# Report

## Cowes East Foreshore: Erosion Management Options

Bass Coast Shire Council

08 August 2018

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# GLOSSARY AND DEFINITIONS

| | |
|---|---|
| AHD | Australian Height Datum. 0 m AHD approximately corresponds to mean sea level. |
| AEP | Annual Exceedance Probability: The measure of the likelihood (expressed as a probability) of an event equalling or exceeding a given magnitude in any given year. |
| Astronomical tide | Water level variations due to the combined effects of the Earth's rotation, the Moon's orbit around the Earth and the Earth's orbit around the Sun. |
| Exceedance probability | The probability of an extreme event occurring at least once during a prescribed period of assessment is given by the exceedance probability. The probability of a 1 in 100 year event (1% AEP) occurring during the first 25 years is 22%, during the first 50 years the probability is 39% and over a 100 year asset life the probability is 63%. |
| Fluvial | Geological term to describe sediments which are derived from a river environment. |
| HAT | Highest Astronomical Tide: the highest water level that can occur due to the effects of the astronomical tide in isolation from meteorological effects. |
| Holocene | Geological epoch beginning approximately 12,000 years ago. It is characterised by warming of the climate following the last glacial period and rapid increase in global sea levels to approximately present-day levels. |
| Hydro-isostasy | Impact of addition or loss of water on the earth surface elevation. |
| Lacustrine | Geological term to describe sediments which are derived from a lake environment. |
| MHHW | Mean Higher High Water: the mean of the higher of the two daily high waters over a long period of time. When only one high water occurs on a day this is taken as the higher high water. |
| MHWS | Mean High Water Springs: the height of MHWS is the average, throughout a year when the average maximum declination of the moon is 23.5°, of the heights of two successive high waters during those periods of 24 hours when the range of the tide is greatest. Used when semi-diurnal tides are present. |
| MSL | Mean Sea Level: the long-term average level of the sea surface. |
| Pleistocene | Geological epoch from 2.5 million to 12,000 years before present that spans the earth's recent period of repeated glaciations and large fluctuations in global sea levels. |
| Quaternary | Geological period beginning approximately 2.6 million years ago and continuing today. |
| Significant wave height | The average of the highest one third of all waves. |
| Spring – Neap tidal cycle | A spring tide refers to the tide during new and full moon conditions. Seven days after a spring tide, the sun and moon are at right angles to each other. This produces moderate tides known as neap tides – meaning that the high tides are a little lower and low tides are a little higher than average. |
| Storm surge | The meteorological component of the coastal water level variations associated with atmospheric pressure fluctuations and wind setup. |
| Storm tide | Coastal water level produced by the combination of astronomical and meteorological (storm surge) ocean water level forcing. |
| Tuffs | Soft and porous rock formation formed by the compaction of volcanic ash. |

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# 1 INTRODUCTION

Water Technology was engaged by the Bass Coast Shire Council to undertake an investigation into management options to mitigate shoreline erosion and storm tide inundation hazards under existing conditions and projected future climate change conditions on the Cowes East – Silverleaves foreshore between Erehwon Point and Observation Point. The extent of the study area is shown in Figure 1-1 below.

It is important to note that while the study area extent displayed in Figure 1-1 was the primary area of interest, areas outside this were considered in the background review of coastal processes and geomorphology for this study.

The key objectives of the project as outlined in the project brief issued by Bass Coast Shire Council were the following:

- Review the effectiveness of the existing shoreline protection works under current conditions and considering future climate change impacts.
- Determine options to provide protection to adjacent public infrastructure assets from shoreline erosion and storm tide inundation hazards under existing conditions and considering future climate change impacts.
- Determine the requirements for repair, maintenance and/or replacement of existing works to provide a level of protection for current conditions and considering climate change impacts.
- Provide recommendations on current and future coastal management options for inundation and erosion of the Cowes East and Silverleaves townships.


**FIGURE 1-1 STUDY AREA**

This report is an updated of an earlier 2011 Water Technology report into coastal hazard management options on the Cowes East Foreshore between Erehwon Point and Sanders Road.

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# 2 BACKGROUND

The problem of beach erosion in the study area first became a concern in the late 1940's. In 1986 a grant was provided to the Phillip Island Conservations Society (PICS) to 'collate all available information on erosion of the northern coastline of Phillip Island and produce a report identifying options for action.' The report titled 'The Problem of Beach Erosion on the North Coast of Phillip Island – A Position Paper,' was undertaken in consultation with Dr Eric Bird, a coastal geomorphologist. The report comprises a significant body of work describing the coastal processes and contemporary shoreline change observed within the study area and much of the findings of this study remain relevant to this day. The report provides a chronology of the works undertaken to limit shoreline erosion from the 1940's to the late 1980's and the relative success, or otherwise, these structures have had in mitigating coastal erosion impacts along the coastline.

While much of the findings from the PICS study remain relevant to today, the following factors are considered to provide impetus to review the coastal erosion and inundation hazard issues in the study area and identify strategic options to mitigate them:

- The age and ongoing deterioration of the existing coastal protection structures.
- Intensification of development along the study area coastline over the last decade.
- The impact of large storm surge events on the study coastline observed over recent years
- New scientific evidence on the expected increase in mean sea levels this century and associated changes to State Government policy requiring the consideration of the impacts of no less than 0.8m of mean sea level increase to 2100.
- Improved data sources for undertaking coastal process assessments via the Future Coast LiDAR data sets
- Changes in coastal policy and strategy in Victoria.

# 3 METHODOLOGY

The methodology outlined in Figure 3-1 has been undertaken to investigate the causes of the existing shoreline erosion and inundation hazards on the study area and to explore management options to mitigate these hazards. This combined the work detailed in the previous 2011 study report along with the review and updates for the present study.

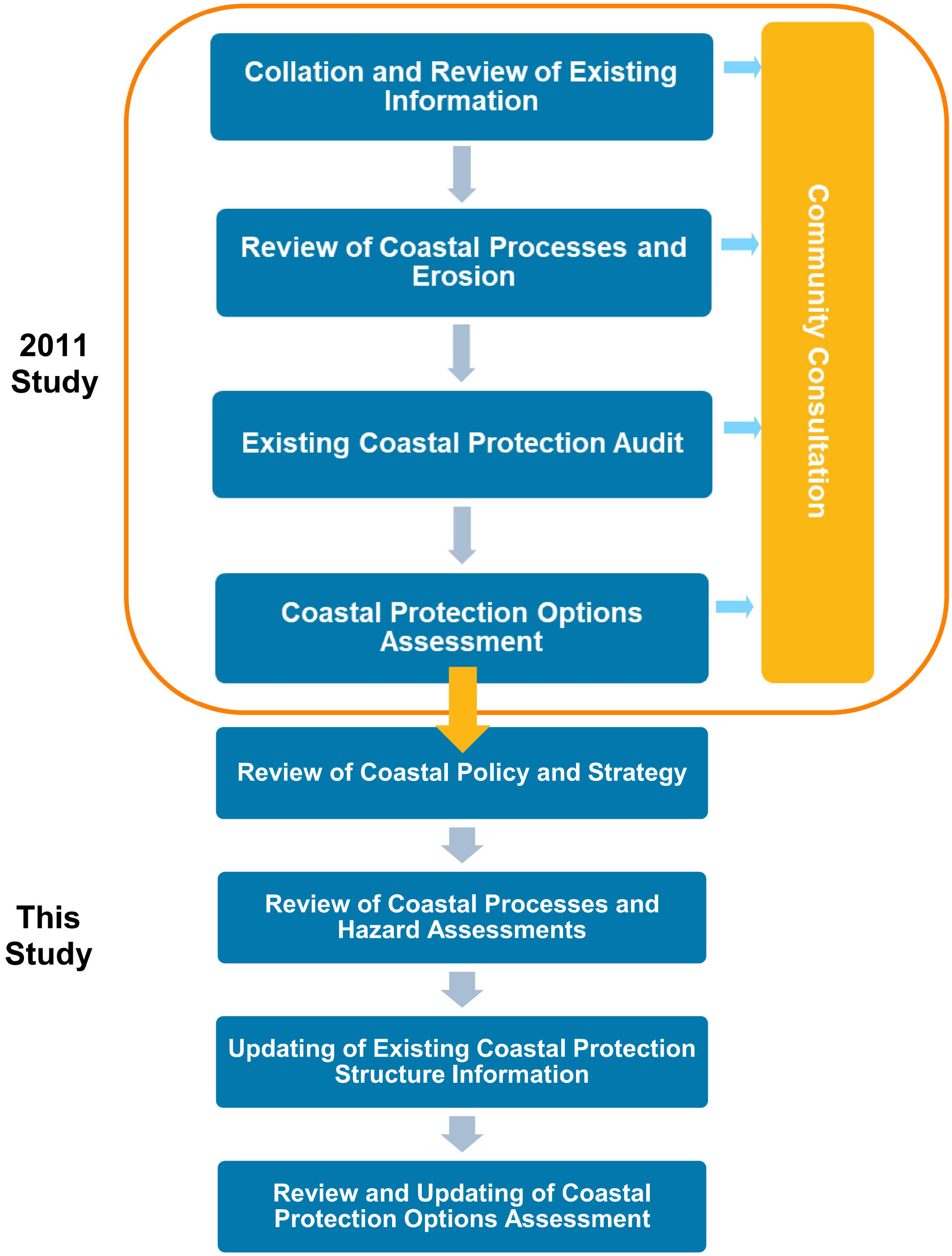


FIGURE 3-1 PROJECT METHODOLOGY

# 4 COMMUNITY CONSULTATION

A series of community information sessions were conducted at Cowes on the 27th October 2010. The sessions were held to inform the community of the study and provide an opportunity for the community to contribute their local knowledge to the study investigations and to voice their opinions in relation to aspects of the study including the impact of existing shoreline protection works on the coastline and preferences relating to any potential future shoreline protection works.

Community members were encouraged to bring historical photos of the study area coastline to the information sessions and these photos were scanned and details of the location and approximate date of the photos were recorded. A selection of these photos has been used to document and compare changes to the coastline to present day within this report. In addition, a summary of community feedback from the sessions and the period before and after, including all community photos have been included in Appendix B. Additional photos taken in July 2018 have also been added to show the current context.

# 5 REVIEW OF COASTAL PROCESSES AND EROSION

## 5.1 Geomorphology

A review of the geomorphologic evolution of the study area is considered to provide important context to the assessment of the erosion issues along the study area and provides important insights into the likely magnitude of the shoreline response that could be expected on this coastline due to projected 21st Century sea level rise. The following sections outline the geomorphologic evolution of the main coastal landforms in the study area. This information is drawn in part from the background information provided by Dr Eric Bird in the PICS study.

### 5.1.1 Regional Context

Four main phases are recognised in the development of Western Port in the Quaternary (Marsden and Mallet, 1974).

- Port Phillip and Western Port sunklands were initiated by downfaulting in the Quaternary. Western Port sunkland is bounded by pronounced fault scarps of the South Gippsland Highlands and Mornington Peninsula. Within the Western Port sunkland, minor faulting forms the uplifted blocks of present day Phillip Island and French Island.
- Extensive fluvial and lacustrine deposition took place within the Western Port sunkland during high sea level phases associated with interglacial periods in the Pleistocene.
- During the last glacial phase and sea level fall, Western Port emerged and the streams draining the sunkland incised deep valleys within Western Port before extending out onto the emerged plain of Bass Strait.
- Approximately 18,000 years ago, the last glacial phase came to an end and sea levels rose rapidly during the early Holocene. Western Port was submerged starting approximately 10,000 years ago. Local sea levels reached their maximum approximately 1.5m higher than present in the mid-Holocene approximately 7,000 years ago. The eastern entrance to Western Port at San Remo is presumed to have opened at approximately this time. A possible combination of climate change and hydro-isostasy resulted in a local sea level fall to approximately present-day sea level 3,000 years ago.

### 5.1.2 Cowes Embayment/Rhyll Inlet

The main features of the geomorphology of the Cowes Embayment/Rhyll Inlet area are displayed below in Table 5-1.

The area between Cowes and Rhyll initially existed as an open embayment that formed during the mid-Holocene when sea levels reached a maximum approximately 1.5 meters higher than present day, some 7,000 years ago. The embayment was backed by sections of wave steepened cliffed coastline where the initial mid-Holocene shoreline intersected outcroppings of Older Volcanics Basalt. The location of the initial mid-Holocene shoreline can be identified by the steep cliff and emerged shore platforms caused by wave action that occur around the margins of present day Rhyll Inlet. Beach ridge systems developed on the gently sloping shorelines of the embayment between the sections of wave steepened cliff coastline. The beach ridge systems subsequently sealed off minor inlets associated with the broader embayment. Rhyll Swamp was the most significant of these areas to be isolated from the broader embayment by beach ridge development. The configuration and orientation of the ridges systems along this mid-Holocene coastline suggest a pattern of wave and or current action that resulted in an east to west longshore transport within this earlier embayment.

Sediment supply from the east coupled with the fall in sea levels initiated the development of a succession of prograding sand spits which extend in an easterly direction from the Older Volcanic Basalt Headland at Erehwon Point. A corresponding succession of tidal inlets developed behind these spits and marine influence was gradually reduced within the embayment. Colonisation by mangroves and saltmarsh trapped and consolidated sediments and prograded the shorelines within Rhyll Inlet such that today the open water area is confined to a relatively small number of tidal channels.

