Lucky Bay Shack Settlement – Coastal Review, Concept Option Development and Detailed Design

Coastal Processes and Concept Design Report
(DRAFT)

December 2013

SMEC

Prepared for: **District Council of Franklin Harbour**

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PREPARATION, REVIEW AND AUTHORISATION

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EXECUTIVE SUMMARY

The Snowy Mountains Engineering Corporation (SMEC) was commissioned to undertake the Coastal Processes and Concept Design Report on behalf of District Council of Franklin Harbour. This report delivers protection options that address the coastal hazards at Lucky Bay.

The beach at Lucky Bay has historically undergone periods of shoreline recession due to a net deficiency in the sediment supply. This is due to changes in the shoreline to the west which subsequent reduces the rate of longshore drift entering the Lucky Bay embayment while the rate at which it exits the embayment to the east has remained constant. The development of Lucky Bay Ferry Harbour has also had an impact of the net west to east longshore drift, altering beach processes. Facing into the dominate wave direction, Lucky Bay is infrequently exposed to large waves and storm surges with can cause hazardous storm erosion.

45 shacks are under immediate risk from storm erosion with 93 shacks expected to be under risk by 2050. At present shacks most threatened by coastal erosion hazard are in the eastern and middle sections of Lucky Bay, while by 2050 the entire eastern sector is threatened. Furthermore, in the event of an extreme storm surge and high tide, 94 shacks are expected to be threatened by the coastal inundation over the 2050 planning period. Based on a recent survey of the shacks floor levels, the average depth of flooding during such an event is expected to be around 0.4 m. The entire western sector is most threatened by coastal inundation hazard.

Coastal protection works are likely to extend the life of the shack settlement, possibly out to 2100, but would not be permanent solutions. The lease arrangements at Lucky Bay offer flexibility to manage coastal hazards that are likely to become more severe in the future. Regardless of the coastal protection measure adopted, it is not recommended that the lots be converted to freehold title. However, feasible and cost-effective measures are available to enable the granting of the next long-term lease. In view of this, a combination of options and a stage approach is recommended to maximise the timeframe over which occupation of the shacks is viable. Ultimately the preferred solution to take forward falls to Council and the shack owners, however, based on the finding of this investigation, the recommended Lucky Bay coastal protection strategy is:

- Implementing the Lucky Bay beach nourishment/ replenishment strategy with an estimated capital cost **$1.3 million**, and ongoing costs of around **$20,000/yr**.
- Raising Lucky Bay Boulevard to protect against coastal inundation, at an estimated capital cost **$0.7** million
- Staged filling of the Recreation Reserve to provide an opportunity to build new shacks as existing shacks are damaged or become at risk post 2050.
- New shacks to be relocatable so that over the longer term they can be moved if/ when they become at risk.

The costs provided above do not account for significant reduction in the costs that may be achieved if a suitable arrangement can be made with the developers of the Lucky Bay CUEF.

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PART A
Concept Design Options

1 INTRODUCTION

Lucky Bay is located approximately 11 kilometres east of Cowell on the western shore of Spencer Gulf in South Australia (see **Figure 1**). Lucky Bay is a small indent in the coastline located 5 km up the coast (north east) from the Franklin Harbour embayment.

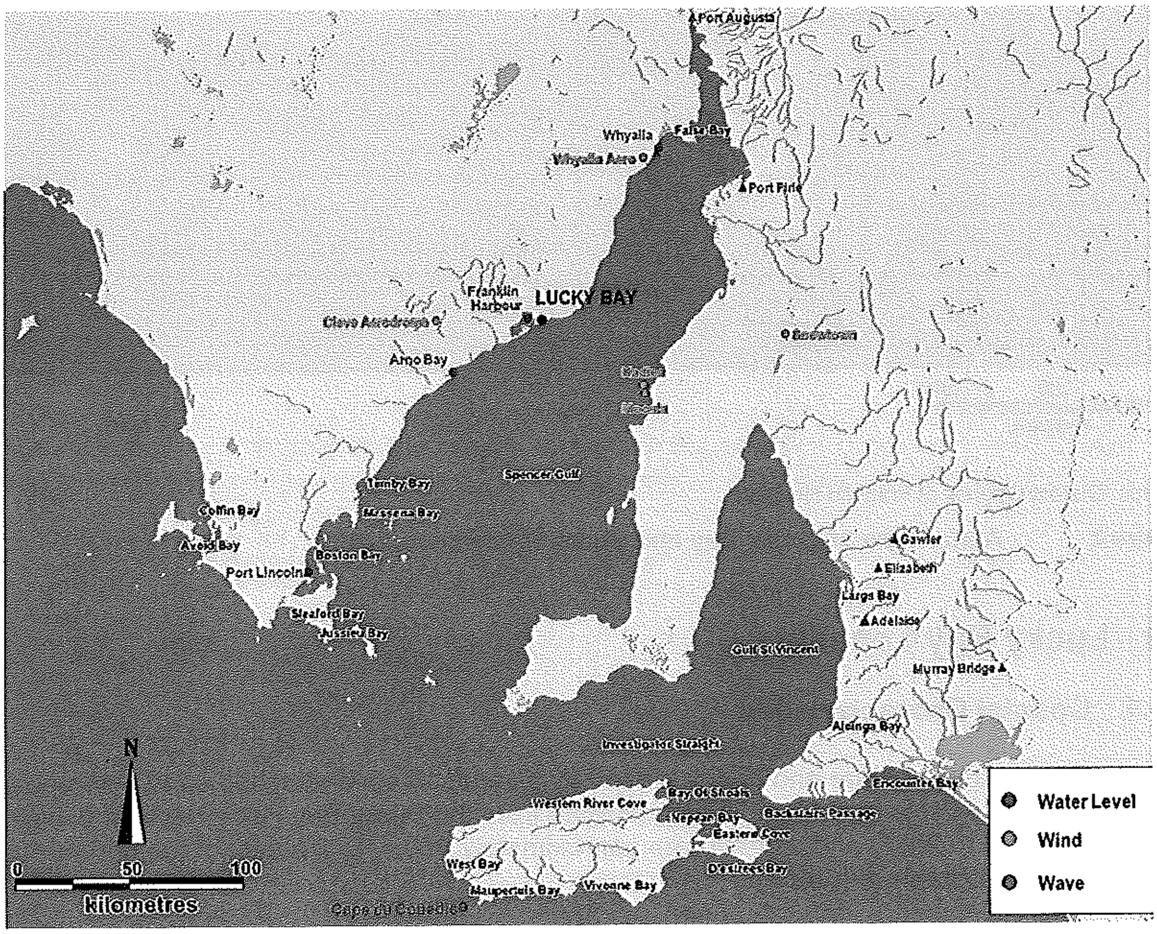


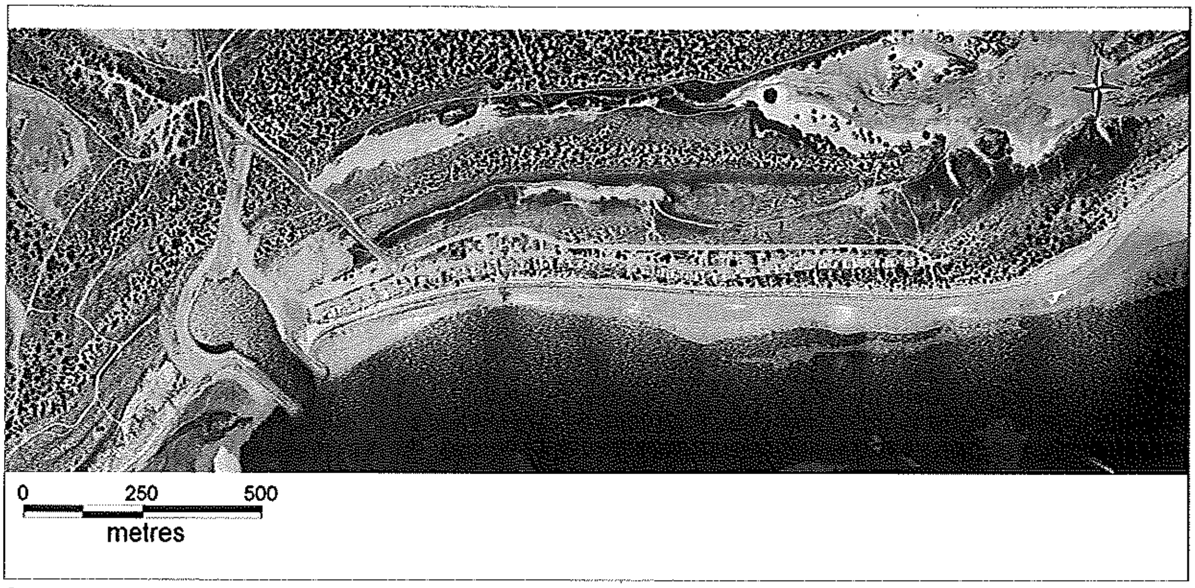
Figure 1 **Locality Plan and Location of Known Data**

Lucky Bay comprises 124 shacks arranged in a linear fashion along the coastal frontage, see **Figure 2**. The shacks were constructed between 1945 and 1970. The majority are occupied seasonally and some are privately rented. The shack settlement is Crown leasehold tenure which expires in 2026.

The Lucky Bay foreshore has undergone various episodes of storm erosion and areas of shoreline recession for many years. Various forms of *ad hoc* erosion control works have been implemented over the past decades. These have not been effective and are, in some locations, exacerbating the erosion problem.

Fargher Maunsell (1985) noted that...*all shacks will be subject to significant unacceptable risks from seawater inundation over the next 100 years. These risks arise from a combination of coastal erosion, potentially high sea levels relative to shack levels and the flooding of access roads* (Franklin Harbour District Council 1989).

Renewal of the leasehold requires a long-term solution to the coastal hazards currently facing the Lucky Bay shacks. If a feasible solution cannot be found it is likely that the shack settlement may no longer be viable.



Source: District Council of Franklin Harbour

Figure 2 **Aerial View of Lucky Bay and Shack Settlement (2012)**

1.1 Lucky Bay Locality

1.1.1 Coastal Characteristics

The coast is sandy in nature and characterised by a series of semi-attached sand bars and tidal inlets. The foreshore is largely undeveloped apart from the Lucky Bay Ferry Harbour (which was constructed in 2006) and a boat ramp approximately 450 m to the east of the harbour (see 2012 aerial photograph, **Figure 2**).

