 and 3) has reached the end of its effective lifetime.

5 Adaptation Pathways and Recommendations

5.1 Pathways

The VMACP (DELWP 2020) defines a pathways approach to decision-making as inclusive of the following aspects,

- A comprehensive list of all available and relevant management options,
- A list of thresholds or triggers for when new decisions need to be made.

After identification of these, different possible pathways of management action can be mapped over time. These pathways are defined by certain decision points when land managers will need to change the management strategies they employ because of increased risk from coastal hazards. These points are defined by the identified trigger values.

As outlined above, there are 5 possible management strategy options for Kilcunda, all with relevant trigger values for their implementation. These are,

- Option 1 – Non-Intervention (Not Recommended)
- Option 2 – Retreat the Bass Coast Rail Trail on the Dune Crest
  - Trigger Point – when the dune erosion escarpment is within 5 m of the current trail edge.
- Option 3 – Re-Route the Bass Coast Rail Trail behind the dune
  - Trigger Point – when the dune erosion escarpment is within 5 m of the edge of the then-current trail alignment.
- Option 4 – Nature Based Beach and Dune Nourishment
  - Trigger Point – when the dune erosion escarpment is within 5 m of the trail edge in any alignment.
- Option 5 – Short-Term Protection of Dune
  - Trigger Point – when the dune erosion escarpment is within 5 m of the trail edge in any alignment.
- Option 6 – Beach/Dune Protection and Nourishment
  - Trigger Value – when either available retreat option (Option 2 and 3) has reached the end of its effective lifetime

It is important to note that the trigger value for Option 2, 3, 4 and 5 have already been reached/exceeded. This means that land managers are currently at a decision point on how to proceed with future management of the site.

It should also be noted that the options in this study are specifically related to the erosion hotspot area. If the existing seawall fails (possible in the short- to mid-term), this should trigger a similar adaption options assessment for that zone (options for this would be very similar to this study).

Utilising these options and trigger values, some possible pathways for coastal adaptation at Kilcunda have been constructed. These are outlined below and summarized in Figure 5-1.

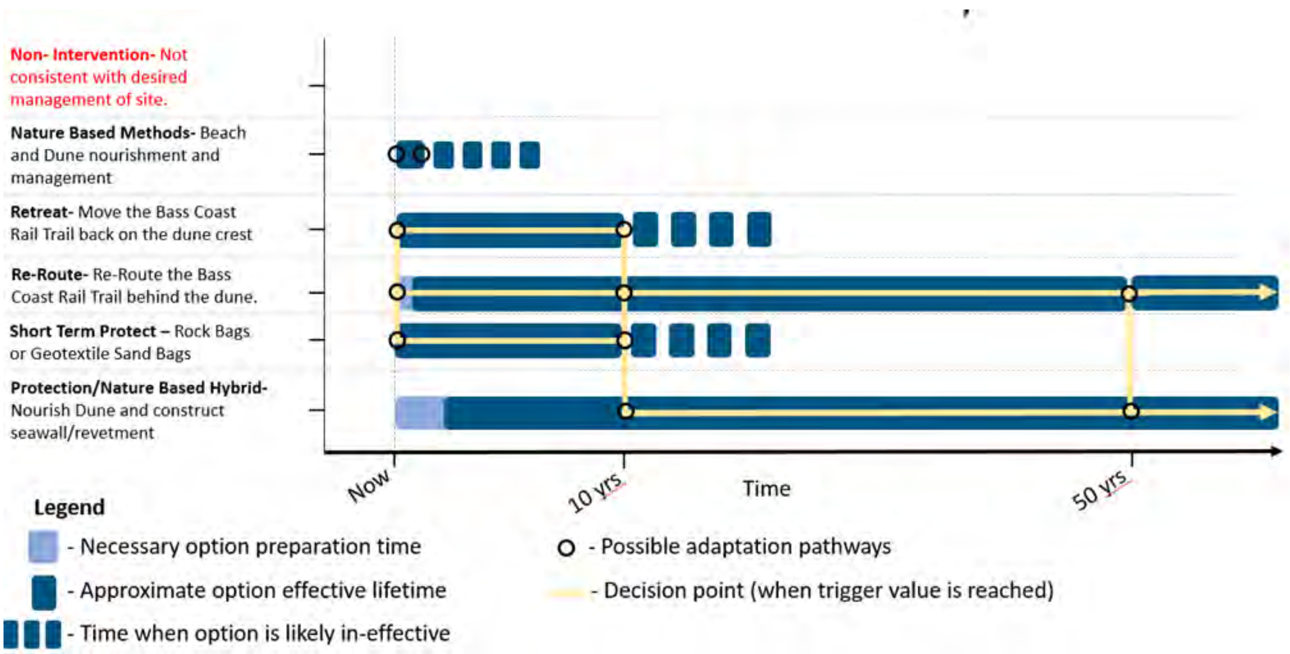

Figure 5-1 Possible Adaptation Pathways – Kilcunda

5.1.1 Pathway Option 1 – Staged Retreat

(1) Retreat the Bass Coast Rail Trail as far as possible while remaining on the dune crest (with or without short-term protection).

(2) When the erosion scarp is within 5 m of the retreated trail edge (possibly 0 – 10 years), re-route the Bass Coast Rail Trail down, behind the dune (Figure 4-3).

(3) In the future (possibly 50 years or more) if erosion again threatens the trail, consider further retreat, protection or other options for coastal defence.

5.1.2 Pathway Option 2 – Rapid Retreat

(1) Immediately re-route the Bass Coast Rail Trail behind the dune.

(2) In the future (possibly 50 years or more) if erosion again threatens the trail, consider further retreat, protection or other options for coastal defence.

5.1.3 Pathway Option 3 – Retreat then Protect

(1) Retreat the Bass Coast Rail Trail as far as possible while remaining on the dune crest (with or without short-term protection).

(2) When erosion again threatens the Rail Trail, construct a revetment at the dune toe to protect the crest alignment of the trail.

5.2 Recommendations

It is recommended that Pathway Option 1 is utilised at Kilcunda due to the relative ease of immediately moving the Rail Trail on the dune crest which would maintain community values surrounding the trail. The further re-routing of the Rail Trail in this option is much cheaper than constructing a revetment and would be effective over a similar time frame.

The next steps for this option would involve preparing concept designs to confirm engineering requirements and cost estimates for both the initial trail retreat and the eventual trail re-routing. This will save time in future when the decision point is reached at the end of the effective lifetime of the initial trail retreat, allowing immediate implementation of the re-routing option rather than needing to close the trail while construction designs are drawn up.

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