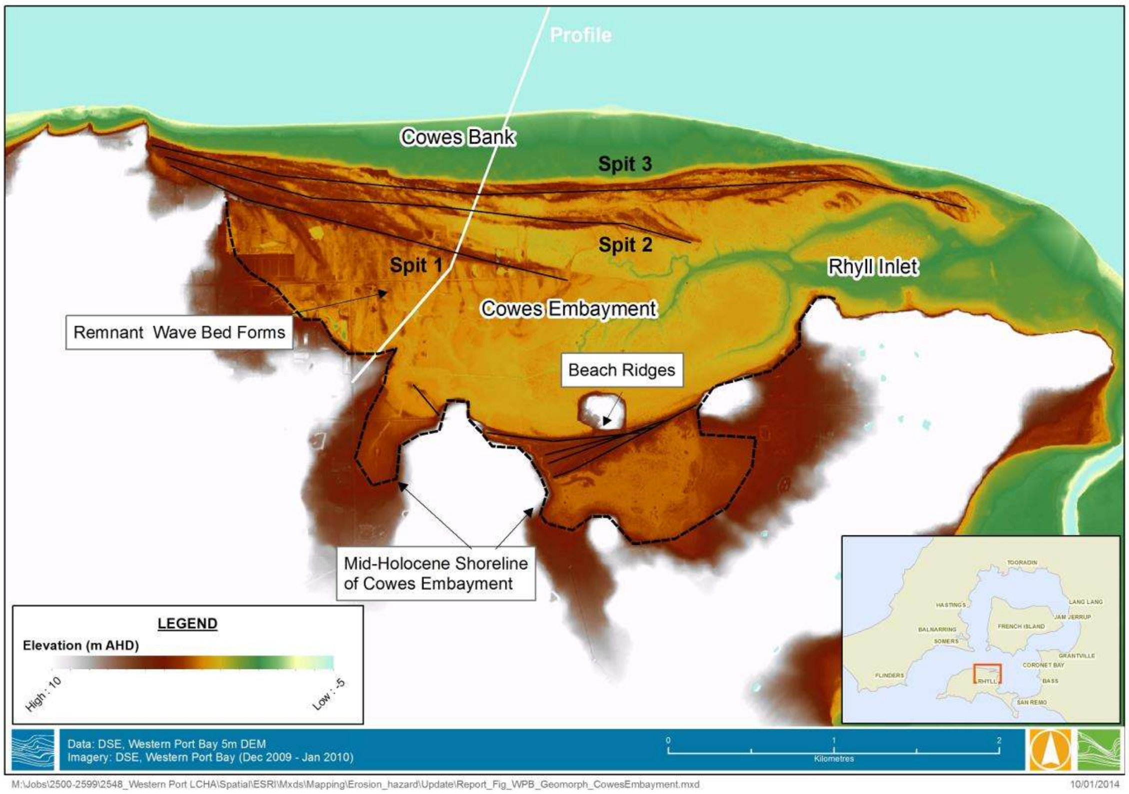


**FIGURE 5-1 GEOMORPHOLOGIC CONTEXT OF STUDY AREA**

## 5.1.3 Silverleaves Spit

The study area shoreline is comprised of the western most end of a compound recurved spit that has built out in an easterly direction from the Older Volcanic basalt headland at Erehwon Point and terminates at Observation Point. The spit has been created by the easterly drifting of calcareous sand from the floor of Bass Strait by prevailing south westerly swell and wind-wave conditions following the Holocene marine transgression that flooded the floor of Western Port approximately 10,000 thousand years ago. Erosion of basalt shore platforms and cliffs to the west of the study area does not produce sandy sediments that add to littoral supply along the study area. Episodic injections of calcerous sand past Erehwon Point migrate along the study area coastline as sand lobes, resulting in patterns of erosion and accretion along the study area.

Evidence of up to three former stages of evolution of the spit are apparent in the morphology with the distill end of these earlier spits still preserved in the lee of the present-day shoreward spit (see Figure 5-1). The earliest spit (spit 1) trends more south easterly and is approximately 3.0km long. A series of small, parallel ridges emanate from the inside edge of the spit orientated in a south-south easterly direction. It is speculated that these ridges are remnants of a sand bar feature caused by wave action across a subtidal sand sheet when this area was an open embayment, potentially similar to sand bar features that exist on the present-day Cowes Bank.

The conditions resulting in the distinct stages of spit evolution along the study area are not entirely clear although they are likely to have been significantly influenced by the fall in sea levels from approximately 1.5 meters higher than present in the mid-Holocene approximately 7,000 years ago. Changes to sediment supply may also have contributed to the observed sequences of spit evolution. It has been speculated that the opening of the eastern entrance to Western Port at San Remo caused changes to the tidal dynamics of Western Port that resulted in stronger easterly flood tide currents (Marsden and Mallet, 1975). Increases in the easterly flood tide currents may have increased the rate of sediment supply along the coastline and assisted in the easterly spit progradation.

Despite the uncertainties in the precise causes of the sequence of spit evolution observed along the study area, it is clear from the morphology preserved in the study area that the position of the coastline has been very dynamic over relatively recent geological history. The alignment of the spit and therefore coastline position is particularly sensitive to either sea level or a combination of sea level and sediment supply and this is considered to have important implications when considering the potential impact of projected future sea level rise on the study area coastline.

## 5.2 Coastal Processes

The following sections summarise the coastal processes currently operating on the study area coastline. Developing an appreciation for the nature and dynamics of the coastal processes that operate on the coastline is considered important to enable informed assessment of the cause of erosion and inundation hazards observed on the coastline and in the consideration of the potential suitability of different shoreline protection options for the study area. Refer to glossary definitions and terminology.

### 5.2.1 Tides

Astronomical tide refers to the rise and fall of the sea surface due to the gravitational attraction between the earth, moon and sun. Water level variations in coastal areas due to the astronomical tide can be reliably predicted provided a reasonable length of continuous water level observations is available. Tidal plane information from a combination of Cowes Pier (where available) and nearby Stony Point, as listed in the Victorian Tide Tables (2017), is presented in Table 5-1.

TABLE 5-1 COWES TIDAL PLANE (VICTORIAN TIDE TABLES 2017), * STONY POINT TIDAL DATA

| Tidal Plane | Level (m AHD) |
|---|---|
| Highest Recorded Tide* | 2 |
| HAT* | 1.62 |
| MHWS | 1.11 |
| MHWN | 0.71 |
| MLWN | -0.59 |
| MLWS | -1.09 |

An estimate of the average net tidal and wind driven currents at Cowes East was developed by extracting simulated tidal and wind driven currents from a hydrodynamic model of Western Port that was simulated over a spring-neap tidal cycle.

As is typical for Western Port, tidal currents are relatively strong, with depth averaged current speeds likely to exceed 0.5m/s (1kt). Surface currents may approach 0.7m/s (1.5kts) on occasions.

### 5.2.2 Storm Tides

The term *storm tide* refers to coastal water levels produced by the combination of astronomical and meteorological ocean water level forcing. The meteorological component of the storm tide is commonly referred to as *storm surge* and collectively describes the variation in coastal water levels in response to atmospheric pressure fluctuations and wind setup.

Melbourne Water has recently updated their guideline for Western Port storm tide levels for the existing and future conditions based on storm tide inundation modelling conducted by Water Technology (Melbourne Water, 2017). As a result, the 1% AEP graduated flood levels both for existing and 2100 conditions have been revised across Western Port. The updated 1% AEP storm tide for existing conditions in the study area based on this assessment is presented in Table 5-2. The 10% AEP storm tide values are based on previous work by the CSIRO (McInnes, 2009).

**TABLE 5-2 EXISTING 10% AND 1% AEP STORM TIDE LEVELS**

| Storm Tide | Level (m AHD) |
|---|---|
| 10% AEP | 1.62 |
| 1% AEP | 2.20 |

### 5.2.3 Wind – Wave Climate

The wind-wave climate along the study area was determined using a spectral wave model of Western Port and wind-wave hindcasting techniques. To undertake the wave hindcast, 30-minute observations of wind speed and direction from Rhyll was obtained for the Bureau of Meteorology for 2007-2009. The wave hindcast was carried out for a three-year period and significant wave heights, peak wave periods and wave directions were extracted from the spectral wave model at a location offshore of Cowes Bank in 5 meters depth of water. The results from the wave hindcast are summarised as seasonal wave rose plots in Figure 5-2. Figure 5-2 shows the following aspects of the wind-wave climate at the study area.

- Wave heights are greatest in winter when larger waves are generated from strong northwest to northerly winds.
- During summer, a larger portion of waves are generated from light to moderate north-east to easterly winds.
- Greater than 80% of the time, the wind-wave climate is calm, i.e. significant wave heights are less than 0.2 meters. This is associated with the northerly aspect of the study area coastline that is sheltered from the prevailing south through to west wind climate.

The more persistent and larger waves from the northwest experienced in winter along the study area compared to summer contribute to the net easterly drift of sediment observed along the coastline.

Small, long period swell waves propagating into Western Port from Bass Strait and refracting into the study area coastline are occasionally observed however their influence on the coastline and potential sediment transport rates are considered negligible.

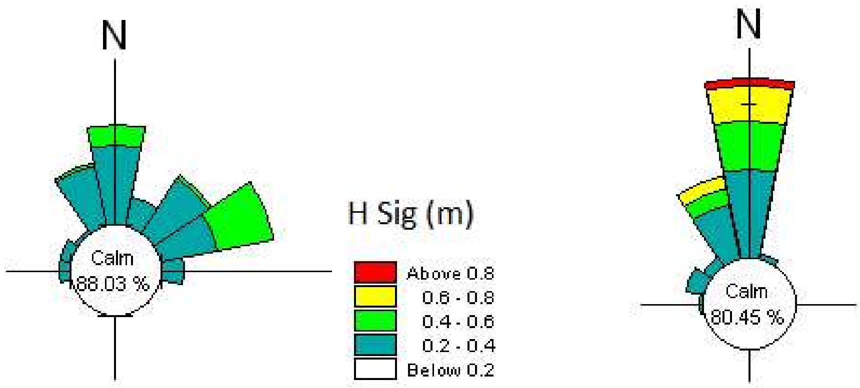


FIGURE 5-2 COWES SIGNIFICANT WAVE HEIGHT ROSES. SUMMER LEFT AND WINTER RIGHT

## 5.2.4 Sediment Transport Processes

The following summary of sediment transport processes in Western Port, relevant to the study area is based on work undertaken for the Western Port Local Coastal Hazard Assessment (Water Technology, 2014).

### 5.2.4.1 Sandy Spit Shorelines

The spatial extent of unconstrained sandy shorelines in Western Port is relatively limited. This is both a function of the geologic setting of Western Port which (apart from the northern shorelines) results in relatively bold coastal relief, and the lithology of the cliffed shorelines which yields little beach material when eroded.

Unconstrained sandy shorelines are limited in extent within Western Port and include the shoreline between Cowes and Rhyll Inlet. These landforms comprise the terminal sediment sinks resulting from the longshore drifting of sediment along this shoreline. These landforms are therefore young, having only come into existence following the Holocene marine transgression approximately 10,000 years ago. They are also exceptionally dynamic, and their geomorphology reveals evidence of rapid changes associated with variations in sea level and sediment supply (Marsden, Mallett and Donaldson, 1979).

### 5.2.4.2 Key Processes and Dynamics

The key geomorphic components and processes operating on this sandy spit conceptual shoreline type are displayed in Figure 5-3 and are discussed in more detail below.

**Geomorphic Components**

The key physical components of this shoreline type comprise the following:

- Offshore sandy bed;
- Backshore migrating sand lobes;
- A series of parallel/sub-parallel dune ridge sequences which have formed successively as foredunes behind a prograding sandy beach

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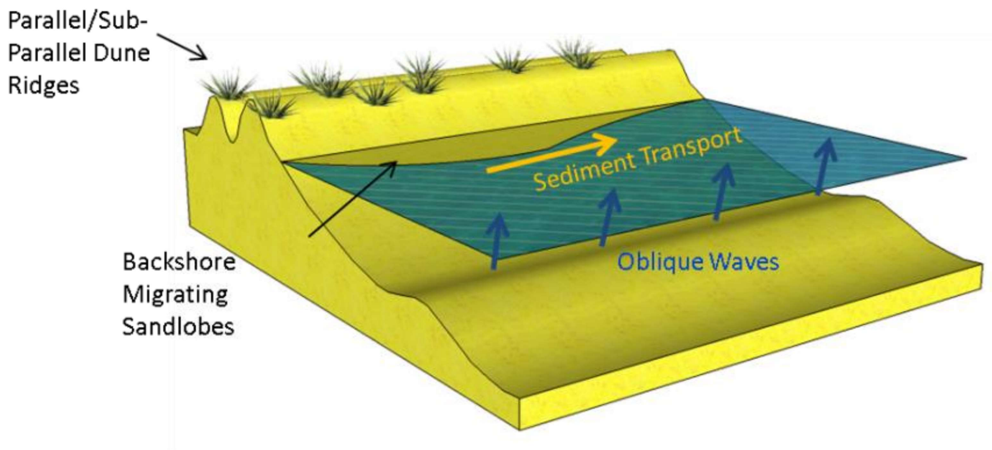


**FIGURE 5-3 SANDY SPIT CONCEPTUAL SHORELINE TYPE (WATER TECHNOLOGY, 2014)**

**Waves**

Waves arrive obliquely along these shorelines, generating longshore currents that drive the sediment transport processes towards the heads of the spits.

**Sediment Transport**

Longshore sediment transport processes play a critical role in shoreline position and variability along these shoreline types in Western Port. A longshore drift of sediment towards the spit heads is generated by obliquely incident waves. Longshore sediment transport along these shorelines is also possibly reinforced by residual tidal currents as well as aeolian transport driven by predominate westerly winds. The main source of sediment for these areas is from offshore, through the Western Entrance.

A pronounced feature of the sediment transport processes of the study area coastline is the formation and easterly migration of backshore sand lobes. Theses sand lobes are considered to be initiated by the episodic injection of sand past Erehwon Point. An example of a migrating sand lobe in the vicinity of the Silverleaves Estate is displayed in Figure 5-4. These lobes of sand are gradually transported eastward by the action of waves and as these lobes of sand migrate eastward along the shoreline they cause alternating patterns of accretion and erosion. The migration of the sand lobes results in relatively dynamic fluctuations in the width of the beaches along the study area shoreline over relatively short times scales (i.e. 1 – 5 years). Appreciating the process of sand lobe migration along the study area shoreline and its effect on the short to medium term beach condition is considered important when evaluating the relative merits of shoreline protection works to mitigate shoreline erosion hazards along the study area.