The Lucky Bay beach planform is predominately east-west orientated but curves south-east toward the ferry harbour. There are extensive seagrass beds immediately offshore from the beach. The size of the incipient dune indicates a low energy wave climate.

1.1.2 Land Use

Current land uses around Lucky Bay are shown in **Figure 3**. Two areas to the north of the Lucky Bay settlement have been cleared of vegetation and are used for cropping, with the majority of the surrounding land to the north having been used for grazing. The tidal flats immediately to the north and east of the settlement and those west of the harbour have also been used for grazing. There is a narrow coastal reserve along the foreshore of Spencer Gulf to the east and west of the shack settlement.

1.1.3 Services

A waste transfer station and landfill are located to the north-west of the settlement, with a gravel quarry further away to the north-west. The location of electricity, telecommunications and private water supply mains are also shown on **Figure 3**.

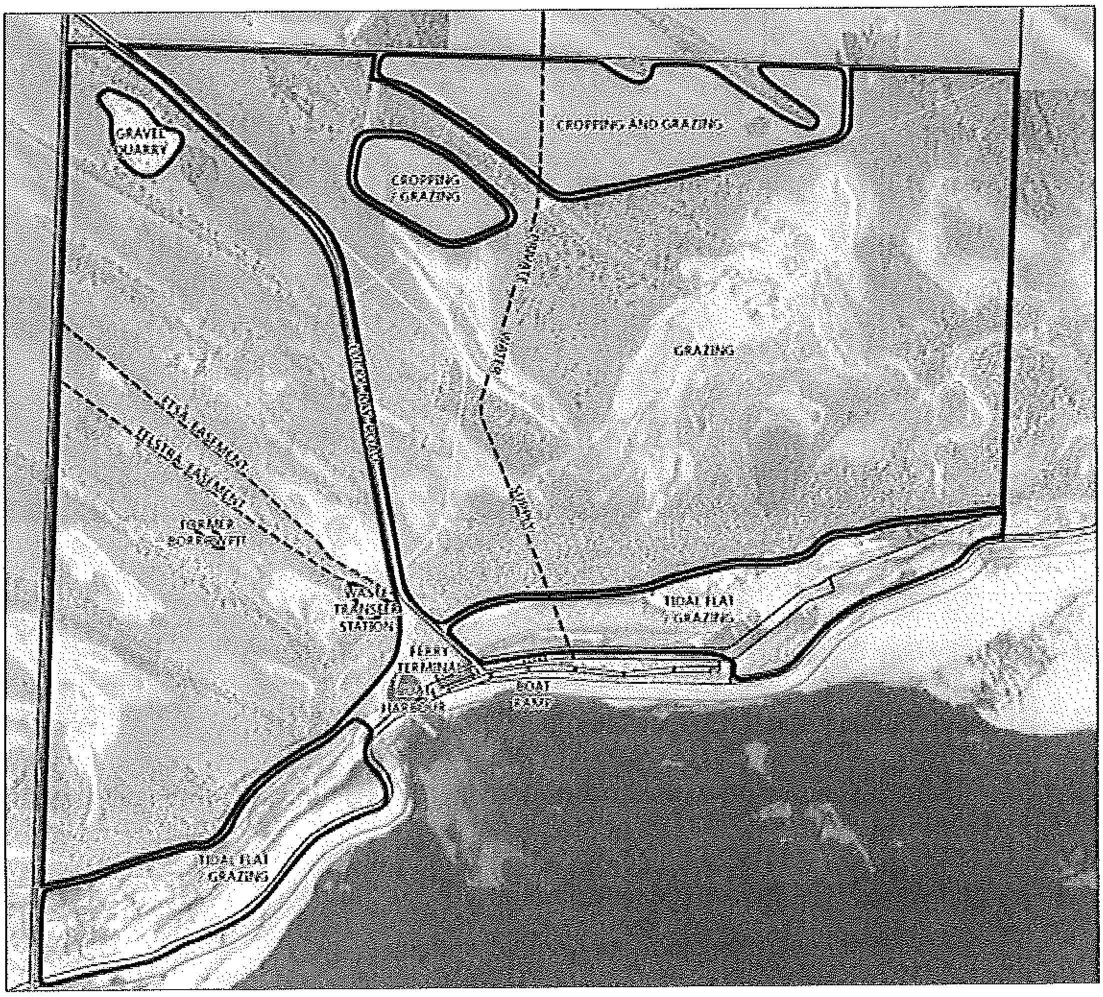


Figure 3 Land Use (Masterplan SA Pty Ltd 2011a)

1.1.4 Tenure

The shacks are located in Sections 38-44 Hundred Plan 533300 which are seven rectangular super lots each containing multiple shacks. A number of additional lots were created in 1995 (DP 42395) including four larger lots on the northern side of Lucky Bay Boulevard, see **Figure 4**).

Lots 1-12 DP 42395 to the north of the existing shacks and west of Lucky Bay Road were created to accommodate shack relocations, but remain vacant. It also appears that lot 16, east of Lucky Bay Road and north of the shacks, was created as a super lot for shack relocation. The existing shack super lots (Blocks 1 to 6 in **Figure 4**) and other ancillary land in DP 42395 are leased to Council for shack administration purposes, with sub-leases for defined shack boundaries established by Council. Historically the lease to Council has been renewed every 10 years for a further 30 year period.

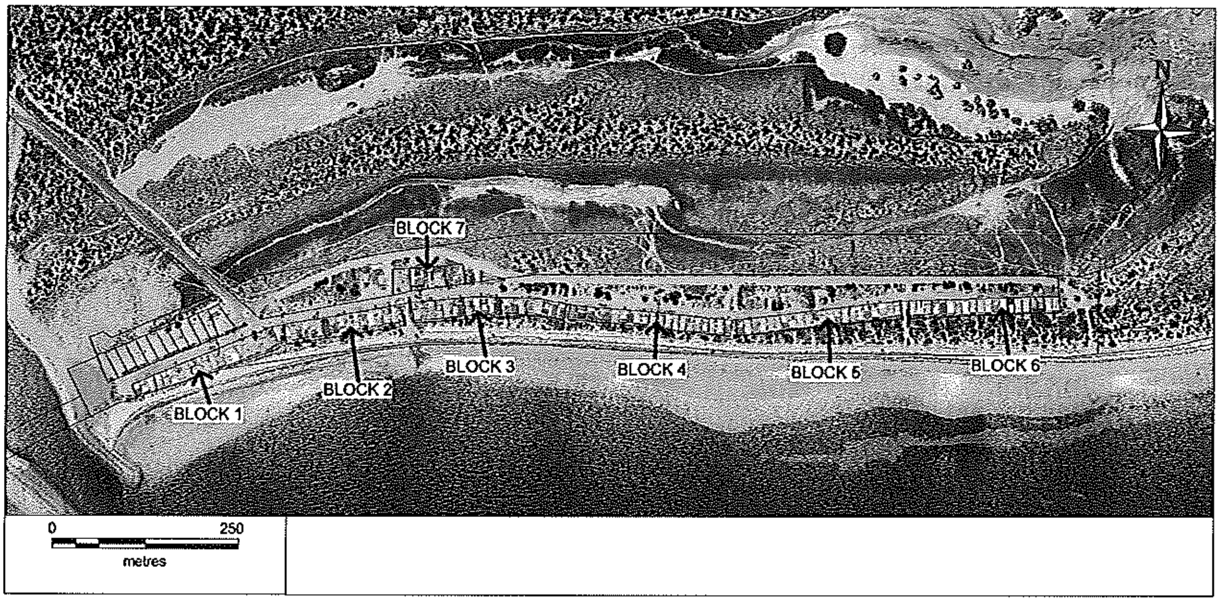


Figure 4 Lucky Bay Shack and Lot Boundaries

1.2 Study Scope and Objectives

In response to the issues being experienced at Lucky Bay, Council has commissioned SMEC to:

- undertake coastal processes investigations
- identify and assess feasible management options
- identify a preferred option(s) and undertake detailed design and cost estimates.

The study area for this investigation incorporates the 1.4 km length of the Lucky Bay foreshore fronting the shack settlement. The wider area of the Spencer Gulf estuary is included in the study area insomuch as it influences erosion along the Lucky Bay foreshore. This report covers initial investigations as described below.

Part A provides a summary of coastal processes and risks, and identifies feasible and practical options for long-term management of coastal risks to the shack settlement at Lucky Bay. This includes an assessment of the most practical options taking into consideration environmental, social and economic factors. Part A concludes with a recommendation for a preferred option based on practicality, cost-effectiveness and our improved understanding of sediment transport processes along the beach.

Part B provides a technical review and analysis of information for the purposes of determining coastal processes at Lucky Bay. This assessment includes sediment transport and water level processes, both of which can be potential hazards affecting the long-term suitability of coastal protection options at Lucky Bay.

Based on the Return Brief and discussions at the inception meeting, the main objectives of this study are:

- Review of existing data and provision of advice on the level of risk to the existing settlement from coastal processes over the next 30 years.

- Development of concept options for protection of the shack settlement from coastal hazards. For options to be further considered they must be capable of adequately protecting the shack settlement from coastal processes for a period of at least 100 years.
- Preparation of preliminary cost estimates for three identified options, i.e. revetment, beach replenishment, and shack relocation.
- Assessment of the three options, including cost estimates to the shackholders.
- Development of detailed design and a cost estimate for the preferred option.

Minutes from the inception meeting attended by representatives from Council, MasterPlan SA Pty Ltd and SMEC are included in **Appendix A**.

1.3 Summary of Coastal Processes

Three coastal compartments (as indicated below) were identified for the purposes of describing coastal processes, in the absence of the influence of the Lucky Bay harbour. The net longshore sediment transport affecting these compartments is to the east.

Western Sand Spit (now west of the ferry harbour training walls):

- Sand slug migration partly feeds net accumulation of sediment along this spit.
- Net accumulation of sediment pushes eastern end of sand spit 'sand headland' east as spit extends.
- Net bypassing occurs along two pathways, the dominant pathway (approximately 6,000 m^3) around the shoreline and possibly a 'storm shortcut' pathway from the 'sand headland' through deeper water and then to Lucky Bay beach.
- Episodic rapid erosion of the 'sand headland' and transport along the 'storm shortcut' pathway is likely to occur.

Lucky Bay Beach (from Western Sand Spit to about two-thirds the way along the shack settlement):

- Recession of the shoreface is due to net deficit in sediment supply, estimated to be -2,000 m^3/yr between 1985 and 2013.
- Beach embayment changes shape as 'sand headland' control extends east (or retreats west) resulting in a change in the geometry of the shoreline, with accretion in one location and recession in another.
- Localised protrusion, 'lump' (see **Figure 2**), in seagrass/ sandy seabed interface about two-thirds along the shack settlement foreshore is likely to be where the 'storm shortcut' sediment pathway re-joins the shoreline littoral drift system.
- Periods of accretion at Lucky Bay are possible if material from the 'sand headland' is washed into the beach embayment by storms.
- Storm erosion (cross-shore process) is a constant threat particularly in winter during stormy years.

Eastern Sand Spit and Inlet Area (from the 'lump' to, and including the shoals around the eastern tidal inlet):

- Beach face accretion of 2,850 m^3/yr is likely to be a steady ongoing process.

- Beach face accretion is only part of a much higher expected accretion across the spit sand flats and inlet system.
- Net accretion is fed by longshore drift including erosion of Lucky Bay beach and bypassing from the Western Sand Spit, 'sand headland'.

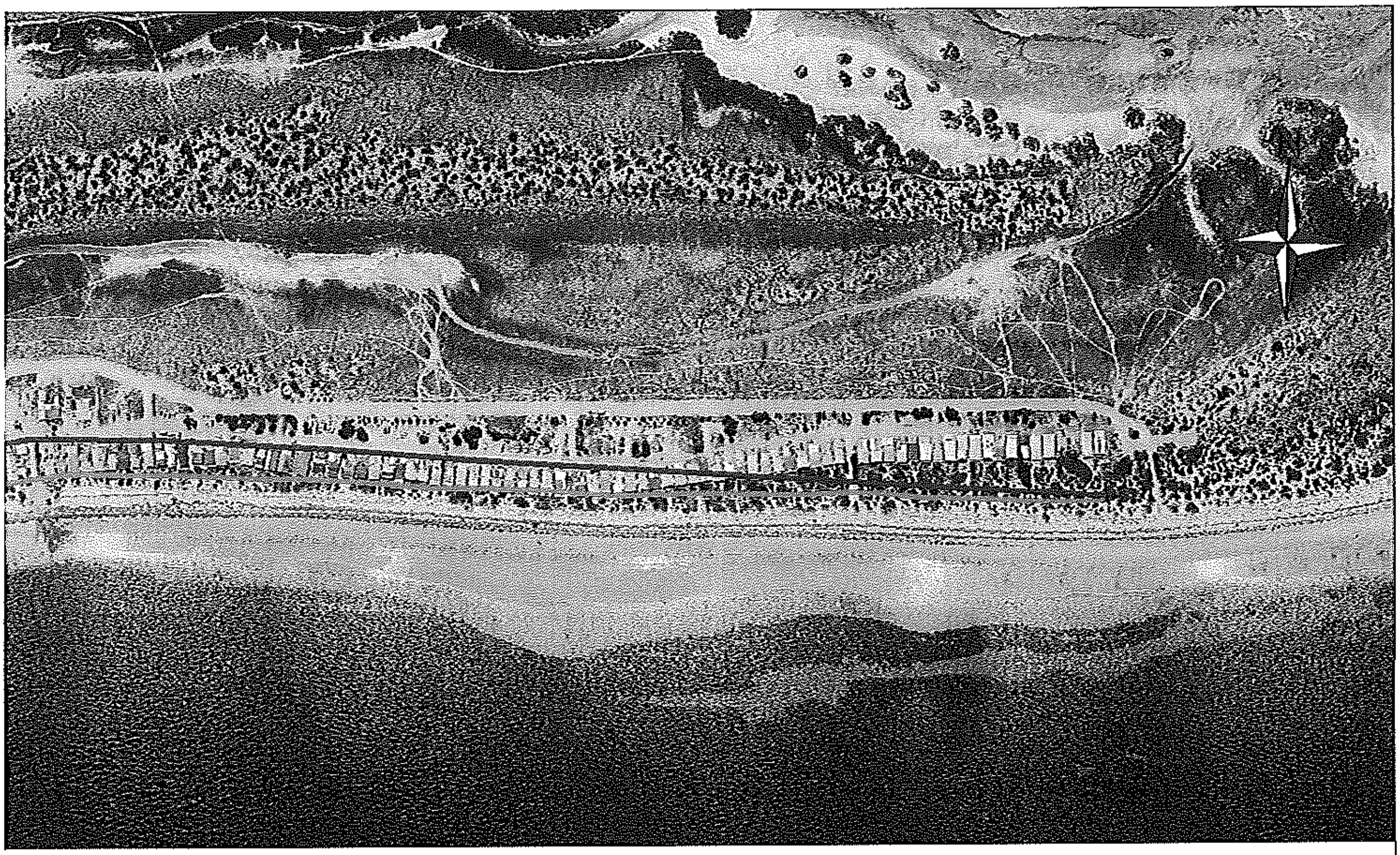
Refer to **Part B**, **Section 5.2.1** for further information.

1.4 Coastal Hazards Risk Assessment

Beach erosion and shoreline recession are the two most significant coastline hazards that have the potential to affect the shacks at Lucky Bay. These two hazards have been reviewed and the position of coastal hazard lines[1] mapped for the shack settlement. **Figure 5** presents the immediate and the 2050 hazard lines resulting from this assessment.

As indicated in **Figure 5**, 45 shacks are expected to be impacted by the immediate hazard line with 93 shack expected to be impacted by the 2050 hazard line. At present shacks most threatened by coastal erosion hazard are in the eastern and middle sections of Lucky Bay, while by 2060 the entire eastern sector is threatened (see **Figure 5**).

[1] Coastal hazard lines are used to identify areas that are at risk from coastal hazards such as storm erosion. Here the immediate coastal hazard line is defined as the position of the landward setback to the top of the storm erosion scarp, following a coastal storm with an average recurrence interval (ARI) of 100-years. The 2050 coastal hazard line is defined as the position of the top of the storm erosion scarp following a 100-year ARI coastal storm occurring around the year 2050. The 2050 coastal hazard line includes an allowance for shoreline recession between now and 2050.



	IMMEDIATE HAZARD LINE		2050 HAZARD LINE

ıy

1.4.1 Storm Erosion

As there are no known measurements of local storm demand[2], 50 m^3/m has been adopted based on similar values identified by Gordon (1987) for protected beaches (i.e. beaches within embayments as opposed to those on the open coast). A recent topographic survey (June 2012) was used as the base for pre-storm beach profiles. To calculate the immediate hazard line (2010), the 50 m^3/m storm demand volume was removed on a profile by profile basis after the method established by Nielsen *et al* (1992).

The hazard lines presented are in the absence of any measures taken to reduce the impact of storm erosion or long-term sediment losses.

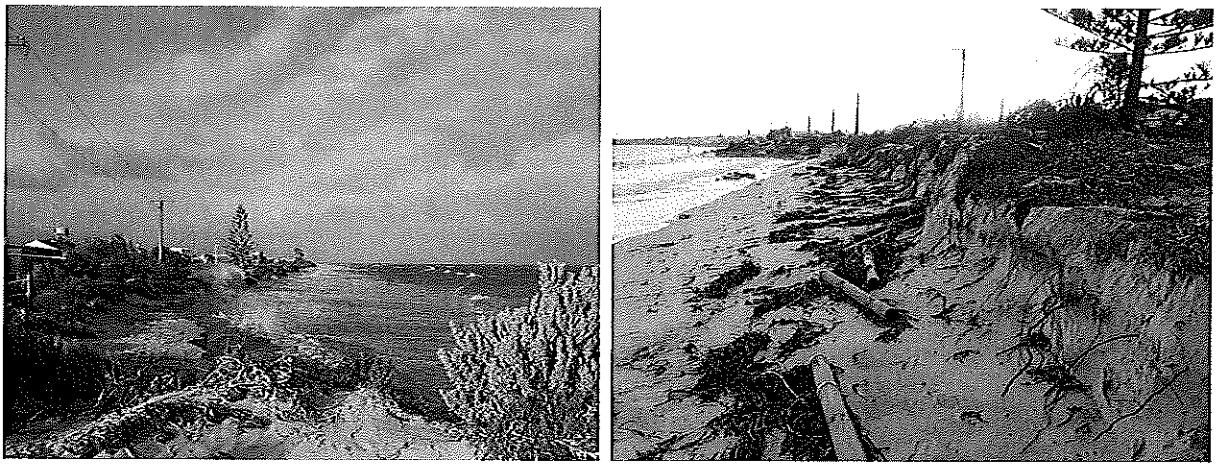


Figure 6 Examples of Storm Erosion May 2010 (area east of boat ramp)

1.4.2 Shoreline Recession Due to Net Sediment Loss

For some beaches, the amount of sand taken out of the beach compartment exceeds that moving into the compartment from adjacent areas or other sources. For these beaches there is a direct and permanent loss of material from the beach and a deficit in the sediment budget (i.e. a net sediment loss). This will result in long term shoreline recession and an increased potential for dune erosion during storms.

An assessment of the beach profile data (see **Section 6.3**) provided by the Coastal Protection Board (CPB) suggests that the long-term rate of sediment loss, when averaged across the beach compartment is around 2,000 m^3/yr. This translates to a landward shoreline recession of around 0.7 m/yr, when averaged across the eroding compartment. These rates are based on available data from 1985 to 2006, a period when the shoreline was in a natural state, prior to the construction of the harbour training walls. The net recession is added to the immediate hazard line to determine a hazard line for the 2050 planning period. The long-term 'natural' recession rate of 2,000 m^3/yr, or 0.7 m/yr, has been applied in this case because:

- it is conservative in the sense that it is greater than the compartment averaged recession observed since construction of the harbour, although recession since is likely to be masked by the associated nourishment works; and

[2] Storm demand is the volume (expressed in cubic metres per metre of beach length or m^3/m) of sand which can be removed during a significant storm event. This quantity is generally measured above 0 m AHD.