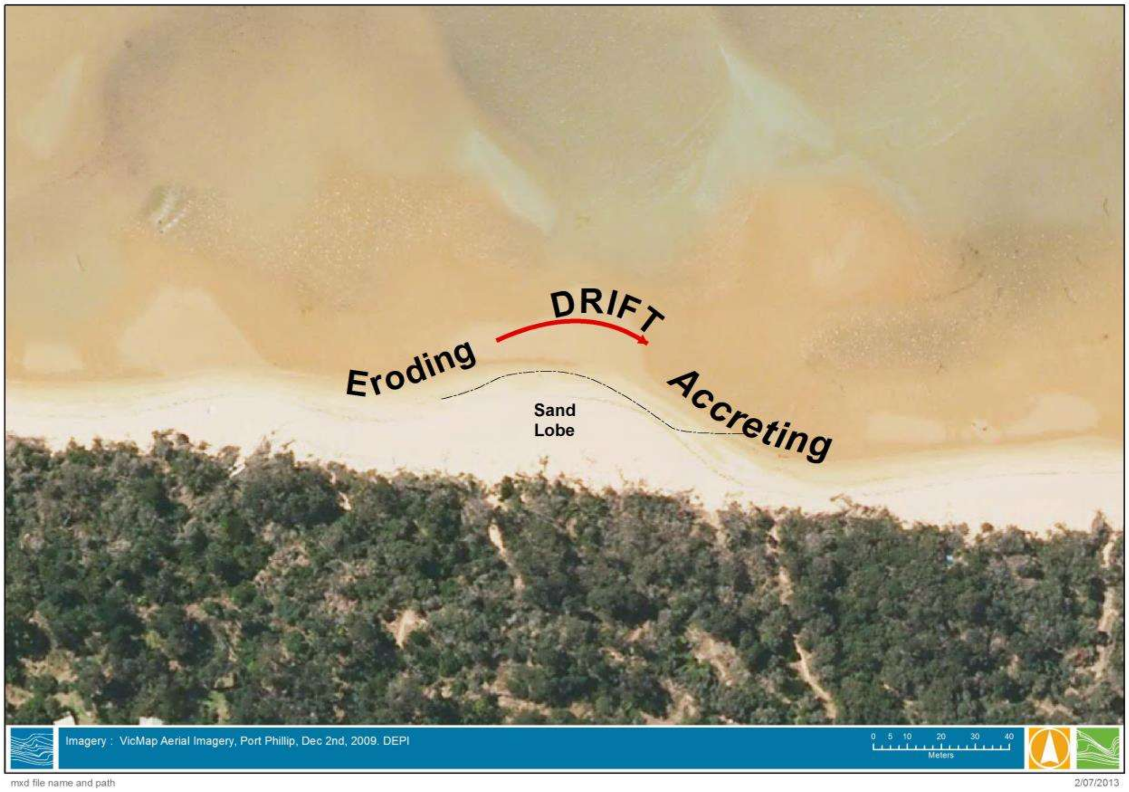


**FIGURE 5-4 MIGRATING SAND LOBE IN THE VICINITY OF SILVERLEAVES ESTATE**

### 5.2.4.3 Numerical Sand Transport Model - LITPACK

Gaining an understanding of the processes and magnitude in which sediment is transported within the study area is considered important when considering the causes of shoreline erosion along the study area and evaluating options to mitigate shoreline erosion hazards.

In order to develop some insight into the potential magnitude of the longshore transport of sediment along the study area coastline, the numerical sediment transport model LITPACK (Littoral Processes and Coastline Kinetics) has been employed to estimate the potential magnitude of the longshore sediment transport due to the action of waves and currents on the study area coastline. The model requires as input a cross shore profile, description of the sediment characteristics and detailed wave, tidal water level and tidal current information. From this information, the model predicts the one-dimensional cross shore distribution of the annual potential net and gross longshore sediment transport rates.

The LITPACK model was setup for a representative shoreline profile approximately half way along the length of the study area coastline and the model was simulated with wave and current information developed in the previous sections.

Figure 5-5 shows the modelled cross shore distribution of potential gross alongshore sediment transport for the study area estimated by the LITPACK model.

Positive sediment transport rates correspond to easterly sediment transport. It should be noted that the model provides estimates of potential sediment transport rates only. Significant differences between the predicted and actual rates of sediment transport could be expected, however, the magnitude of the rates predicted by the model are considered reliable. From Figure 5-5 the following important points regarding the predicted longshore sediment transport processes along the study area can be drawn:

- Overall rates of potential sediment transport are relatively small, this reflects the sheltered northerly aspect and resulting mild wave climate that exists to transport sediment along the coastline.
- The large majority of the sediment transport is predicted to occur offshore on the seaward edge of Cowes Bank. This is where the largest waves break, and only smaller waves are able to propagate across Cowes Bank and onto the shoreline at high tides, resulting in lower potential for sediment transport on the shoreline.
- The magnitude of the annual rate of longshore sediment transport on the shoreline is particularly small however, during the combination of a large storm surge and wave event on the coastline, significant quantities of sediment can be transported over short periods along the shoreline.

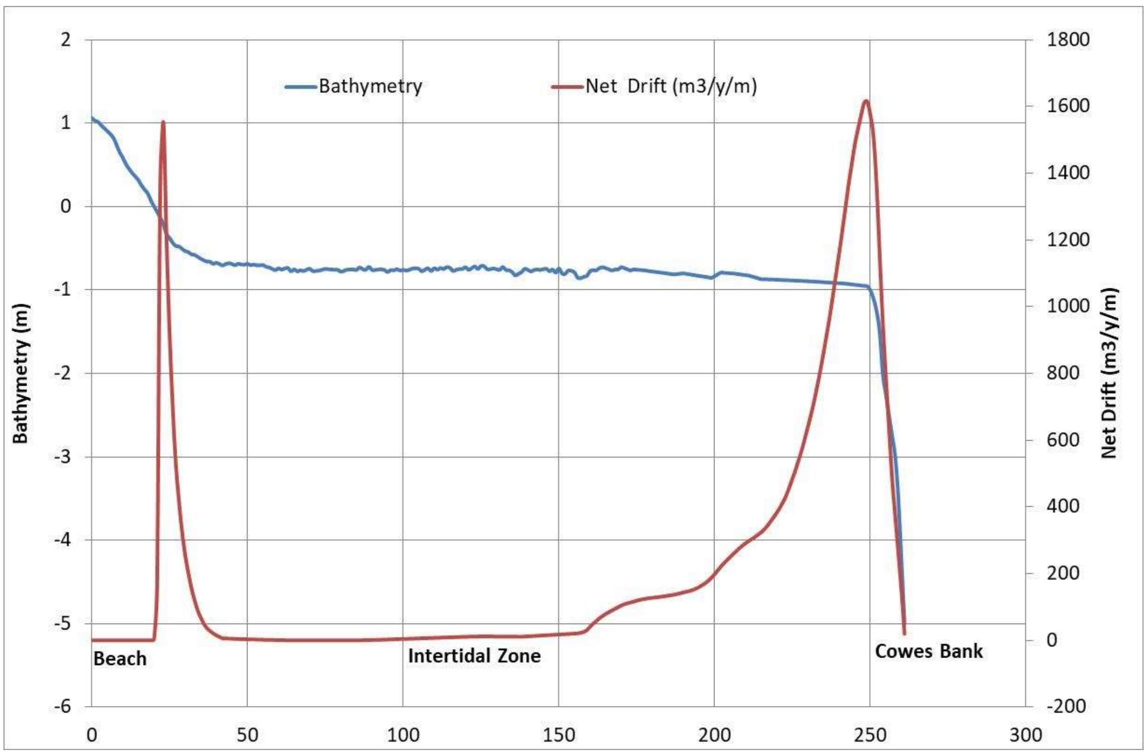


**FIGURE 5-5 POTENTIAL ANNUAL NET EASTWARD LONGSHORE SEDIMENT TRANSPORT DISTRIBUTION**

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### 5.2.5 Historical Shoreline Changes

In order to document the contemporary changes to the study area coastline and update the analysis undertaken in the PICS study, historical aerial photography archives were reviewed and compiled. Additionally, recent aerial imagery was also included in this assessment. The following provides the list of available aerial imagery to assess historical shoreline changes at Cowes East:

- 1960, C. Nr .126, Film 1334;
- 1968, Cowes – Rhyll Project, Film 2217
- 1983, Westernport Foreshores, Film 3807
- 1989, Melbourne Extension South East Project 2020, Film 4294-120
- 2009, Port Phillip, December, 35cm, MGA55
- 2017, Bass Coast, January, 10cm, MGA55

The images were georeferenced and plotted on a common scale and the outline of the 2017 shoreline as inferred from the vegetated dune extent was delineated and superimposed onto the earlier photos to show the changes that have occurred to the shoreline over contemporary history, as shown in Figure 5-6 and Figure 5-7.

In addition, a variety of photographs of the study area shoreline taken as part of the earlier PICS study as well as additional photographs provided as part of the community consultation have been used to compare and contrast the condition of the coastline at different times over the last century.

The following images summarises the major changes observed to the coastline from the comparisons of the historical aerial photography and additional local photographs.

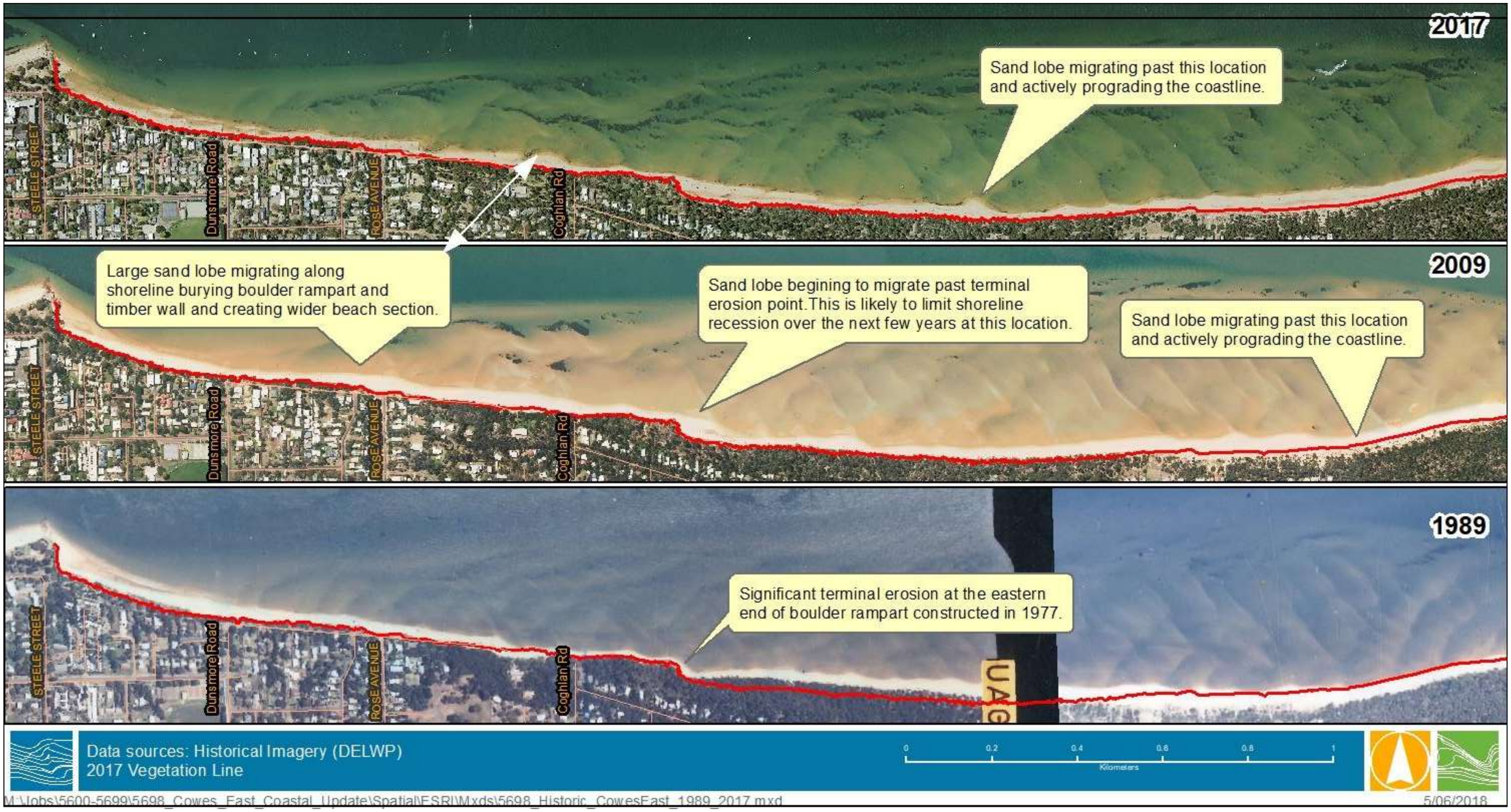


**FIGURE 5-6 HISTORICAL SHORELINE CHANGE (1989-2017)**

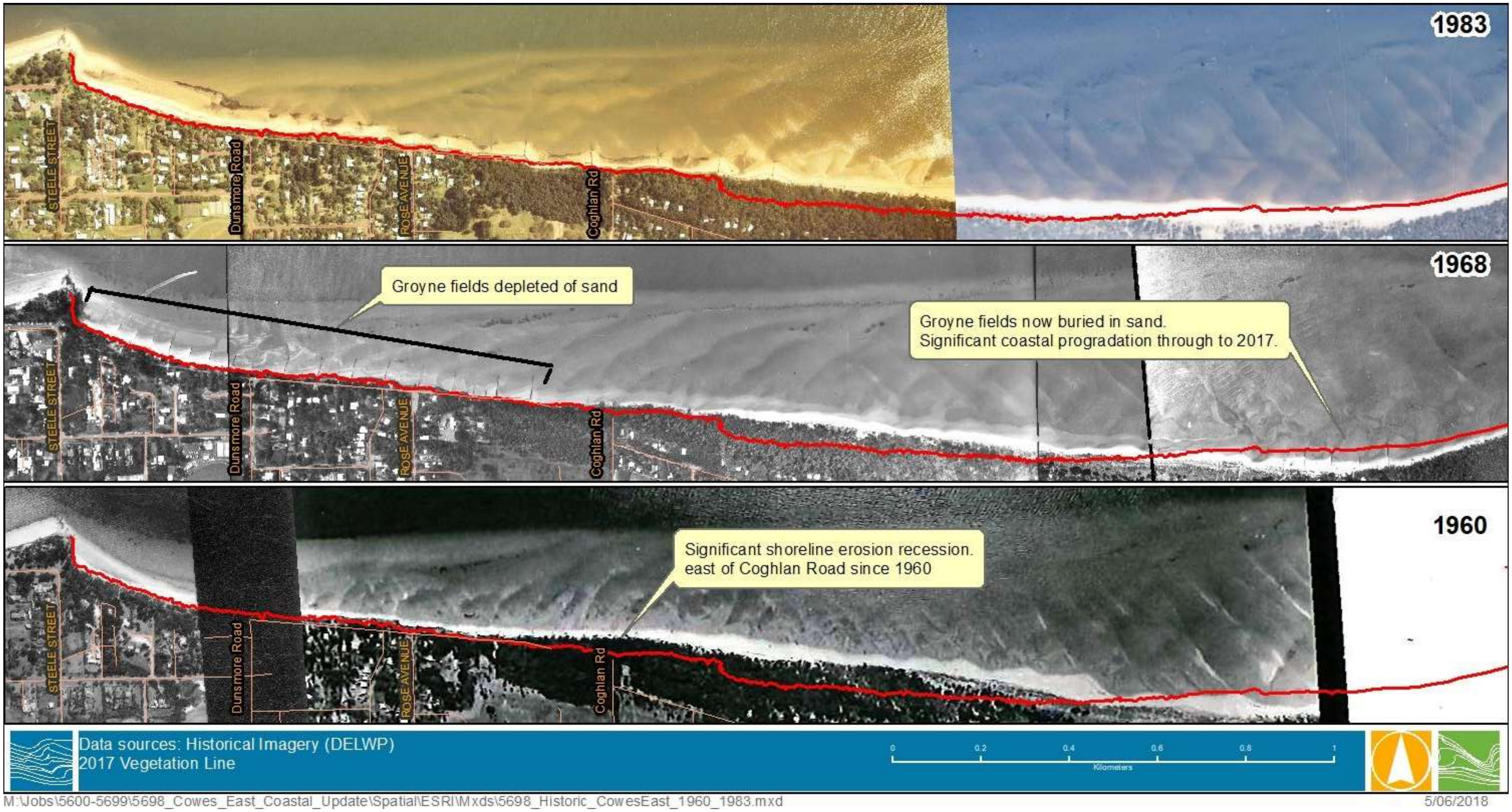


**FIGURE 5-7 HISTORICAL SHORELINE CHANGE (1960-1983)**

#### 5.2.5.1 Erehwon Point to Dunsmore Road

Between 1960 and 1968, there was a marked loss of sand along the beach from Erehwon Point to Dunsmore Road. The groyne fields had however captured a significant quantity of sand, mitigating the impact on the beach and the extent of shoreline erosion. By 1983 however, significant quantities of sand had returned to the shoreline and groyne fields were almost completely buried. Between 1983 and 2010 this section of the shoreline is considered to have remained reasonably stable with a similar width of beach observed between photos as shown in Figure 5-8. By the July 2018 image, the groyne field is more exposed than in previous images indicating a lowering of the beach profile has occurred along this area, as result of recent storm events.