- it is anticipated that net easterly longshore drift will re-establish via bypassing of the training walls. The long term recession has been applied taking into consideration of the harbour training walls and the likely resulting beach equilibrium shape. At the eastern end of Lucky Bay there is net accretion. Consistent with a conservative approach, a zero recession rate of has been applied in this location.

1.4.3 Shoreline Recession Due to Sea Level Rise

An allowance for shoreline recession due to rising sea levels, predicted to result under future climate change projections (IPCC, 2007), has been applied to the 2050 hazard line. This allowance has been calculated using the Brunn Rule (Brunn, 1962) which is based on the concept that sea level rise (SLR) will lead to erosion of the upper shoreface, followed by re-establishment of the original equilibrium profile a distance landward. The landward recession distance calculated via the Brunn Rule is equal to the SLR multiplied by the average inverse slope of the active beach profile. The Brunn Rule is considered applicable to Lucky Bay as the beach profile geometry has generally been maintained over the period of record from 1985 (Brunn, 1988). Based on this and the CPB beach profiles, the adopted slope of the active beach profile is 1 in 10.

The CPB sea level rise policy is an increase above 1990 mean sea levels of 0.30 m by 2050 and 1.00 m by 2100 (CPB 1992). Adopting this, the 2050 Hazard Line includes a 3.3 m setback allowance for shoreline recession due to the 0.3 m rise in sea level.

1.4.4 Coastal Inundation

The 100 year ARI design water levels for Lucky Bay were based on an analysis of 16 years of water level data from nearby Wallaroo (see **Section 7.2**) and are presented in **Table 3**. These values include allowances for astronomical tide, storm surge, and local wind set-up, wave set-up and wave run-up.

Table 1 Design Water Levels (m AHD) for Lucky Bay

100 year ARI Present Day (2013)	100 year ARI water level including 2050 SLR of 0.3 m	100 year ARI water level including 2100 SLR of 1.0 m
2.3	2.6	3.3

For the purposes of assessing coastal inundation, it is considered appropriate to adopt a design water level of 2.6 m AHD, which includes a 0.3 m allowance for SLR for the planning period to 2050. **Figure 7** provides the expected extent of coastal inundation in the event of a storm surge event (sometimes referred to as a king tide) around the year 2050.

From **Figure 7** it is clear the Lucky Bay shacks will be subject to coastal inundation from both the beach frontage and the eastern tidal inlet and associated samphire swamp. **Figure 8** provides some examples of historical inundation events at Lucky Bay.

In the event of a large storm surge and high tide, 94 shacks are expected to be threatened by the coastal inundation over the 2050 planning period. Based on a recent survey of the shacks floor levels, the average depth of flooding is expected to be around 0.4 m. The entire western sector is most threatened by coastal inundation hazard (see **Figure 7**).

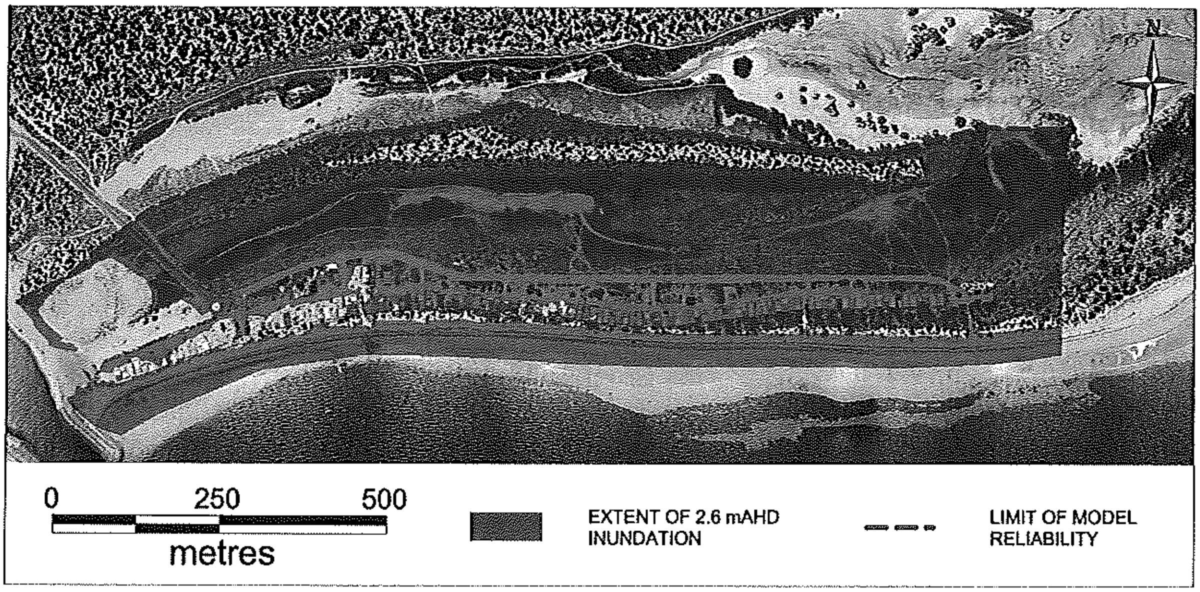


Figure 7 2050 Inundation Extents for 100-year ARI Event (includes 0.3 m of SLR)

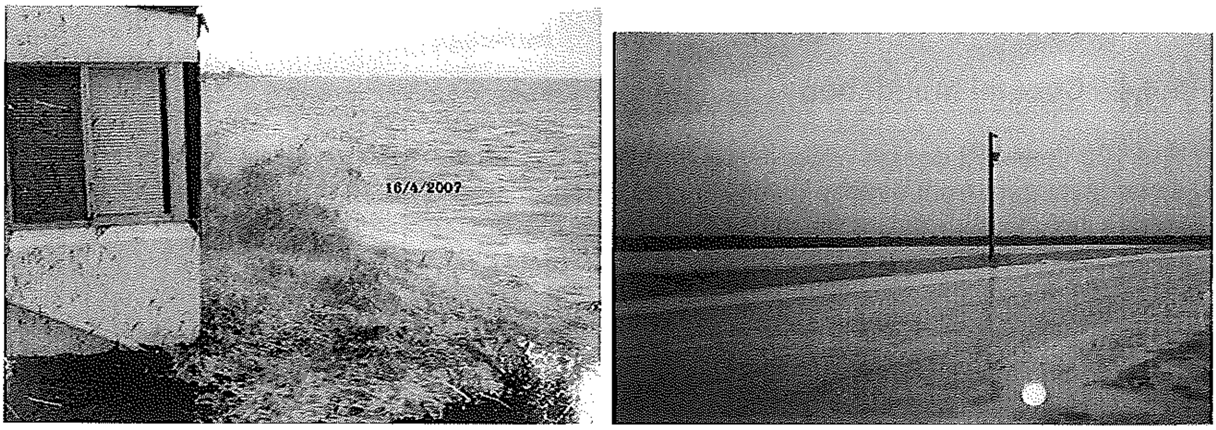


Figure 8 Examples of Lucky Bay Coastal Inundation (left: from the coast and right : from the tidal inlet

2 BACKGROUND INFORMATION

2.1 Foreshore Zones and Issues

As noted in the summary of coastal processes (**Section 1.3**), the Lucky Bay area was divided into three compartments. In addition to this, Lucky Bay beach was divided into four zones, based on natural and anthropogenic characteristics.

A site inspection was undertaken by SMEC consultants and Michael Richardson from MasterPlan SA Pty Ltd on 15 May 2013. The main objectives of this site visit were to gain:

- an understanding of the foreshore environment and relevant coastal processes
- a better appreciation of priorities and issues affecting the Lucky Bay foreshore guided by Council staff who are familiar with the area
- insight into historical changes (e.g. anecdotal accounts of storm conditions and erosion events)

Observations and insights gained through the site visit, including a selection of site visit photographs, are provided below for each of the defined foreshore zones, see **Figure 9**.

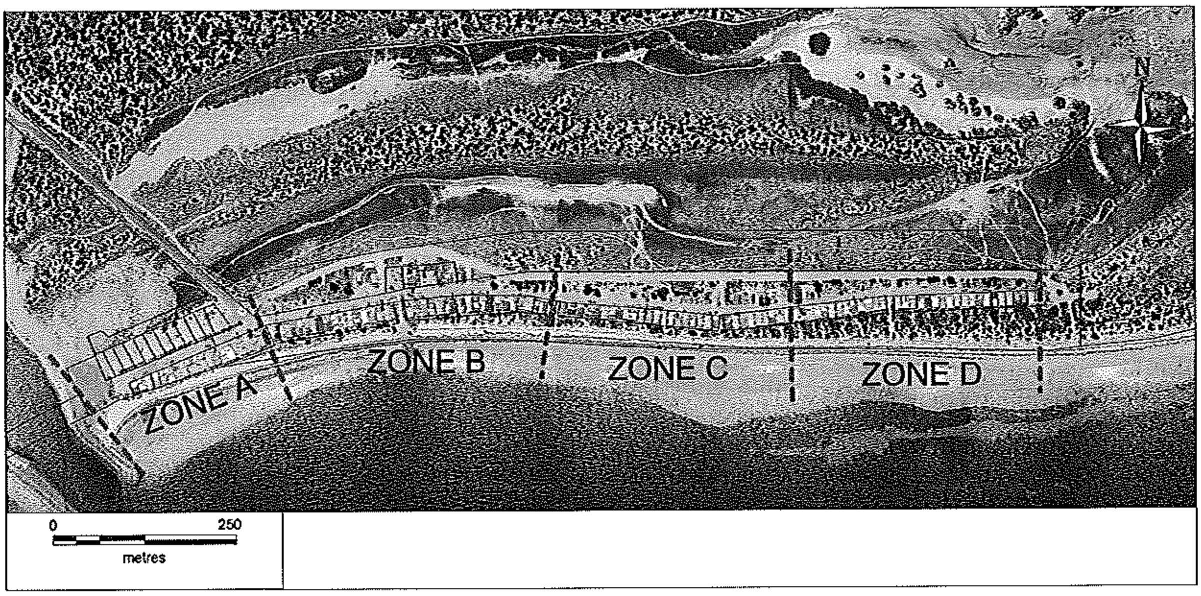


Figure 9 Lucky Bay Beach Management Zones

2.1.1 Zone A – Western Beach

This zone extends around 250 from the eastern training of the harbour. The following observations were made in relation to this zone:

- Beach in a healthy state with an incipient dune and vegetation regrowth.
- Presence of *ad hoc* protection measures (hay bales, vertical timber seawall, dumped rock walls etc.) indicates historical foreshore erosion.
- Elevated (piled) beach access structures (redundant) are also present (see **Figure 10**).

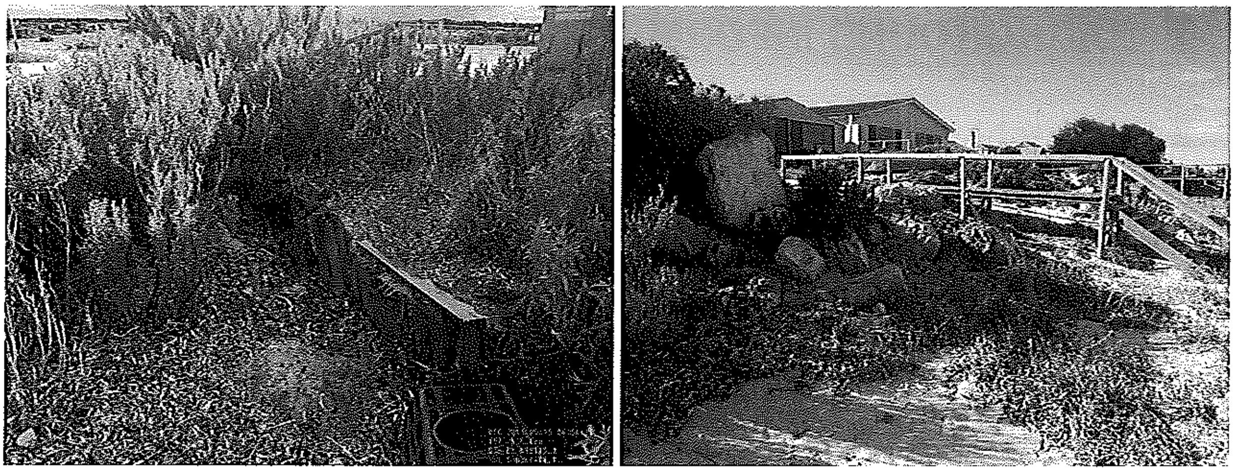


Figure 10 ***Ad Hoc*** **Protection Measures and Timbr Beach Accessway**

2.1.2 Zone B - Central Western Beach

This zone includes the boat ramp. The following observations were made in relation to this zone:

- Coastal erosion evident with significant lowering of the beach profile.
- Change in observable sediment characteristics, i.e. more shell grit and gravel.
- Boat ramp is a shoreface sediment control point with sand accumulating on the western side of the ramp, and on the eastern side a lower beach level and incipient foredune. Hard rock protection on either side of the boat ramp, possibly indicating previous undermining due to storm erosion.
- Navigation aids (netball posts) for boat ramp located in swash zone (see **Figure 11**).
- Eastern shacks aligned further from the shoreline in this zone.
- Appeared to be reduction in incipient dune height

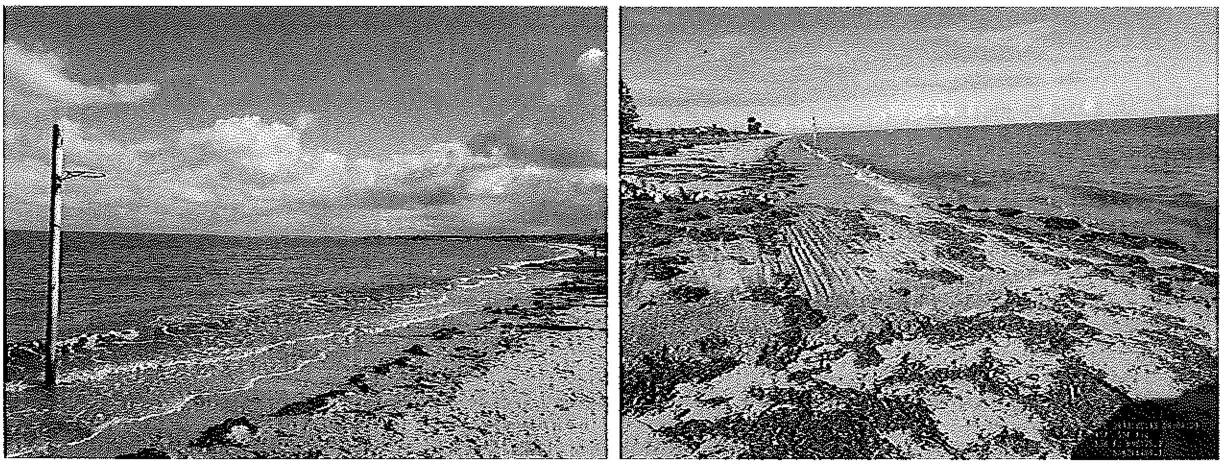


Figure 11 Goal Posts and Boat Ramp

2.1.3 Zone C – Central Eastern Beach

The following observations were made in relation to this zone:

- Shack setback from the foreshore increases at the eastern end of this zone.
- Some shacks are aligned close to the shore.
- Mature eucalypt stands on dune crest (estimated to be 30 years old, see **Figure 12**), with lower branches chopped off, possibly dying.
- Some evidence of what appears to be beach replenishment seaward of the foredune which is slowly being revegetated.

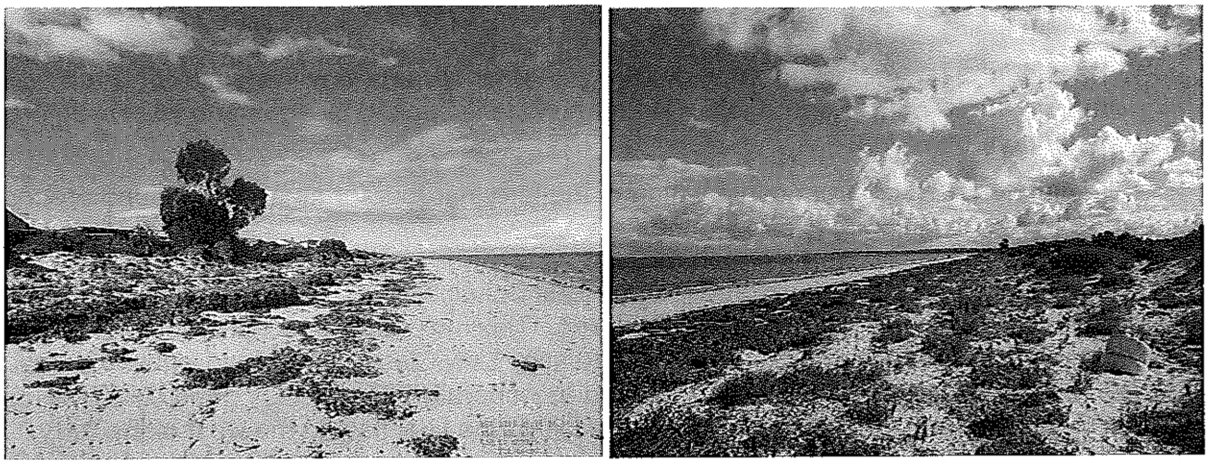


Figure 12 Mature Eucalypts and Dune Revegetation

2.1.4 Zone D – Eastern Beach Zone

The following observations were made in relation to this zone:

- Remnant erosion scarp in the hind dune with incipient dune formation with primary vegetation, indicating a currently stable or accreting beach.
- Westerly alongshore wave driven current observed in wave breaking zone immediately adjacent to the shoreline. Angle of incident wave action estimated at 20-30 degrees.
- Uniform beach profile to the north of this zone until the spit alignment changes near a wide point in the beach.

Beyond the eastern end of Zone D, the following observations were also noted:

- East of alignment change, alongshore wave driven current appears stronger despite observations of reduced wave action.
- Multiple beach berms within profile
- Significant deposition of seagrass wrack.
- Wide nearshore delta with very flat slope and wave breaking across sub-tidal sand flats..
- Reduction in primary dune height.

2.2 Topography and Vegetation

Figure 13 shows a map of the topography across the study area. Key features are as follows.

- Lucky Bay is a small embayment with a sandy beach that predominantly faces south but curves around to the south-east at the western end. The beach is backed by a low dune system, except in the area adjacent to the harbour where shacks are located in the back beach zone. The height of the dunes fronting the shack settlement ranges from 1.5 m to 3.4 m AHD.
- The shacks have floor levels ranging from 2.2 to 3.2 m AHD. Landward of the shacks, the reserve and access road levels are typically 1.5 to 2.0 m AHD.
- Landward of the access road the eastern intertidal inlet and associated samphire swamp area is generally below 0.5 m AHD and is directly connected to the Spencer Gulf by tidal channels.
- Backing the low-lying samphire swamp is another barrier dune system, with levels ranging from 2.5 to 4.0 m AHD. This dune ridge is backed by another unsurveyed area of samphire swamp.
- Excavated material from construction of the ferry harbour forms a large mound around 7.5 m AHD high, immediately to the east of the harbour.

Figure 14 shows a vegetation map based on Rural Solutions SA (2009) site analysis and environmental assessment of the Lucky Bay area. This includes a description of vegetation communities and their condition. The Samphire ssp. Low Closed Shrubland within the tidal flats east of the shack settlement was identified as generally being in very good condition, as was the Samphire ssp. Low Closed Shrubland within the tidal flats to the west of the ferry harbour. The dryland tea-tree/ southern cypress/ green tea-tree low mallee to the north of the tidal flats adjacent to the shack settlement was also described as being in very good condition.

The vegetation community fronting the shack settlement and to the east, and within the tidal flat area adjacent to the settlement, was described as Sandhill Wattle/ Boobialla Open Shrubland. Identified issues associated with dune vegetation included invasion of woody weeds, e.g. African boxthorn and revegetation with non-locally indigenous species (mostly Western Australian species).