1987 2010

2018

FIGURE 5-8 COMPARISON OF SHORELINE CONDITION AND GROYNE FIELDS EAST OF EREHWON POINT 1987-2018.

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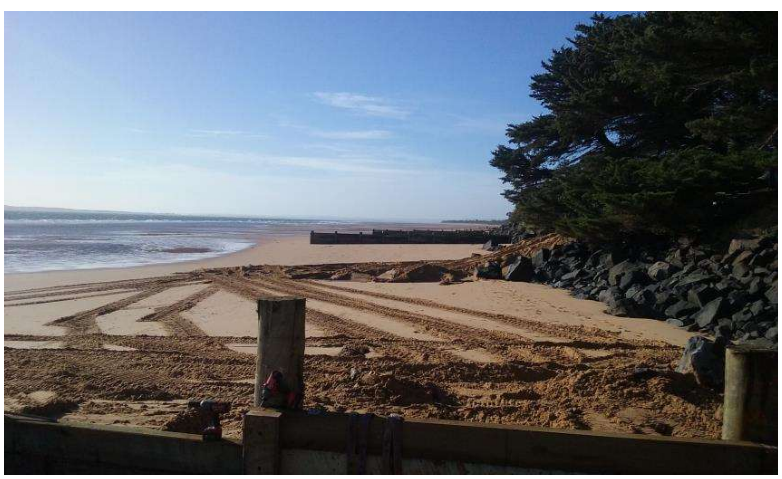
### 5.2.5.2 Dunsmore Road to Rose Avenue

The section of shoreline between Dunsmore Road to Rose Avenue shows similar changes to the shoreline east of Erehwon Point. A marked loss of sand from the beach occurred between 1960 and 1968, considerably depleting sand from this section of beach. There is evidence that sand captured in the groyne fields west of Dunsmore Road starved this section of beach of sand, contributing to the shoreline erosion observed at this time. A significant increase in beach width was however evident along this section of shoreline between 1968 and 1983. The beach widths continued to increase, albeit less dramatically, through to 2009 as shown in Figure 5-9. Since 2009 this trend has reversed and a continued decrease in beach width and beach volume has been observed in this section of the beach due to the east ward migration of the sand lobes. There is also considerable variability because of storm events.

1987

2010



2018

**FIGURE 5-9 COMPARISON OF SHORELINE CONDITION EAST OF DUNSMORE ROAD (1987 – 2018)**

#### 5.2.5.3 Rose Avenue to Coghlan Road

The width of beach between Rose Avenue and Coghlan Road shows evidence of sustained decline from 1960 to 1983 and significant shoreline recession is evident towards Coghlan Road over this period. A series of timber walls and boulder revetments was constructed along this section of shoreline towards Coghlan Road. A boulder revetment was subsequently constructed behind these walls apparently halting the rate of shoreline recession although the beach width remains minimal through to the 1986 aerial photo.

The 2009 aerial photo shows evidence of significant accretion of sand and increase in beach width due to the migration of a broad sand lobe along this section of shoreline. The width of beach on this section of shoreline appears to be the greatest it has been over the available period of aerial photography.

Figure 5-10 presents a view of a section of exposed timber wall looking east towards Silverleaves.

Figure 5-11 shows the extent of accretion that occurred in the vicinity of the timber wall between the mid-1980s and 2010 along this section of shoreline. The eastward migration of a broad sand lobe in this section of the beach resulted in a slight decrease in beach width by 2017 and in the 2018 photo there has clearly been a reduction in beach volume with increasing exposure of the timber wall and associated rock work as a result of the resent storm events in July 2018.

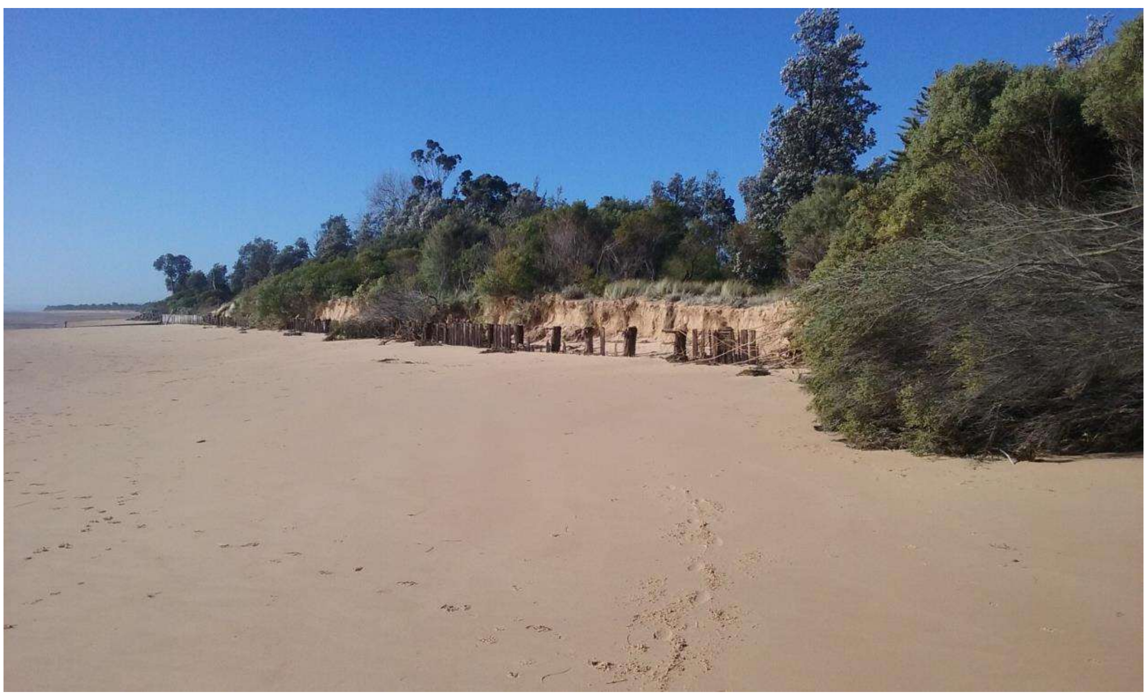


**FIGURE 5-10 VIEW LOOKING EAST TOWARDS SILVERLEAVES**

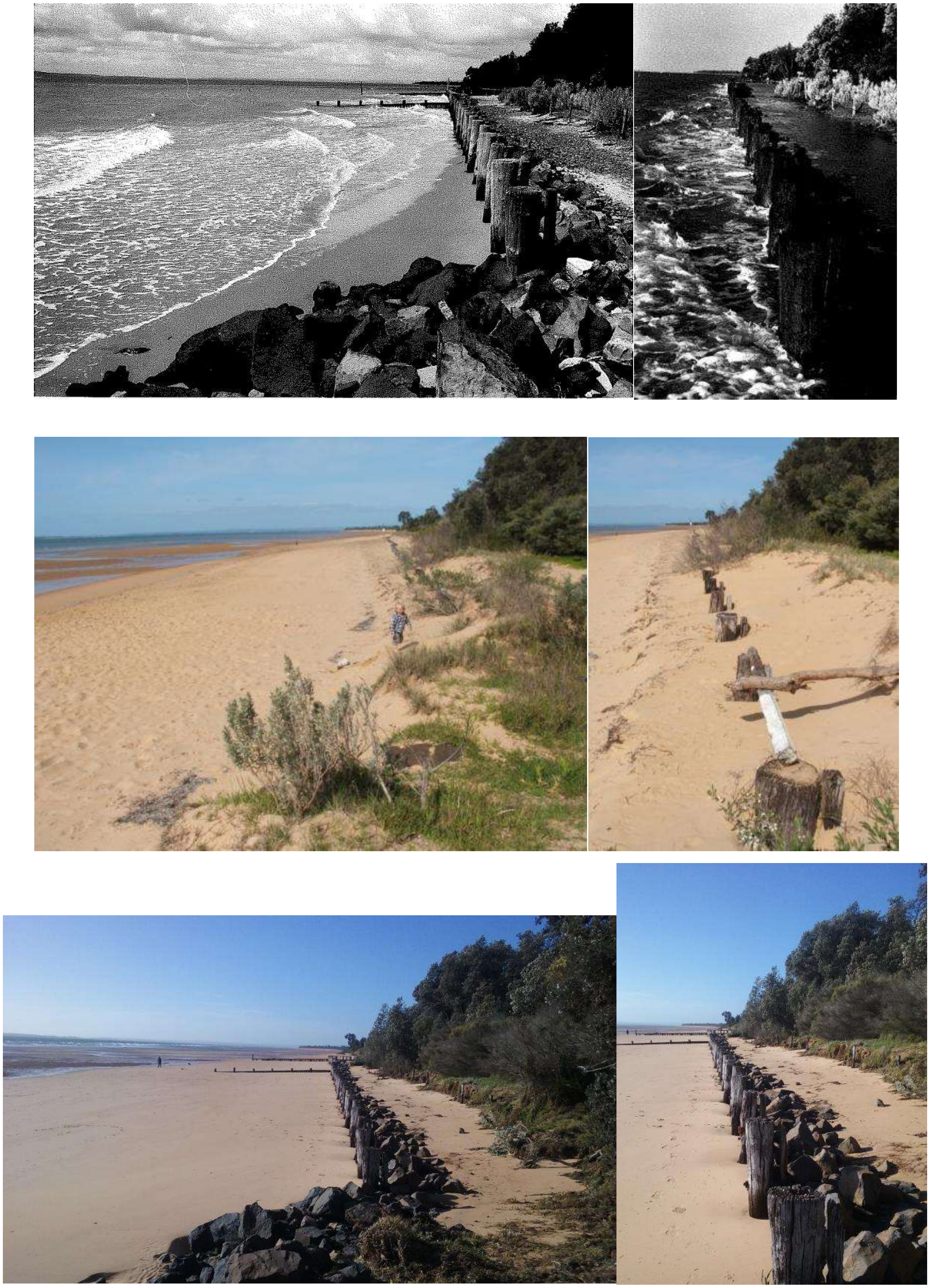


**FIGURE 5-11 TIMBER WALL EAST OF ROSE AVENUE 1986 (TOP), 2010 (MIDDLE), 2018 (BOTTOM)**

#### 5.2.5.4 Coghlan Road to Sanders Road

Very significant shoreline recession has occurred over the available record of aerial photographs between 1960 to present between Coghlan Road to Sanders Road as shown in Figure 5-12. Shoreline recession dramatically increased towards Sanders Road following the construction of a boulder revetment to protect the shoreline east of Coghlan Road. Terminal scour around the end of this boulder revetment has caused the shoreline to recede by approximately 50 metres between the 1968 and 2017 photo. However, sand lobe migration from the west along this shoreline is apparent in the 2009, 2017 and 2018 photographs and has effectively widened the beach and is beginning to migrate past the end of the boulder revetment. The increasing supply of sand past the terminal scour point near Sanders Road may result in some advancement of the shoreline whilst the sand lobe migrates through this area.

1968 2017

2018

FIGURE 5-12 BOULDER REVETMENT EAST OF COGHLAN ROAD

(A) Looking East towards Observation Point

(B) Looking West at the end of the Rock Revetment

**FIGURE 5-13 VIEWS OF THE TERMINAL SCOUR AT THE END OF THE EXISTING ROCK REVETMENT**

#### 5.2.5.5 Rhyll Inlet and Silverleaves Spit

Between 1947 and 2013 the continuing growth of the Silverleaves Spit is observed in Figure 5-14. Accretion can be observed at the end of the spit facilitated by the sediment transfer from the west to the east along the beach face. The tip of the spit has increased in length with a greater vegetation cover indicating that this extension has been stabilised. Another key observation is the infilling of the large indent within the beach face just east of the inlet mouth. This section of coastline can be seen to be much more linear within the more recent image with little left to be able to distinguish the indent that was once present.

In summary, these images show that there is a large amount of sediment moving across the Cowes East beach system which is resulting in large scale accretion at the eastern most point of the spit system.

FIGURE 5-14 COMPARISON OF SILVERLEAVES AND RHYLL INLET BETWEEN 1947 (LEFT) AND 2013 (RIGHT)

# 6 EXISTING COASTAL PROTECTION AUDIT

## 6.1 Existing Coastal Protection Assets

An inspection of the coastal protection assets existing along the study area was undertaken by a senior coastal engineer. As part of the inspection the location, extent and condition of the assets was noted, and photographs were taken.

The three main coastal protection assets present along the study area coastline can be categorised as the following:

- Groynes
- Boulder Revetments
- Timber Walls

Figure 6-1 below displays the location and extent of the three main coastal protection assets along the study area coastline. The following sections summarises the condition and an assessment of the effectiveness of the existing shore protection assets. Seven wooden groynes located west of Broughton Ave have been installed or replaced by Department of Environment Land Water Planning (DELWP) since the 2011 report.


**FIGURE 6-1 EXISTING COASTAL PROTECTION ASSETS**

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### 6.1.1 Groynes

The first series of groyne fields were constructed in 1947 east of Erehwon Point. Approximately fourteen groynes were constructed between Erehwon Point and Rose Avenue. A further eight were constructed between Rose Avenue and Sanders Road. DELWP has replaced or upgraded seven groynes in the section between Charmandene Court and Broughton Ave since 2015.

The groynes are a mixture of piled and horizontal slat and single and two row palisade construction types. The protrusion of the groynes above the sand was limited in 2010 as shown by Figure 6-2 but are now significantly exposed. Figure 6-3 shows an overview of the structures taken in 2014 and again in 2018. The 2018 photo shows many of the structures exposed over significant sections of their length as it was taken immediately following a storm event. Also noting several structures had been newly constructed.

At the time of the 2011 study, the structural condition of the groynes along the study area was considered generally poor with the majority of the piles and slats displaying signs of significant deterioration. A number of groynes had previously been removed due to safety concerns associated with their poor condition following an audit by the Department of Sustainability (Parsons Brinckerhoff, 2009). As noted above, since 2015 DELWP has undertaken a program to replace or install new wooden groynes to address these earlier issues.

The effectiveness of the groyne fields along the study area in limiting shoreline recession and maintaining a wide beach was subject to considerable debate and diversity of opinion during the 2011 community consultation sessions. It was noted that a significant number of community members expressed an opinion that the groynes were useful in limiting the loss of sand during large storm events and helped to reduce the time it took for the beach to recover following storms. Other community members however questioned the effectiveness of the groyne fields and pointed to the supply of sand past Erehwon Point as a more significant factor in maintaining the beach condition.

It is noted that without the application of additional quantities of sand to the beaches via beach renourishment, the impact of the groynes in the study area is essentially a zero-sum game, where the sand held onto the beach by one groyne is sand denied from the beach immediately downdrift. Analysis of the historical aerial photography in Section 5 shows evidence that when sand supply to the coastline was particularly low around 1968, the groyne fields west of Dunsmore Road locked up a considerable quantity of sand resulting in the beaches to the east of Dunsmore Road showing evidence of shoreline erosion, with almost no beach visible in the historical aerial photographs during this period.

The groyne fields along the study area are however likely to be providing a potentially important function in limiting the level that the beach can lower directly in front of the boulder revetments during periods of low sand supply and/or storm conditions. Loss of sand from the footings of the boulder revetments is a common failure mechanism for these types of structures.

Additionally, maintaining the beach levels is an important function for public amenity and to retain the recreational values of the study area.

**2010**

2018

**FIGURE 6-2 GROYNE FIELDS EAST OF EREHWON POINT, TOP (OCTOBER 2010) AND BOTTOM (JULY 2018)**

**2014**

2018

**FIGURE 6-3 TIMBER GROYNE FIELDS, EAST OF EREHWON POINT, TOP (JANUARY 2014) AND BOTTOM (JULY 2018)**

### 6.1.2 Boulder Revetments

Boulder revetments have been constructed sporadically along the study area coastline with the earliest placed between Erehwon Point and Rose Avenue by the Division of Ports and Harbours in 1947 (see Figure 6-4). East of Coghlan Road, a section of then eroding coastline was protected by a boulder revetment in 1977.

The boulder revetments have been constructed from quarried basalt with a wide distribution of rock sizes and crest levels. In places wave action has dislodged smaller rocks from the revetment and these are now lying seaward of the revetment on the beach. Evidence of overtopping by wave action was also observed resulting in erosion behind the revetment and associated slumping in some isolated locations along the study area such as at Dunsmore Road.

Based on the review of the historical shoreline changes undertaken in Section 5, the construction of the boulder revetments has in general considered to have been relatively successful in limiting the degree of shoreline erosion observed, particularly where the erosion has historically threatened private property and council road reserves.

At the time of the 2011 study, the boulder revetments along many sections of the study area were fronted by a prograding beach and were partially buried by sand which had been colonised by vegetation, Figure 6-4. However, since 2011 storm events have continued to erode the beach areas in front of the revetments, exposing more of the structures. Where exposed, rock revetments have a tendency to flatten and lower the beach profile.


(EAST OF COGHLAN ROAD) (WEST OF DUNSMORE ROAD)

FIGURE 6-4 BOULDER REVETMENTS ALONG STUDY AREA FORESHORE (AUGUST 2010)

One section of boulder revetment that has resulted in undesirable impacts on the coastline has been the section of boulder revetment east of Coghlan Road that was constructed in 1977. While this boulder revetment has been successful in stopping shoreline recession along this reach of the study area, the armouring of this shoreline has subsequently locked up a significant volume of dune material that would have naturally been eroded and transported to supply the shorelines to the east. This has resulted in very significant terminal scour and shoreline recession to the east of this boulder revetment since its construction in 1977.

Feedback from the 2011 community consultation sessions regarding the boulder revetments is considered to have generally related to concerns that the boulder revetments made access to the beach difficult and that armour rocks that had been dislodged from the revetment and partly buried in the beach were a potential hazard. Some community members expressed concerns that there was little to no useable beach at high tide in front of some sections of boulder revetment within the study area.

### 6.1.3 Timber Walls

The Division of Ports and Harbours are believed to have constructed a timber wall between Rose Avenue and Coghlan Road in the 1940's. The PICS study showed beach profiles were lowered in front of the timber wall and high tides were flooding behind the timber wall and reflected waves were scouring the beach sand in front of the walls.

Figure 6-5 shows the condition of the timber wall looking east towards Silverleaves (on the left) and then west towards Rose Avenue (on the right) in October 2010 and then again in July 2018. The photos show the shoreline is highly variable, with significant accretion shown in the 2010 photo shown by the burial of the wall and colonisation by vegetation, while the 2018 photos show significant exposure of the timber structure over the majority of its length and the underlying rock protection is also visible.

Storm events during 2012/13 resulted in erosion of sand and increased the exposure of the upper part of the structure as shown in the 2014 photo, Figure 6-6. The 2018 image shows that this trend has continued, with increased shoreward extent of the erosion as well as an overall lowering of the beach level

2010

2018

**FIGURE 6-5 TIMBER WALLS BETWEEN ROSE AVENUE AND COGHLAN ROAD (2010 – 2018)**

2014 2018

**FIGURE 6-6 TIMBER WALLS BETWEEN ROSE AVENUE AND COGHLAN ROAD (2014 – 2018)**

# 7 IMPLICATIONS OF CLIMATE CHANGE

## 7.1 Sea Level Rise

Table 7-1 provides a summary of relevant global mean sea level rise scenarios for planning. Estimates of sea level rise by Hunter (2014), incorporating the IPCC 2014 A1F1 climate change scenario, predict an increase in the mean sea level of 0.82m by 2100. This scenario is considered to meet the minimum sea level rise scenario for planning as per the Victorian Coastal Strategy (VCC, 2014).

Practice Note 53 from the Department of Environment, Land, Water and Planning (DELWP, 2015) also notes the following amendment to the State Planning Policy Framework:

"In planning for possible sea level rise, an increase of 0.2 metres over current 1 in 100 year flood levels by 2040 may be used for new development in close proximity to existing development (urban infill)".

**TABLE 7-1 SEA LEVEL RISE SCENARIOS (VCC, 2014 & HUNTER, 2014)**

| | Scenario and Year | | |
|---|---|---|---|
| | **2040 High** | **2070 High** | **2100 High** |
| Mean Sea Level Rise (m) | 0.20 | 0.47 | 0.82 |

## 7.2 Coastal Inundation

Estimates of extreme coastal water levels (storm tides) at Stony Point, including the impact of the projected sea level rise, have been developed by the CSIRO (McInnes et al, 2009) for different planning periods and are displayed in Table 7-2 for the 10% AEP storm tide levels. The storm tide estimates at Stony Point are considered representative of the storm tide water levels along the study area coastline.

Melbourne Water has recently updated their guideline for Western Port storm tide levels for the existing and future conditions based on storm tide inundation modelling conducted by Water Technology (Melbourne Water, 2017). As a result, the 1% AEP graduated flood levels both for existing and 2100 conditions have been revised across Western Port bay. The predicted 2040 and 2070 1% AEP graduated flood levels have been updated assuming 0.2m and 0.47m sea level rise, increments respectively.

**TABLE 7-2 10% AND 1% AEP STORM TIDE LEVELS INCORPORATING MEAN SEA LEVEL RISE SCENARIOS**

| | Existing (m AHD) | 2030 High (m AHD) | 2070 High (m AHD) | 2100 High (m AHD) |
|---|---|---|---|---|
| Stony Point (10% AEP) | 1.62 | 1.82 | 2.25 | 2.57 |
| Stony Point (1% AEP) * | **2.20** | 2.40 | 2.70 | **3.03** |

**(Melbourne Water, 2017)*

The storm tide level estimates have been mapped based on the LiDAR survey of the coastline to provide an indication of the extent of the coastal inundation hazards that could be observed to 2100, including an increase in mean sea levels of 0.8m. The results of this mapping exercise considering the 1% AEP storm tide levels to 2100 are displayed in Figure 7-2.

A range of wind directions were applied in Water Technology's modelling works to arrive at the storm tide levels as indicated in Melbourne Water's guideline for the existing levels. However, it should be noted that the effect of strong north westerly wind conditions has not been fully investigated. These wind conditions can generate relatively large waves along the study area coastline which can potentially cause additional setup of water levels and consequently a greater inundation extent hazard. The various water level components giving rise to the total coastal inundation hazard are displayed Figure 7-1.

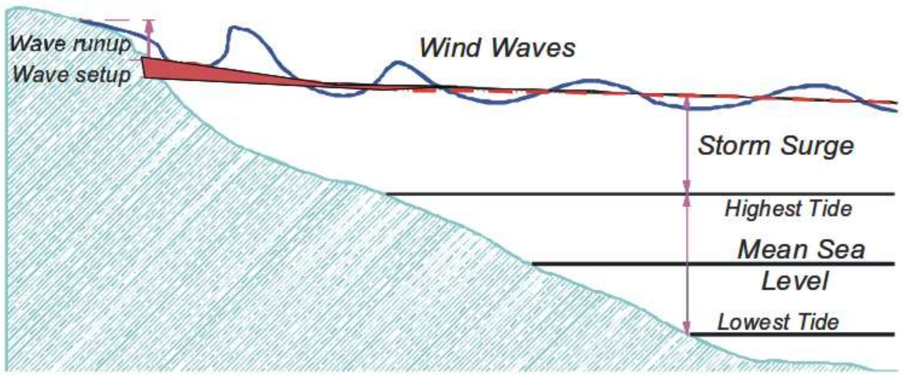


FIGURE 7-1 WATER LEVEL COMPONENTS COMPRISING THE COASTAL INUNDATION HAZARD

In addition, it is noted that the magnitude of the sea level rise projected this century is likely to result in significant shoreline erosion which may result in more significant inundation hazards and is discussed further in Section 7.3. Nevertheless, the inundation extents displayed in Figure 7-2 are considered to provide a reasonable indication of the broad extent of the potential coastal inundation hazards along the study area coastline due to sea level rise.

From Figure 7-2, the following observations are made as to the potential coastal inundation hazards along the study area coastline incorporating the impact of projected sea level rise to 2100:

- An isolated low point is potentially vulnerable to ingress of storm tides centred around Dunsmore Road. A large storm tide event in 2009 caused some minor flooding of the seaward end of Dunsmore Road.
- The shoreline around Coghlan Road is particularly vulnerable to storm tide inundation and these areas are currently below the existing 1% AEP storm tide.
- It should be noted that much of the potential inundation risks to properties and infrastructure near the study area coastline is actually likely to originate from Rhyll Inlet. Storm tides are able to propagate with minimal attenuation into Rhyll Inlet and along the low fingers of land that exist between the successive spit formations towards the existing study area shoreline of Western Port.

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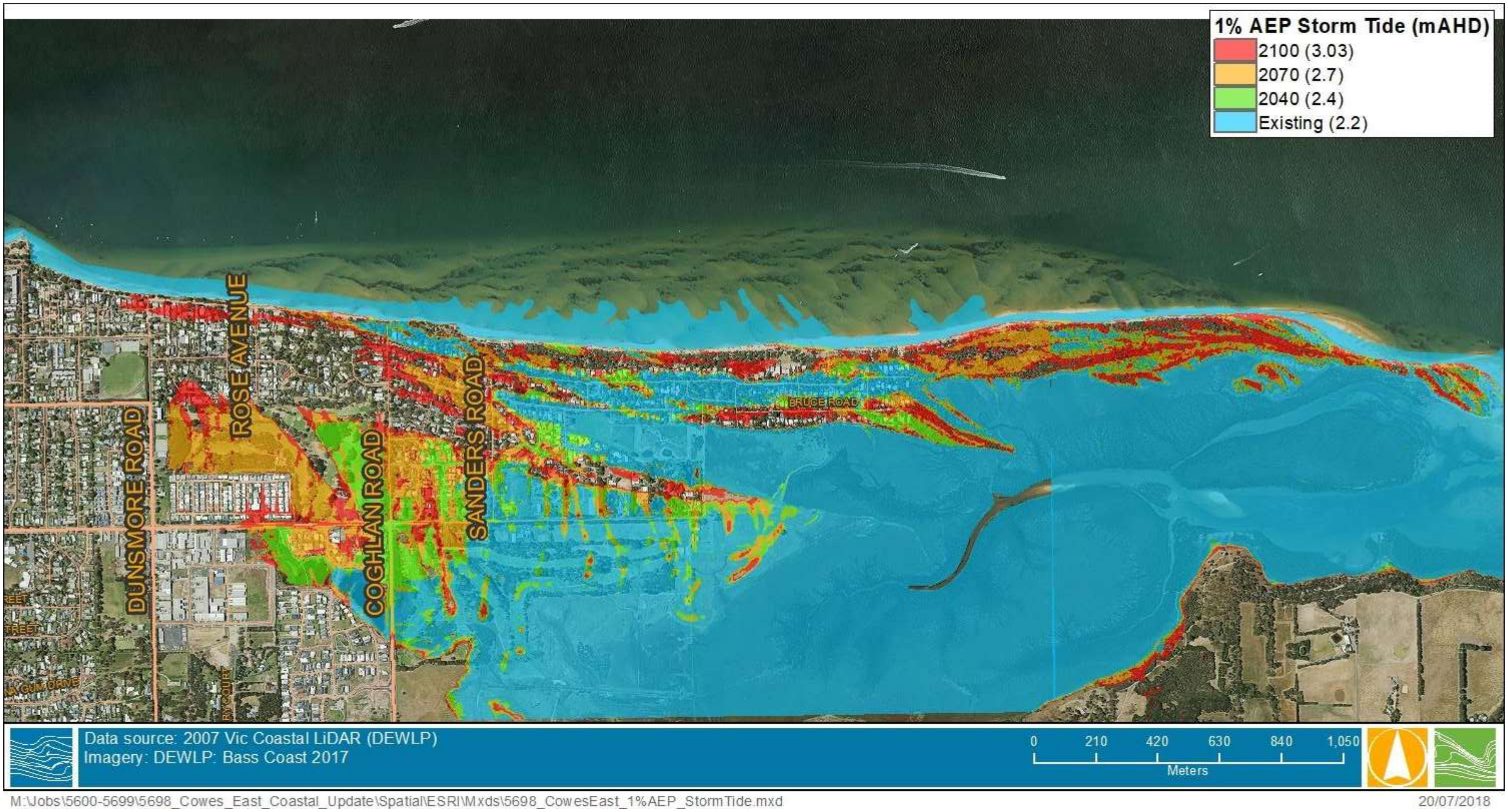


FIGURE 7-2 INDICATIVE 1% AEP STORM TIDE INUNDATION EXTENTS FOR THE EXISTING AND PROJECTED SEA LEVEL RISE SCENARIOS

# 7.3 Coastal Erosion/Shoreline Recession

## 7.3.1 Sandy Spit Shorelines: Key Drivers and Rates of Change

The key drivers and potential rates of change on sandy spit shorelines (present along Cowes East) due to sea level rise or underlying process variability is displayed conceptually for this shoreline type in Figure 7-3, based on the work undertaken for the Western Port Local Coastal Hazard Assessment (Water Technology, 2014).