Figure 13 **Lucky Bay Topography (based on survey by Andrew and Associates, 2012)**

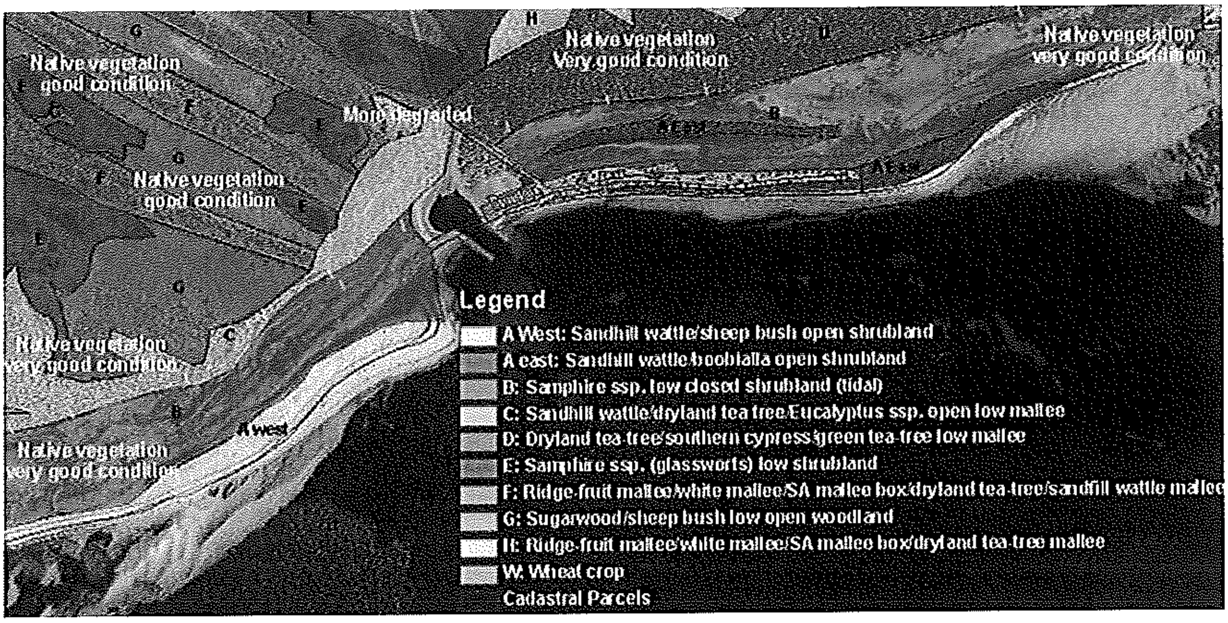


Figure 14 **Lucky Bay Vegetation Mapping (source: Rural Solutions 2009)**

2.3 Existing and Future Development and Works

Past and potential future impacts on coastal and sediment transport processes need to be considered in the assessment of a long term option for coastal zone management at Lucky Bay. Historical information on the shack development, beach protection measures and harbour development and associated works are described below.

2.3.1 The Shack Settlement

The shack settlement was initiated around 1923 when the families of World War I (1914-1918) returned servicemen identified a need for a recreational centre near the sea. Organised by the then Returned Services League (RSL), the site at Lucky Bay was secured for this use. A small shack was constructed, known as Shack 9.

After World War II (1939-1945) demand for the use of the shack increased. This shack was subsequently sold-off as part of a raffle run by the RSL and another shack was constructed.

Since that time the number of shacks has grown to 124. The majority (121) are arranged in a ribbon fronting Lucky Bay beach. These are leasehold and are arranged in blocks, shown as Blocks 1 to 7 (east to west) in **Figure 15**.

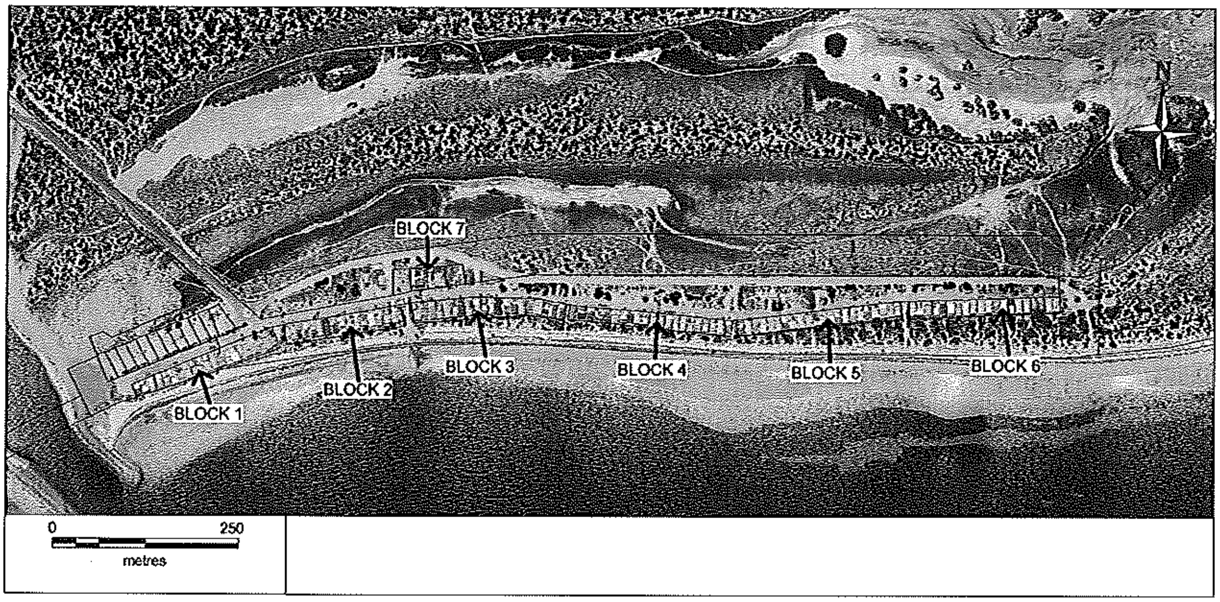


Figure 15 Lucky Bay Prior to Ferry Harbour Construction (2006)

Most areas of the settlement have been previously threatened, to varying degrees, by coastal hazards. Based on available information, the main steps taken to mitigate these hazards include:

- *Ad-hoc seawalls* - over the years, various *ad hoc* foreshore protection measures have been built in different locations along the beach as described in **Section 2.1.1**. These have had limited success in protecting property.
- *Sand replenishment* - Council received approval from the CPB in 2009 to replenish Lucky Bay Beach sand harvested from the eastern end of the beach (beyond the shacks). This material was placed directly adjacent to the eastern edge of the boat ramp (Tonkin Consulting, 2010). Sand replenishment has since occurred three times over the past five years. On two occasions approximately 1,000 to 1,500 m^3 was relocated and on one occasion around 3,000 m^3 was relocated. The sand was used to replenished the base of the dune from the boat ramp, east to around the depression in the beach. The most recent exercise was around August 2011. The works were undertaken by CTS Contractors and Hayden Francis (E. Watterson pers comms Dec 2013) indicted that:
  - Sand is harvested from below the low tide level from the sand flats in the compartment east of Lucky Bay. Sand harvesting presents the greatest risk during the exercise as any failure can easily result in stranding of expensive equipment as the tide comes in. Harvesting can also cause scheduling issues and delays as: summer provides the best tidal ranges for the works; and harvesting needs to be co-ordinated around times of low tide.
  - Typically the equipment used has been a *land plan* (or scraper) which is generally used for agricultural earth moving etc but is well suited to beach scraping.
  - The replenishment sand, placed at the base of the foredune east of boat ramp, is still in this nourished area and due to the following period, with higher than average rainfall, some dune vegetation has been established.
  - The cost for each exercise varied between about $6,000 to $10,000, depending on the volumes moved.

- For future beach scraping it was recommended that the difficulties associated with sand harvesting be overcome by creation of a stockpiling area in the hinddune area, east of the shacks.

Based on observation made on the site and from the anecdotal evidence supplied, it appears that the sand replenishment has been the most successful of the previous mitigation measures attempted at Lucky Bay.

- *Proposed Shack Relocation* – as noted in **Section 1.1.4**, several individual lots and one super lot were created in 1995 as sites for shack relocation. The row of individual lots 1 to 12 behind the existing Block 1 super lot (see **Figure 15**) have been filled.

2.3.2 Lucky Bay Harbour

The ferry harbour was approved in 2005 and developed by the owner, SEA Transport, in 2006. Much of the design of the harbour was undertaken and documented by John Chappell Engineers (2005 – 2006). Construction was undertaken by civil contractors, Lucus. The development involved:

- Excavation of a harbour basin with the material used to raise a low-lying section of Lucky Bay Road (access road) and creation of an emplacement mound of material (see **Figure 13**). It has been estimated, using survey data, that around 60,000 m^3 of material now sits in the emplacement mound, and was gained from part of the total harbour excavation of 80,000 m^3.
- Construction of training walls - the eastern wall is approximately 115 m long and the western wall is approximately 140 m long. The channel width between the two walls is approximately 60 m. The training walls extend from the shoreline and intersect littoral drift.
- Construction of Roll-on-Roll-off ramps for the ferry, vehicle marshalling area and ticket booths and other associated minor infrastructure.

Figure 16 shows some images of the Lucky Bay Ferry Harbour.

Figure 16 Eastern Training Wall and Ferry Harbour

Since construction of the harbour, it is estimated that 6,000 to 6,500 m^3 of material accumulated against the western training wall between 2010 and 2013.

Development approval for a Common User Export Facility (CUEF) at Lucky Bay was obtained by SEA Transport in April 2012. The CUEF will expand the current ferry harbour to allow for transport and transfer of commodities via barges to export vessels several kilometres offshore.

The CUEF involves the construction of a channel and dock to extend northwest from the existing ferry harbour; related earthworks; hardstand area (Stage 1: 20,000 m^2, with ultimate hardstand area of 50,000 m^2); acoustic and landscape buffers; and haul road. The channel extension will be approximately 80 m wide and 200 m long, and to a depth of approximately –4.0 m AHD. Site levels within the footprint of the CUEF vary between 1 and 6 m AHD, with existing natural surface levels in the vicinity of the channel extension being approximately 2 m AHD. The hardstand area will be raised to avoid inundation. It is proposed that raising the Stage 1 hardstand will be achieved by balancing site cut and fill volumes and that excavated material from the harbour extension will be used to raise the footprint of the hardstand extension (MasterPlan SA Pty Ltd 2011b).

More recently (6 December 2013), IronClad Mining gained approval for a mining export facility at the Lucky Bay CUEF).