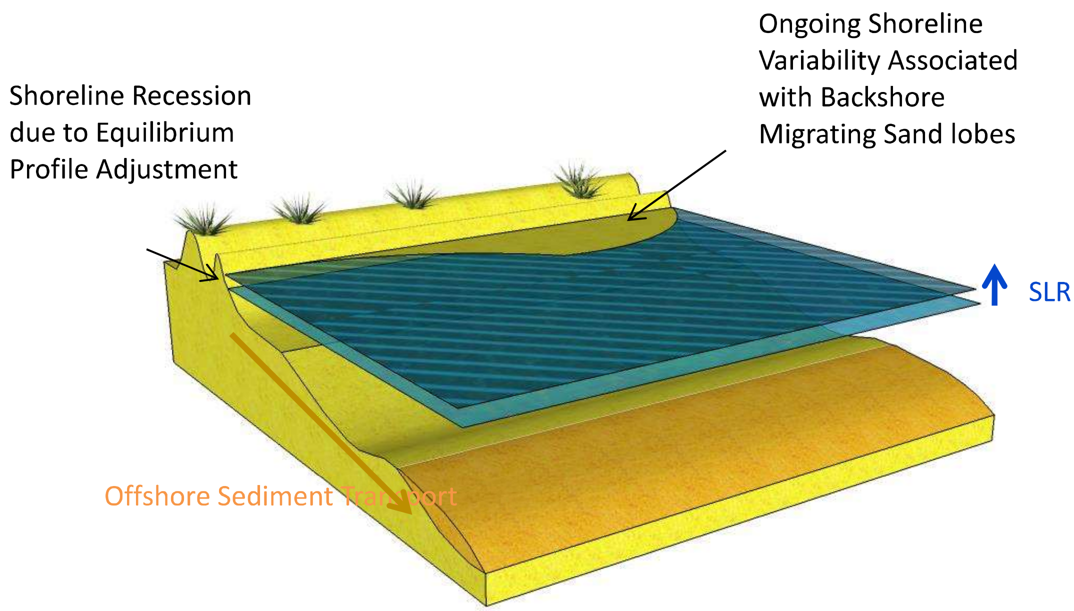


**FIGURE 7-3 SANDY SPIT SHORELINE SEA LEVEL RISE RESPONSE MECHANISM (WATER TECHNOLOGY, 2014)**

### 7.3.1.1 Equilibrium Profile Recession

The Bruun (1962) model is one of the most widely used conceptual models for predicting sandy shoreline profile response to rising sea levels due to its ease of application, and lack of accepted alternatives for long-term shoreline profile response. The Bruun model is based on the concept that for a shoreline profile at, or close to equilibrium with present sea levels, and that is neither gaining nor losing significant volumes of sediment; a rise in relative sea level will lead to erosion as wave action erodes the beach face, transporting sediment offshore. Over time this process translates the shoreline profile shoreward and upward in response to the relative higher sea level. This process results in a redistribution of sediment across the profile but does not lead to net gain or loss of sediment. A conceptual model of this process is shown in Figure 7-4.

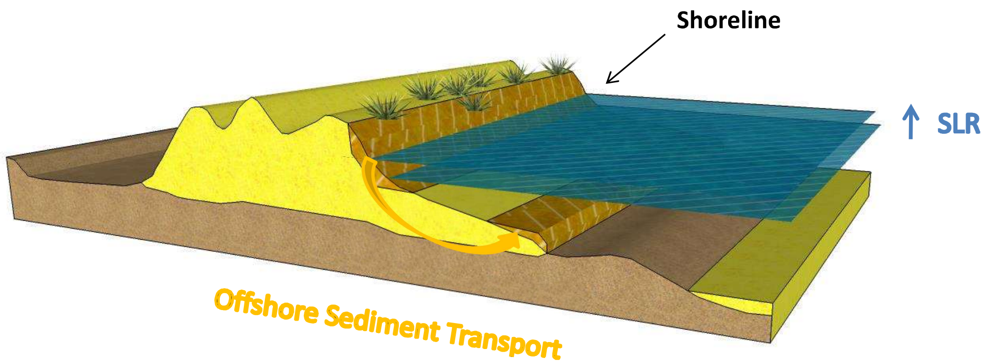


FIGURE 7-4 CONCEPTUAL MODEL OF EQUILIBRIUM PROFILE RECESSION ALONG A SANDY SHORELINE AS A RESULT OF SEA LEVEL RISE (WATER TECHNOLOGY, 2014)

The application of the Bruun model for estimating shoreline profile response to sea level along these sandy spit landforms such as along Cowes East is however considered problematic. Figure 7-5 displays a cross section of the Observation Point shoreline extracted from the LiDAR survey. From Figure 7-5 it can be seen that the depth of closure (describing the seaward extent of potential profile change due to sea level rise) is not readily definable for these shorelines as they are generally fronted by a wide, shallow and/or intertidal sandy bar systems. Sediment across these bars can be mobilised by wave and/or tidal current action and the sediment transport processes between the offshore bar systems and the shoreline are likely to be very complex.

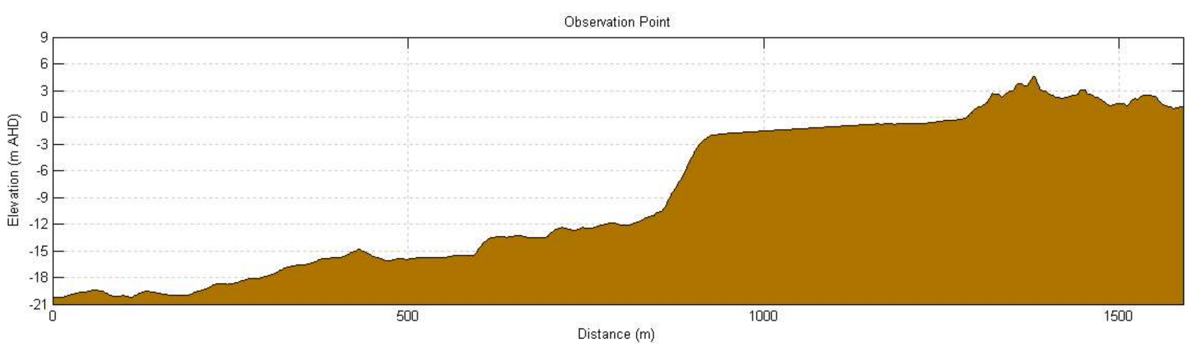


FIGURE 7-5 CROSS SECTIONAL PROFILES THROUGH SANDY SPIT SHORELINES AT OBSERVATION POINT

Due to the particular characteristics of the sandy spit shoreline class at Cowes East, it is difficult to identify an active slope for application of the Bruun model for estimating the extent of equilibrium profile adjustment due to sea level rise on these shorelines. The active slope is simply defined as the ratio of the horizontal distance from the shoreline to the depth of closure divided by the closure depth plus the berm/dune crest height. This active slope yields the 'Bruun Factor' which describes the amount of horizontal profile adjustment (recession) per increment of sea level rise.

It is possible that sea level rise may predominately only impact the beach face and dunes on these shorelines (DEHP, 2013). Consideration of the upper beachface slopes for estimating the extent of the shoreline profile adjustment using this modified approach would however result in relatively small active slopes (Bruun Factor of approximately 12) and shoreline recession estimates. Given the complex offshore geometry and the dynamic sediment transport processes that are observed on these shorelines, it is however considered prudent to adopt a conservative Bruun Factor of 100 for the study are wide assessment. This factor reflects the limited understanding of the potential extent of the sea level rise response of this shoreline class. Table 7-3 summarises the recession distances for the sand spit shoreline class due to equilibrium profile adjustment with an adopted Bruun Factor of 100.

TABLE 7-3 BRUUN MODEL RECESSION DISTANCES FOR SANDY SPITS SHORELINES

| Bruun Factor | Sea Level Rise Scenario | | |
|---|---|---|---|
| | 0.2m | 0.5m | 0.8m |
| 100 | 20m | 50m | 80m |

#### 7.3.1.2 Backshore Sand Lobe Migration/Longshore Sediment Transport

A major component of the shoreline variability and subsequent extent of potential coastal hazard impacts on the sandy spit shorelines will continue to be associated with the migration of backshore sand lobes along these shorelines. This underlying shoreline variability will continue irrespective of presence or otherwise of sea level rise. As noted earlier, sand in these areas is derived from Bass Strait and is transported into Western Port via the Western Entrance

In order to provide an estimate of the potential extents of coastal hazards associated with these processes in the future, the scale and extent of these features observed from available historical aerial photography has been reviewed for landforms in Western Port that correspond to this conceptual shoreline type (Water Technology, 2014).

Available historical aerial photography of the sandy spit landform that terminates at Observatory Point, east of Cowes has been reviewed in Figure 7-6. Figure 7-6 shows the high level of temporal variability in shoreline position that occurs along this shoreline.

The eastward migration of a backshore sand lobe is clearly observed, with the shoreline in the west of the frame receding and the shoreline to the east prograding by a similar amount (approximately 50 m) over the course of the photographic sequence along this landform. Shoreline changes on this landform have also been signficantly influenced by the construction of shore protection works including revetment and groynes which have resulted in down drift,terminal erosion impacts to the shorelines. The shoreline is not therefore considered to be in an equilibiurm state.

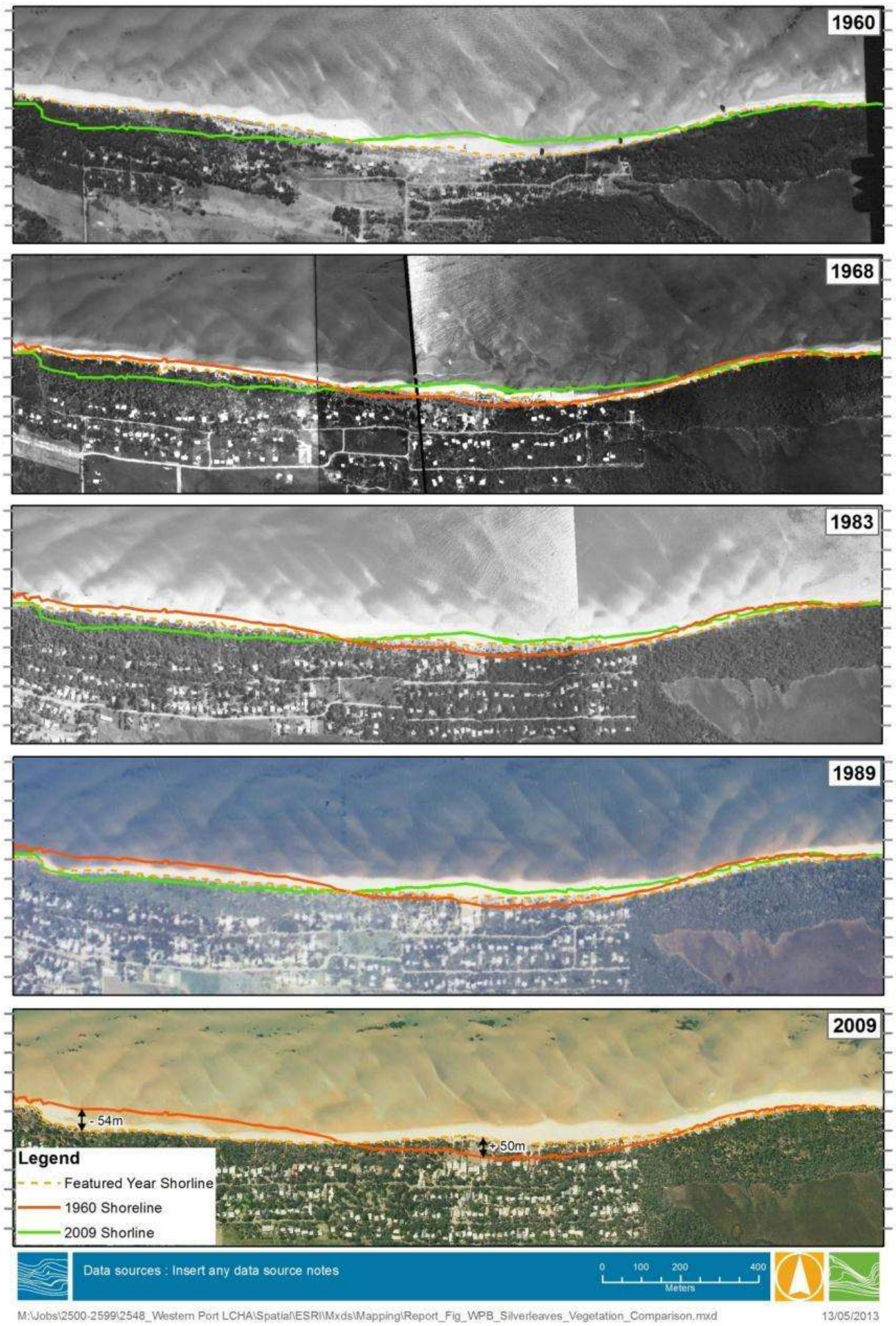


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**FIGURE 7-6 SANDY SPIT LANDFORM, OBSERVATION POINT TO EAST OF COWES (1960-2009)**

Estimating the future location and extent of shoreline changes and associated coastal hazard impacts along these landforms due to these processes is not possible with any acceptable level of precision or confidence. However, detailed dating of the sediments comprising the dune ridges on these landforms would enable the evolution of these landforms and the temporal and spatial scales of the shoreline variability to be better understood which would assist in refining appropriate hazard extents.

Provisional hazard extents have been developed by adopting the maximum shoreline changes attributed to backshore sand lobe varaibility from the analysis of the historical photography and including a factor of safety of two to account for the longer time frames and level of uncertainty that exists in relation to these processes as presented in Table 7-4.

TABLE 7-4 PROVISIONAL HAZARD EXTENTS DUE TO BACKSHORE SAND LOBE MIGRATION

| Location | Backshore Sand Lobe Hazard Extent | |
|---|---|---|
| | Variability Based on ~50 years of Historical Photography (m) | Provisional Hazard Extent x2 Factor of Safety (m) |
| Cowes East to Observatory Point | ~50 | 100 |

### 7.3.2 Coastal Hazard Extent

Table 7-5 summarises the total combined coastal hazard extents incorporating equilibrium profile response due to sea level rise and the underlying shoreline variability due to backshore sand lobe migration, plus a factor of two due to uncertainties associated with this process over long timeframes.

TABLE 7-5 PROVISIONAL TOTAL COASTAL HAZARD EXTENTS FOR THE SANDY SPIT SHORELINE CLASS

| Location | Sea Level Rise Scenario | | |
|---|---|---|---|
| | 0.2m (2040) | 0.5m (2070) | 0.8m (2100) |
| Cowes East to Observatory Point | 70m | 100m | 280m |

Hazard extents at along the Cowes East / Silverleaves shoreline have been mapped based on the estimates provided in Table 7-5 and are presented in Figure 7-7. It should be noted that these mapped erosion extents do not take into account the presence of shoreline protection structures.


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**FIGURE 7-7 EROSION HAZARD EXTENT FOR COWES EAST / SILVERLEAVES**

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Another response mechanism possible for the Cowes / Silverleaves shoreline relates to the reactivation of the broader scale spit landform. This is based on the available geomorphologic evidence which suggests the previous spits response to changing sea level is for the alignment of the spit to pivot about the headland at Erehwon Point. The consequence of this response is that the rate of long-term shoreline recession would potentially increase dramatically further east from Erehwon Point as the spit evolves a more south easterly alignment in response to higher mean sea levels. The possible long term rotational response of the spit alignment is displayed conceptually in Figure 7-8. Due to the high uncertainty associated with this morphological response it has not been explicitly included in the erosion hazard mapping.

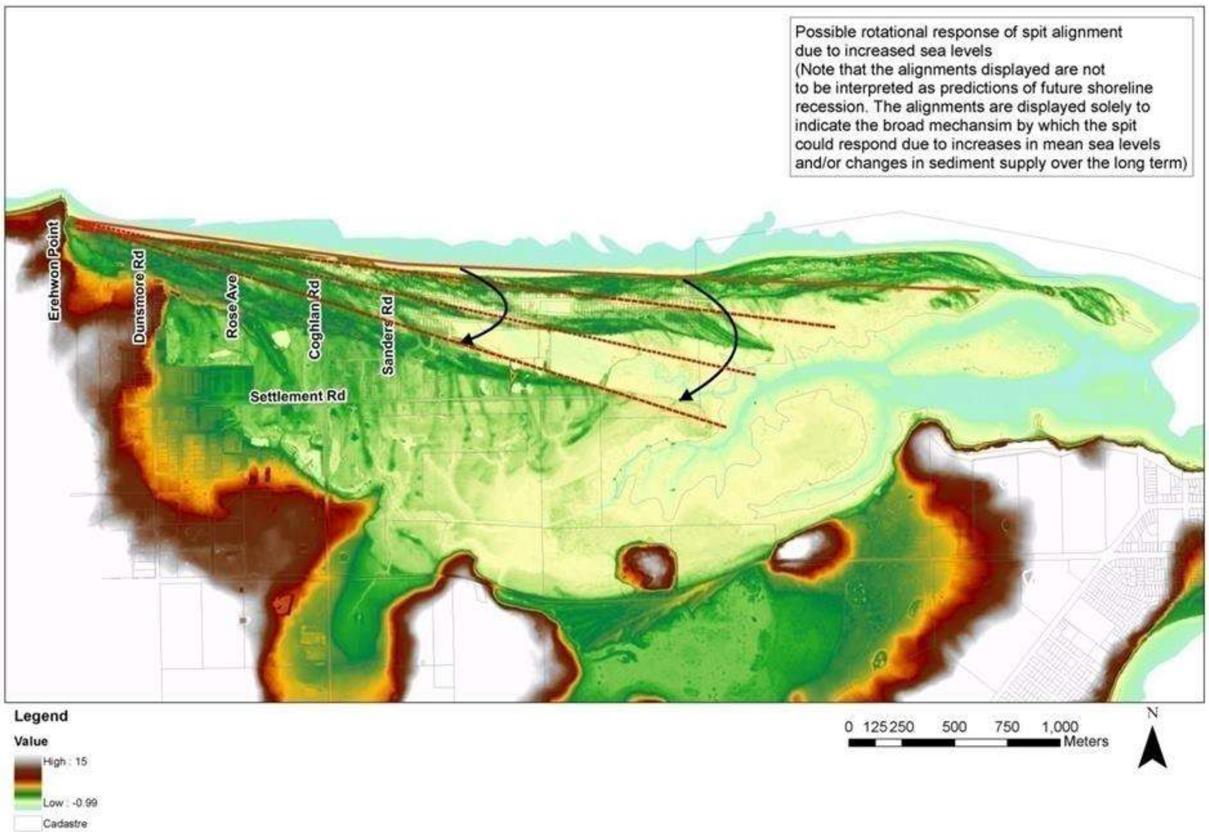


FIGURE 7-8 POSSIBLE LONG-TERM RESPONSE MECHANISM OF SPIT ALIGNMENT TO INCREASES IN MEAN SEA LEVEL OR REDUCTIONS IN SEDIMENT SUPPLY

# 8 COASTAL PROTECTION OPTIONS ASSESSMENT

## 8.1 Overview

Four main concepts guide coastal management and planning processes. These can be summarised as follows:

- Protect - protection options can either be “soft“ options, such as beach renourishment, or “hard“ options, that involve the placement of a structure.
- Adapt / Accommodate - this involves taking measures to allow extended use of affected land. For example, elevating or flood proofing existing structures. They include management strategies that render the risks from identified coastal hazards acceptable (but don’t constitute ‘protect’ options).
- Planned / Managed Retreat - relocation of coastal infrastructure to somewhere inshore of the affected land.
- Do Nothing - do nothing to protect the assets in the immediate coastal region.

Based on the review of the coastal processes and analysis of historical shoreline changes in the study area, it can be concluded that the condition of the study area shoreline, in terms of the beach widths and amenity is highly variable spatially and temporally. At the time of the 2011 study the beach widths and amenity were on average greater than has generally been observed historically. However, since 2011 there has been on-going reduction in beach widths and volumes along much of the Cowes East foreshore.

The changes in beach amenity and erosion/inundation hazard risks along the foreshore, generally relate to the migration of sand past Erewhon Point as a series of sand lobes along the study area foreshore. The increased supply of sand to the study area between 1989 and 2009 increased the width of the beaches generally and tended to mitigate shoreline erosion hazards along the study area coastline. This trend however has not lasted and as expected it appears the shoreline is currently experiencing a periodic reduction in sediment supply which has reduced beach widths and aggravated shoreline erosion hazards in some areas. The cyclical nature of the sediment transport and coastal processes in the study area highlights the risks posed by implementing potentially costly and obtrusive engineering works on the coastline to mitigate natural and cyclical fluctuations in beach widths and shoreline alignments that are a feature of this coastline. Nevertheless, the extent of existing public assets and infrastructure potentially vulnerable to shoreline erosion and inundation hazards in the study area is now such that coastal protection works are required to mitigate these risks to an acceptable level.

In the longer term, the projected increases in mean sea level this century would be expected to result in broad and significant shoreline recession and inundation hazards to the study area. The options for mitigating these risks are however considered to be of a much more strategic scale and have broader social, economic and policy implications. For this reason, the assessment of the options to manage coastal erosion and inundation hazards along the study area has been considered for the following two timeframe/sea level rise scenarios:

- Short to Medium Term Options /Sea Level Rise = +0.2-0.4m increase in mean sea level.
- Long Term Options / Sea Level Rise = +0.5m increase in mean sea level.

## 8.2 Short to Medium Term Options/ Sea Level Rise:0.2-0.4m

### 8.2.1 Groynes

As discussed previously in Section 6.1.1, the structural condition of the groynes along the study area had deteriorated at time of the 2011 study and some of the structures were no longer considered to function as an effective barrier to longshore sand transport. The impact of the groynes on the beach widths along the study area was therefore currently considered modest. As noted in Section 6, DELWP had undertaken upgrade and replacement works to the groyne since 2011. In 2015 three new groynes were constructed at Cowes by DELWP with a cost of $150,000 and a further 4 new groynes were constructed in 2018, with a cost of $187,000.

It should be noted that where the groynes have been effective at trapping sand and maintaining greater beach widths along the study area historically, the aerial photographic evidence suggests that this has come at the expense of downdrift sections of beach along the study area, which have been starved of sand and have undergone significant shoreline erosion.

The groynes along the study area are however likely to be functioning to limit the lowering of the beach immediately in front of the boulder revetments and therefore reduce the potential for the undermining of these structures during periods of low sand supply and/or storm conditions.

The application of groynes to mitigate shoreline erosion and inundation hazards along the study area (as opposed to simply trying to improve beach width and amenity) does not prevent exposure of assets to erosion or inundation hazards in the sense that a boulder revetment or seawall provides protection. Groyne fields are reliant on the supply of sand for them to be effective in managing these hazards and they can be depleted of sand to the extent that erosion hazards can still impact areas landward of the immediate shoreline. This has occurred historically in the study area where the groyne fields have been depleted and shoreline erosion hazards have only been mitigated by the presence of boulder revetments.

Groynes do assist in maintaining beach levels and the associated recreational amenity of the study area. It is important to note though, that at the time any existing groynes are rebuilt, or new groynes installed the beach compartment to the west of the structure should be filled with sand, termed ‘beach nourishment’. It is recommended that they not be allowed to fill by simply intercepting the natural longshore transport that prevails locally. This is because any sand that collects updrift (west) of a groyne to fill a beach compartment deprives the downdrift foreshore (east) of the trapped sand. This then accelerates erosion of the downdrift areas.

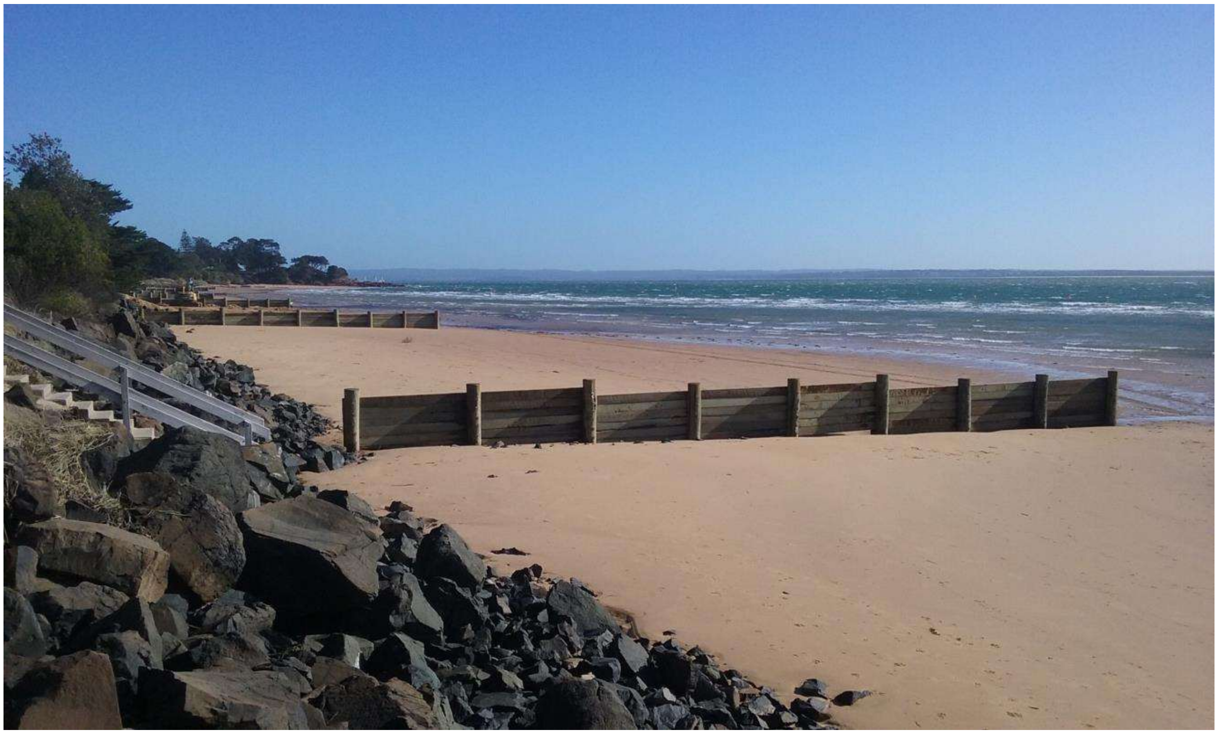

FIGURE 8-1 NEW GROYNE STRUCTURES INSTALLED NEAR BROUGHTON AVE

#### 8.2.1.1 Recommendations

- The maintenance of the landward most sections of the existing groynes, abutting the boulder revetments, will assist in holding sand at the toe of the boulder revetments and limit the potential for undermining and failure of the structures.
- In line with current coastal policy, a program to maintain or replace existing groynes for the primary purpose of maintaining a beach for recreation or amenity purpose could be implemented whilst ensuring that any potential impacts on downdrift sections of the coastline are minimised. This can be achieved through a program of beach nourishment works.

### 8.2.2 Boulder Revetments

As discussed in Section 6.1.2, the boulder revetments are considered to have been relatively successful in limiting the degree of shoreline recession observed along the study area although when exposed they have a tendency to flatten and lower the beach profile. The boulder revetments have provided a last line of protection against shoreline erosion and inundation hazards without, in general, negatively impacting the downdrift section of coastline or the ability of the beaches to naturally rebuild as the cyclical supply of sand to the coastline has increased.

Given the significant historical investment already undertaken in constructing the boulder revetments along the study area and the community's familiarity with these structures on this coastline, where appropriate, their maintenance and upgrade as the primary form of the shoreline protection works is considered likely to be the most economic, effective and appropriate medium-term option for the study area.

The following recommendations are therefore provided for consideration for ensuring an adequate level of protection to assets and infrastructure is provided by the boulder revetments along the study area coastline and that their impact on beach amenity and down drift sections of coastline is minimised over the medium term.