2.3.3 Dredging and Sand Management

As part of the 2006 ferry harbour development, a navigation channel was created to deepen the approach depths to the ferry terminal. It was estimated around 35,000 m^3 of material was removed from the seabed, with around 28,000 m^3 used for beach nourishment.

Conditions of approval for the ferry harbour included that *the proponent shall develop, to the satisfaction of the Coastal Protection Board, a proposal for the collection, removal and relocation of sand from those areas immediately adjacent to the proposed harbour and training walls.*

Further to this condition, John Chappell Engineers prepared the *Future Sand Management Plan for Lucky Bay Ferry Terminal* (2006). This management plan proposes removing sand built up and trapped against the western training wall and transferring this by truck to the eastern side of the harbour entrance. The trigger for carrying out this work is the increase in the level of the sand on the western side of the walls by 1 m, measured at the low water mark and 100 m from the western wall.

It remains unclear as to whether this plan was formally approved by the CPB and further clarification of the obligations of SEA Transport to relocate sand trapped by the training walls to Lucky Bay beach has been sought. A pole located to the west of the training walls was observed during site visits by SMEC's staff, however, extensive enquiries suggest that no sand transfers (from west to east of the harbour) have taken place.

The 2012 conditions of approval for the CUEF included that the *owner of the land is responsible for undertaking ongoing sand and seagrass management (dredging, sand bypassing, seagrass wrack removal) to maintain a navigable entrance to the development site.*

Ongoing navigation channel dredging will be required for the ongoing operation of the existing ferry harbour and approved CUEF. Based on discussion with SEA Transport, the following are preliminary considerations for Lucky Bay coastal protection options:

- 220,000 m^3 is planned to be dredged, potentially as soon as August 2014, to deepen the navigation channel for expansion of the Lucky Bay facility. While it is currently unclear exactly how much of this material would be sand suitable for beach nourishment it is expected that there would be sufficient for current nourishment demand.

- SEA Transport would be open to the use of suitable sand sized dredge spoil for use as beach nourishment material, including direct placement on the beach or in a stockpile located to the east of shacks.
- Other dredge spoil gained through the expansion project could be suitable for filling of lots and as a base for any roadworks proposed to raise the access road.

3 COASTAL MANAGEMENT OPTIONS

3.1 Option 1: Rock Revetment

This option would see a rock revetment constructed along the Lucky Bay foreshore from near the eastern harbour training wall to the eastern end of the shack settlement. Additional measures would be required to ensure this option is a complete coastal protection solution. As a minimum this option would need to be combined with raising Lucky Bay Boulevard (the access road at the rear of the shacks) to protect the shacks from coastal inundation.

Using established coastal design methods, a concept design has been completed for the rock revetment. It would be designed to provide coastal protection up to the 100 year ARI design storm event. Provided appropriate maintenance was carried out, the design life of the structure would be 50 years. Based on preliminary design calculations, **Appendix B** presents a general arrangement and typical cross sections for the proposed revetment option. A typical section is shown in **Figure 17.**

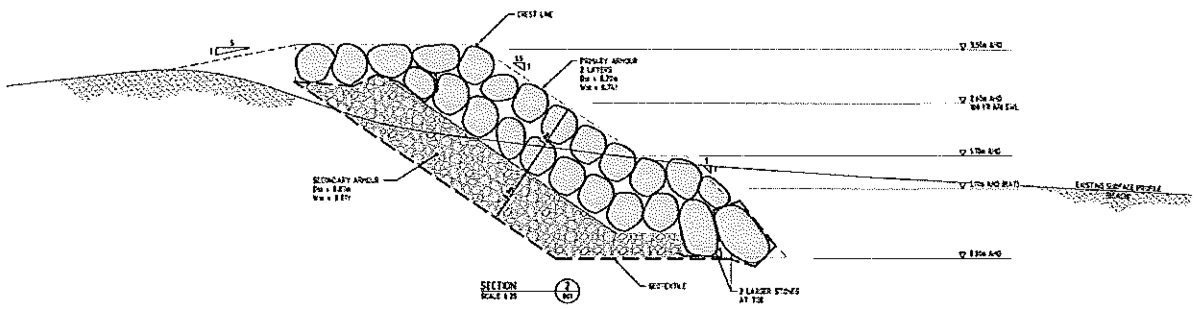


Figure 17 Typical Revetment Cross-Section

Concept design of the rock revetment has been completed to allow comparison of options, including costs. If this option is adopted and the revetment approved it would be subject to further engineering assessment, detailed design and environmental impact assessment, which is likely to result in changes to the design presented here.

3.1.1 Design Philosophy

The revetment option design is based on minimising costs, protecting the shacks from erosion and coastal recession, limiting the impact of the structure on beach amenity and allowing for adaption to sea level rise. The revetment is meant as a last line of defence.

It would be located parallel to the long-term primary dune alignment. In some areas, particularly the western end of Lucky Bay beach, this encroaches on the shack super lots. A seawall built seaward of this in the zone of wave impact will have an influence of beach processes. Locating a revetment further seaward and reclaiming land to create a buffer, as recommended in the 2010 Tonkin report, would expose the wall to more wave action resulting in a dramatic lowering of the beach profile. It would be practically impossible to maintain a sandy beach seaward of such a revetment and it would be much more expensive to construct. Furthermore it would result in more significant downdrift erosion impacts. The end result would be a rock slope where there had once been a sandy beach.

By locating the revetment further inland from the fair weather beach alignment it would typically be partially buried under dune sand making it easier to maintain a sandy beach. Eventually, however, as the shoreline recedes in response to rising sea levels and ongoing sediment loss, the beach would be lost. See **Figure 18** as an example.

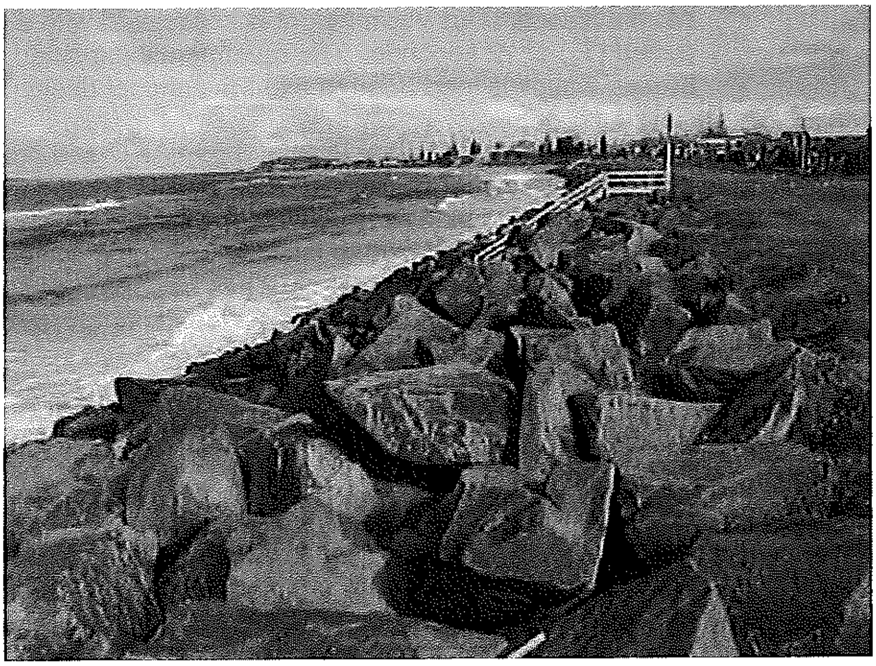


Figure 18 Example of rock revetment with no beach at high tide (Stockton Beach, NSW)

Seawalls can be constructed from various materials. A rock armoured revetment is recommended for Lucky Bay for the following reasons:

- it is a traditional design that has been used extensively for coastal protection and can be designed with confidence to meet expected conditions;
- the slope and voids in the revetment absorb wave energy, reducing wave overtopping;
- the structures are capable of absorbing very large wave energy with comparatively little damage and repairs are relatively straight forward.
- there are a number near-by quarries that can provide suitable armour rock.

3.1.2 Basis of Design

Failure Mechanism	The most likely failure mechanism is wave action causing slumping and loss of armour, possibly due to under sizing of primary armour and poorly founded armour (toe structure). Lack of underlayer armour, particularly at the crest could lead to loss of fines and subsequent slumping or displacement of primary armour into the voids.
Design Water Level Conditions (100 year ARI)	Based on an extreme water level assessment (see **Section 7.2**) the 100 year ARI design still water level has been estimated as 2.6 m AHD. This incorporates a storm tide level of 2.0 m AHD and a component of wave setup of 0.3 m. It also includes an allowance for sea level rise of 0.3 m by 2050, as recommended by the CPB (1992).

Design Wave Conditions (100 year ARI) Based on an extreme wave climate assessment (see **Section 7.3**) and the depth-limited wave conditions expected in front of the revetment a 100 year ARI significant wave height (H_s) of 1.75 m has been adopted. This wave height is associated with a peak wave period (T_p) of 12 seconds. The revetment's expected exposure to broken waves is incorporated into the concept design.

Wave overtopping The revetment has a crest level of 3.5 m AHD and preliminary wave overtopping estimates indicate wave events around the design conditions would lead to significant overtopping. Where possible, drainage may be required to direct overtopping flows away from properties. Some primary armour has been included to protect the crest from wave overtopping but this needs to be reviewed if this option proceeds to detailed design. During large wave events and king tides pedestrian safety and the stability of minor structures close to the crest may be an issue.

Key Feature of Concept Design

Length of Structure 1,330 metres. A revetment at Lucky Bay needs to extend across the entire shack frontage. This is mainly due to end effects as the structure would cause significant erosion at the downdrift (eastern) end.

Crest Level 3.5 m AHD was selected, based on the design water level and wave conditions. Based on a recent land survey (Andrew and Associates, 2012) the level of the foredunes along Lucky Bay beach are between 1.5 and 3.4 m AHD, with an average of 2.6 m AHD. The shacks have an average floor level of 2.4 m, so the revetment crest would be around 1.1 m above the floor levels and 0.9 m above the existing dune levels.

Toe Level 0 m AHD was selected to prevent scour undermining the structure.

Slope A steep slope of 1:1.5 was selected due to space constraints. Depending on rock availability and the final configuration of the revetment it may be slightly more economical to reduce the slope.