#### 8.2.2.1 Recommendations

- A gradual program of upgrades to the boulder revetments is required in general to bring the revetments up to an appropriate and uniform engineering design standard and increase the resilience of the revetments to increasing sea levels and potentially more prolonged exposure to wave action in the medium term.
- To prevent armour stones from being dislodged from the revetments and deposited on the beach and to improve the stability of the revetments for the public when they are accessing the beach, larger and more uniformly sized armour stones should be applied during the upgrade of the revetments.
- The section of boulder rampant near Dunsmore Road as shown in Figure 8-2 is the highest priority for reconstruction/upgrade as it is currently vulnerable to overtopping due to combined storm tide and wave action. Some upgrade works have been undertaken at this location since the original 2010 study, as shown in the figure.
- A rock revetment design for the shoreline in the vicinity of Dunsmore Road is provided in Figure 8-3 (AME, 2012). This design proposes a crest elevation of around 3m AHD and is assumed to include provision for wave action and projected sea level rise over the next 20-30 years. Typical unit costs for construction of this type of structure are generally in the order $7,000 - $8,000/ linear meter. This cost does include background investigations and approvals, preliminaries (detailed design, mobilisation/demobilisation, surveys, engineering inspections etc), but not associated works such as pathways or beach access structures. Any new wall needs to be constructed to predicted 2070 design levels with consideration of the likely requirements to 2100, i.e. increased rock sizing and crest elevations.
- The alignment of the boulder revetment constructed east of Coghlan Road has locked up a significant quantity of sand resulting in very significant terminal scour to the east around Sanders Road. The present alignment of the boulder revetment east of Coghlan Road is considered unlikely to allow for the natural accumulation of sand on the beach in front of the revetment and significant downdrift erosion problems are considered likely to occur again in the future. As a low priority action, Council could investigate options for realigning this section of boulder revetment so that its impact on downdrift sections of coastline is reduced in the future.
- As an alternative to stone/rock, geotextile sand containers could be considered for reconstruction of revetments in the study area. Geotextile sand containers provide a ‘soft’ finished alternative to stone and are generally considered to have lower visual landscape impact on shorelines. Geotextile sand containers do however come with cost and durability trade-offs compared to stone/rock. They have a maximum design life of around 25 years and are consider more a short to medium term management option.

2010

2018

**FIGURE 8-2 BOULDER REVETMENT AT DUNSMORE ROAD REQUIRING RECONSTRUCTION**

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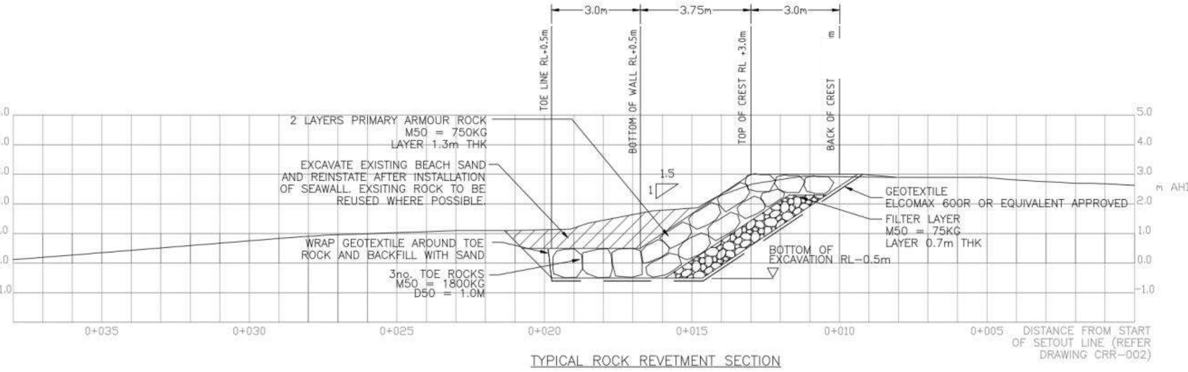


FIGURE 8-3 CONCEPTUAL ROCK REVETMENT UPGRADE DESIGN (AME, 2012)

### 8.2.3 Timber Walls

The timber wall between Rose Avenue and Coghlan Road is currently exposed. The timber wall is backed by a boulder revetment, also now exposed. The historical evidence suggests the timber wall was not effective in preventing shoreline erosion and the reflection of waves in front of the timber wall appeared to lower the beach and limit the ability of the beach to naturally rebuild as the supply of sand increased.

#### 8.2.3.1 Recommendations

- A short-term option to address the on-going erosion of the shoreline at the rear of the timber wall is to provide sand nourishment between the wall and the backshore. This additional volume of sand would provide an erosion buffer and assist in supporting the structure to allow time to implement long term solutions.
- Removal of the timber wall and replacement with a suitable protective structure may require consideration in the future if the beach in front of the wall begins to recede such that the timber wall becomes further exposed and either presents a safety hazard or begins to reflect waves and lower the beach continues. Costs to replace the timber wall with a rock revetment would be in the order of $7,000 to $8,000 /linear meter. Assuming a distance of around 370m between the start of the current timber wall and Coghan Road, the costs would be in the order of $2,590,000 to $2,960,000. This does not include the cost of removal of the existing wooden and rock structure or providing beach access and/or associated works such as walkways and revegetation.

### 8.2.4 Beach Nourishment

Beach renourishment is a soft protect option for erosion management that has minimal impact on the surrounding coastline. The most important factor for beach renourishment is that there is enough sand on the beach to provide a buffer during a storm event. The key contributing factors for the nourishment to be successful is sourcing the right sized sand, the profile in which it is placed and the ongoing monitoring and management of the nourishment. The sand size needs to be of the same size or larger than that experienced at the beach face as smaller sediment is more easily eroded and will be moved away from the area of interest at a relatively fast rate.

Water Technology has recently undertaken a coastal erosion management report for the Cowes Main Beach Foreshore Reserve which details a beach nourishment option (Water Technology 2018). As stated within the Cowes Main Beach report there is the potential for sand to be acquired from the Anderson Road boat ramp which is located just over 2km from Erehwon Point, the benefits of which is that the sediment size is likely to be of the same size. The sediment can be placed in a specific profile which aims to mimic that of the existing beach or it can be dumped and naturally redistributed by wave action. The benefit of sculpting the profile is that the beach maintains it amenity which is not the case when the sand is placed in piles on the beach face.

Sand for renourishment works can come from a range of sources, including:

- Beach scrapping, where sand from within the local sediment compartment is utilised,
- Pumping of sand from nearby sources, potentially outside the local sediment compartment,
- Imported sand from other sources such as quarries.

Beach nourishment works will likely be required on a regular basis to build resilience in the coastal system particularly given the episodic supply of sand to the area.

#### 8.2.4.1 Recommendations

- As discussed in Section 7.3.1, eastward migration of the backshore sand lobe indicates a dominant west to east sediment transport in the study area. Therefore, beach nourishment works could be accompanied by other protection options such as groynes to hold the sediments in place and limit sediment loss to the eastward sand lobe migration.
- Beach nourishment requires ongoing monitoring as the sand is transported within the nearshore coastal zone and off the beach face.
- Beach nourishment should be included with any groyne upgrades or when new structures are provided.
- Specific locations for priority beach nourishment works include:
  - Those areas where groynes have been upgraded or new groynes installed,
  - The area affected by terminal scour between Coghlan Road and Sanders Road, and
  - Between Rose Ave and Coghlan Road where the timber wall is currently exposed.

Particularly where the timber wall is exposed, beach nourishment works would provide an immediate buffer to mitigate against further storm erosion.

### 8.2.5 Vegetation and Access Management

Access to significant sections of the beach along the study area is currently gained via multiple informal tracks and beach users are required to climb or descend the boulder revetments at many locations along the study area (see Figure 8-4). The limited management of beach access along the study area has resulted in the trampling of vegetation and exposure of mobile sand dunes. A number of community members reported annoyance at the extent of windblown sand that drifted across roads and into private property along the study area.

#### 8.2.5.1 Recommendations

- Formalisation of access and fencing of dune vegetation along the study area is recommended to limit the loss of sand from beaches and limit nuisance windblown sand impacts.
- Additional staircase and/or ramp access points across the boulder revetments are recommended to improve beach access for those less able.

FIGURE 8-4 MULTIPLE BEACH ACCESS PATHS AND WIND-BLOWN SAND IMPACTS NEAR ROSE AVENUE

## 8.2.6 Planning Controls

The enforcement of planning controls and assessment of the vulnerability of new developments to coastal hazards under existing conditions and under projected sea level rise scenarios is considered a critical component of the various options available to manage shoreline erosion and inundation hazards along the study area.

Bass Coast Planning Scheme includes planning controls known as overlays, which provide special conditions relating to development. Schedule to the Land Subject to Inundation Overlay (LSIO, 2018) includes provisions for coastal development summarised here.

For land below 5m AHD, the responsible authority may require that a Coastal Hazard Vulnerability Assessment be prepared to accompany subdivision, accommodation and earthwork permit applications. The following should be included:

- Location plans,
- Elevation plans,
- Site plan shown coastal inundation extents for a 1% AEP storm tide levels for the present day and projected 2040, 2070 and 2100 conditions.
- A set of coastal hazard maps for the sediment compartment for the planning periods: present day, 2040, 2070 and 2100 showing the geographic extent of the coastal hazards in relation to the site.
- Statement of actions or measures required to the siting and design of the buildings or works to reduce the risk to individuals, property, infrastructure and the environment over the predicted life of the buildings or works. These actions may include the consideration of adaptation options such as planned retreat, setbacks, accommodation of changes through floor heights, site and land forming and drainage works.

#### 8.2.6.1 Recommendations

- Continue to enforce planning controls and assess the vulnerability of new developments along the study area to existing coastal hazards risk and those associated with projected sea level rise.

## 8.3 Long Term Options / Sea Level Rise > ~0.5m

The broad and significant shoreline recession and inundation hazards identified in the study area due to the sea level rise projections for the end of this century are such that a strategic scale adaptation plan for the study area will be required to be developed to appropriately plan for and manage the risks posed by sea level rise. The adaptation plan will require analysis of the social and economic costs and benefits of various adaptation options for the study area and the establishment of thresholds or trigger points for optimal timing of the adaptation responses to be undertaken.

Adaptation approaches for managing coastal hazards risks to infrastructure and assets can be most conveniently summarised in terms of protect, accommodate and retreat. To provide an indication as to the range of possible adaptation options that might be considered as part of a strategic adaptation plan for sea level rise for the study area coastline, adaptation options encompassing these three adaptation approaches are considered in the following sections. It should be noted that these potential adaptation options do not constitute recommendations for the study area.

### 8.3.1 Do Nothing

- Leaving the shoreline to naturally erode and accrete without any intervention,
- Make no changes to existing coastal protection infrastructure within the region.

This is a difficult option to implement along the study area given the long history of intervention.

### 8.3.2 Protect

- The boulder revetments would require major upgrade along the entire length of the study area shoreline. The upgrade would include the following;
  - Significant increases in the height of the revetment to prevent storm tide and wave overtopping,
  - Increases in rock armour size to protect the revetment against the action of larger design wave conditions, and
  - More extensive toe foundation works to prevent the revetment from being undermined as the beach lowers in front of the revetment due to sea level rise.
- A bund/levee system would potentially be required to mitigate the ingress of tidal and storm surge flows from Rhyll Inlet towards the study area coastline from the south.
- An ongoing beach renourishment program could be implemented.

### 8.3.3 Accommodate

- Floor levels of buildings and finished levels of roads and other infrastructure in the study area would be required to be increased above the 1% AEP storm tide levels, including freeboard provisions.
- The stormwater system and drainage systems would require modification to enable them to provide free egress of stormwater under higher tailwater level conditions.
- Septic and sewerage systems in the study area would require upgrades to seal them from higher saline coastal groundwater systems.

- Planning controls will require strengthening and enforcement to prevent intensification and/or expansion of development in the study area where protection options are not considered appropriate or viable over the long term.

### 8.3.4 Retreat

- Retreat would include removal of any existing redundant coastal protection structures,
- Either compulsory or opportunistic acquisition of vulnerable properties would be required to gradually retreat from areas deemed too vulnerable/expensive to protect.

### 8.3.5 Recommendations

It is recommended that a long-term coastal adaptation response strategy be developed across the whole study area, which considers the coastal hazard risks as well as the economic, environmental, and social considerations relating to the coastal protection. Such a strategy will need to integrate the do nothing, protect, accommodate and retreat approaches across the study area, and may have different trigger points for adaptation options in different areas.

The strategy should allow Bass Coast Shire to periodically review the latest climate change projections produced by relevant authorities to determine the significance of any changes, particularly in terms of the predicted rate of sea level rise, on the assessments undertaken in this review. This may alter trigger points for options under the various categories.

In developing such a strategy, a cost-benefit analysis should be undertaken, including implementation, operation/maintenance, environmental, and social considerations to assist in determining the relative benefits or otherwise of upgrading or new coastal structures to protect against erosion and accommodate increased mean sea levels and storm tides.

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# APPENDIX A
# COMMUNITY CONSULTATION FEEDBACK

*Summary of community comments received prior to and during the 27 October 2010 Community Information Sessions*

| |
|---|
| Cannot make it to community information sessions. Have lots of knowledge of the study area over time, family goes back generations with a property in the area. Husband saw the rock wall go in. Has information dating back to the 1930s. There is a photo in Cowes Photo First that is a good image of the area from the beach. |
| Can't make it to Community Information Sessions. Tea-tree is important in protecting against wave erosion but it must be trimmed, when it gets too tall it falls over. |
| ■ Concern about the downstream effects at Observation Point if we put in infrastructure at Cowes East.<br>■ You should be looking at the whole north shore, not just Cowes East, back to the Knobbies.<br>■ Feel that the study should look further west.<br>■ Wind data from Rhyll may be different to Cowes East.<br>■ What effect has illegal vegetation removal had on anchoring soil at Silverleaves and where the Cypress was removed at Stradbroke Avenue Cowes?<br>■ There used to be significant sand dunes at Lovers Walk and Banksia at Silverleaves. |
| We have owned our property for 60 odd years. I believe groynes need replacing and maintenance. |
| Will you build more groynes? |
| Would like copies of the Water Technology photos that were displayed at the Community Information Session. Keen for the groynes to stay and be extended. |
| Groynes require full replacement after accidentally being "cut apart" a few years ago in 'Lovers Walk'/Stradbroke Av areas. Due to Erehwon Point protection from westerlies, any northern wind which erode sand and foreshore; these groins held sand together |
| Groynes Must be reinstated. Have a look at the internet and see how groynes have worked at other places in the world. Regional development Australia could be a potential funding source. |
| I want to put some sand bags over the boulders in front of my place. I have toddler grand children who may injure themselves. The rocks are jagged and unsafe. I'm willing to pay for the sand bags myself. |
| Have observed that swell waves are quite predominant in the area (I ride a kayak in the area regularly). Ebb tide appears to be fiercer than flood tide when kayaking, mainly in the area between Cowes Jetty and Erehwon Point. Is there a way of measuring |

# APPENDIX B
# COMMUNITY HISTORICAL PHOTOS

FIGURE 9-1 COMPARISON OF TIMBER WALL IN THE VICINITY OF SANDERS ROAD: TOP – CIRCA 1970S, MIDDLE – JULY 2011, BOTTOM – JULY 2018

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**FIGURE 9-2 COMPARISON OF GROYNES NEAR SANDERS ROAD: TOP – CIRCA 1970, MIDDLE – JULY 2011, BOTTOM – JULY 2018**

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