Primary Armour 2 layers of rock with D_{50} = 0.7 m and W_{50} = 0.74 tonnes. Recommended thickness of the primary armour layer is 1.3 m. Grading to be such that minimum rock mass (W_{min}) is 0.55 tonnes and maximum rock mass (W_{max}) is 0.92 tonnes.

Typical rock specifications would be required including: sound igneous or metamorphic rock with a density of 2,650 kg/m^3, rough and angular rocks placed so they interlock.

Suitable rock is expected to be obtainable from the Granite Mine, 40 km from the site. It is understood that the rock used for the construction of the Lucky Bay Harbour was provided free of charge (John Chappell Engineers, 2006).

Secondary Armour A secondary armour layer 0.9 m think with boulders of D_{50} = 0.07 m and W_{50} = 0.07 tonnes.

Construction

The typical construction sequence would be: site establishment, removal of dune vegetation, excavation of a trench in the foredune/beach area, preparation of the slope surfaces, laying geotextile fabric, dumping filter and secondary armour on the slope, placing primary armour, filling landward batter slopes, drainage, landscaping and rehabilitation of dune vegetation.

3.1.3 Other Considerations

Approvals

The revetment would be constructed on crown land. It would require statutory approvals including environmental impact assessment. The CPB is likely to oppose the construction of a rock revetment as a long-term solution for coastal protection at Lucky Bay as it doees not accommodate natural beach processes and would impact on the beach and adjacent environments.

The process of securing approvals could be costly, take considerable time, and there is no guarantee of success.

Coastal Inundation

In order to protect shack sites from storm tide inundation, raising lot levels and the access road would also be required. This is further discussed in **Section 3.4.2** .

Possible relocation of Block 1 shacks

The crest of the revetment has been located as far landward as possible in an attempt to limit the effect on beach processes. For Block 1 shacks this may necessitate relocation, as construction without disturbing the shack foundations would be difficult. Alternatively, the revetment alignment could be moved seaward along this section. For the purposes of options assessment it has been assumed that all shacks, including Block 1, would remain in their current location for the revetment option.

Boat ramp

The existing boat ramp would need to be removed and a replacement boat ramp constructed adjacent to the Lucky Bay harbour entrance. This is further discussed in **Section 3.4**.

Adaptability

Rock revetments are adaptable to sea level rise, as the crest level can be raised if required in the future.

Beach/Water Access

Timber stairs would be required to provide pedestrian access across the revetment crest to the beach. While this would be a significant additional cost it would have the benefit of formalising beach access. Vehicle access would be restricted to the boat ramp if a revetment was constructed.

Funding

Funding would be more difficult as the large capital cost associated with this option would be needed up-front. Council could establish a low-cost loan for these works which could be paid back through an annual contribution from shackholders, as part of their lease agreements.

Constructability	It would be necessary to consider construction issues as part of detailed design. Survey of the existing *ad hoc* seawalls along the foreshore would be required as these might affect design/construction. It would be necessary to undertake geotechnical investigations as well as monitoring for acid sulphate soils in excavation areas. Summer presents the best construction conditions as this is when the calmest weather occurs. However, peak beach usage would be limited by construction works. A suitable contractor would need to be engaged. Inquiries could be made with Sea Transport about the contractors used for the ferry harbour construction project.
Maintenance	Sufficient buffer width is required for maintenance vehicle access to the crest for repairs.
Stormwater	Any existing or future stormwater outlets would need to be incorporated into the revetment or may be better redirected to the tidal inlet landward of the shacks.
Terminal erosion effects	Although the eastern most shacks are fronted by a dune system, the revetment would extend across this frontage with a return, as a shorter structure would be likely to result in erosion of this buffer due to scour and end effects. It is for this reason that a shorter revetment is not proposed.
Beach Amenity	The revetment is likely to cause some lowering of the beach profile, particularly following storms, with a significant loss of beach amenity expected. For this reason, beach replenishment could be considered in combination with this option, see **Section 3.2**.

3.1.4 Costs

Based on the concept design shown in **Appendix B**, the estimated cost for the revetment would be in the order of **$3.9 million**. Maintenance would typically occur every 5 years and be around **$120,000/5yrs** on average. The associated cost to raise Lucky Bay Boulevard is estimated at **$700,000**.

3.1.5 Summary

While a rock revetment is likely to provide protection to the shacks it would have the effect of lowering the beach face immediately seaward of the wall and would cause further downdrift erosion to the north east. It is an expensive structure. This option alone would not provide protection from coastal inundation.

Rock revetments are typically appropriate where the land and assets behind the beach are more valuable (economically or otherwise) than the sandy beach.

3.2 Option 2: Beach Nourishment/Replenishment

This option would see massive initial nourishment of the Lucky Bay beach compartment (assuming sand could be sourced from navigation channel dredging as part of the Lucky Bay

Harbour expansion), followed by ongoing beach replenishment via Lucky Bay Harbour sand by-passing activities, supplemented by sand replenishment from the eastern spit if required.

As for Option 1 (revetment), additional measures would be required to ensure this option is a complete coastal protection solution. As a minimum this option would need to be combined with raising Lucky Bay Boulevard (the access road at the rear of the shacks) to protect the shacks from coastal inundation.

Initial massive nourishment to meet storm demand would need sufficient sand in the beach and dune profile to provide an adequate buffer up to the 100 year ARI design storm event. We have presented a concept level nourishment strategy based on use of local plant, experience already gain from previous beach replenishment activities at Lucky Bay and the likely availability of large volumes of sand from navigation channel dredging or harbour expansion. Nourishment could provide protection from coastal erosion, however, additional measures would be required to protect against inundation. Provided appropriate ongoing beach replenishment is undertaken, this option could ensure the viability of the shack settlement beyond 2050.

The beach nourishment strategy is at concept design level and has been developed to allow a comparison of options, including costs. If this option is adopted and beach nourishment/ replenishment approved, it would be subject to further engineering assessment, including a review of the nourishment strategy and volumes and environmental impact assessment, which may result in changes to the design presented here.

3.2.1 Nourishment/ Replenishment Philosophy

The beach nourishment strategy for Lucky Bay is based on providing mutually beneficially outcomes for shack protection and other developments (both past and future) to minimise costs, protection of the shacks from erosion and coastal inundation, maintaining/ improving beach amenity and allowing for adaption to sea level rise. Fundamentally the beach nourishment strategy works with nature and is flexible so that is can be modified in response to changing conditions.

Beach nourishment involves placement of beach sand on the upper beach face and dune, to re-establish a sandy beach after a storm and to provide a sediment supply for subsequent storm events. **Figure 19** shows local examples of beach nourishment works in progress.

Figure 19 Examples of beach nourishment (left : Adelaide beach using sand carting and right – Lucky Bay using a dredgeand pipeline).

The key factors that have guided the development of the beach nourishment/ replenishment option are:

- Establishing and maintaining a storm buffer of 70 m^3/m to allow for storm demand and beach amenity;
- Providing an ongoing supply of sand to the Lucky Bay beach compartment to mitigate the observed long-term sediment loss, as well as an allowance for predicted sea level rise;
- Addressing potential future coastal inundation issues, including wave overtopping, by building up the hinddune area (i.e. behind the frontal dune);
- Allowing the shacks to remain in their current location, to at least the end of the next lease period (around the year 2050) while also promoting planning for staged relocation of the most exposed shacks beyond that;
- Minimising costs to shackholders by promoting a mutually beneficial link with development activities planned for the Lucky Bay Harbour.
- Targeting areas that either currently, or will in the future, need sand.
- Establishing a more intense beach monitoring to enable fine-tuning of the strategy in the future as more data is available;
- Establishing a nourishment review panel to ensure the strategy is optimised in the future.

While the beach nourishment strategy has taken into consideration numerous possibilities, many of these have been excluded. For example, beach nourishment is often supplemented with the construction of groynes which trap longshore drift and nourishment sand, and help to hold sand where it is required. However, for groynes to be effective in trapping sand they have to extend out into deep water, this means they have to be constructed across the surf zone making them extremely expensive structures. This alone excludes them from consideration, as previous experience elsewhere in Australia indicates that the cost of groynes is typically well beyond the means of individuals or local Councils. Furthermore, groynes do not account for offshore losses, they are associated with downdrift erosion and are unlikely to be effective in addressing long term sea level rise.

3.2.2 Review of Locally Appropriate Methods of Beach Replenishment

The discussion below on traditional earth moving equipment and pumping units is based on supply of sand for beach replenishment from the beach/ shoals east of the shack settlement. Sand would also be available from the beach/ shoal on the western side of the Lucky Bay Harbour as required to minimise the impacts of the training walls on Lucky Bay beach and to reduce siltation of the navigation channel. This would require trucking and dumping at Lucky Bay beach, unless a sand by-passing system was installed.

The discussion on floating plant relates to sand dredged for future expansion of the Lucky Bay Harbour and for navigation channel dredging. The initial navigation channel dredging for the CUEF could be a source of sand for the initial massive nourishment/ replenishment of Lucky Bay beach. Navigation channel maintenance dredging could be a source of sand for ongoing maintenance sand replenishment, however, the need to replenish sand at Lucky Bay beach may not always coincide with maintenance dredging. However, as a general coastal zone management principle, sand from maintenance dredging and harbour expansion should be placed to the east of the breakwater and spread along Lucky Bay Beach where required. This is particularly relevant for Lucky Bay because, as noted earlier, the construction of the breakwaters extending out from the shoreline intersects littoral sand drift.

Traditional earth moving equipment

This technique has been used previously at Lucky Bay to scrape sand from the eastern end of the beach and transport and spread and for beach replenishment. Sand was moved on three separate occasions over a period of 4 years. Information provided by CTS Contractors indicated that for previous beach scraping exercises, approximately 4,500 m^3 was moved and placed at a cost of around $22,000, given an estimated cost per m^3 of approximately $5.

Onshore pumping unit

Utilises conventional earth moving equipment to load sand into a hopper unit that mixes the sand with water to form a slurry, which is then pumped through a pipeline (above ground or buried, fixed or temporary) to the replenishment site. BMT WBM (2012) indicated that a propriety unit, the Slurrytrak (capital cost of around $1.7 M), has a pumping rates of about 75 m^3/hr or 1800 m^3/ day, assuming a 24 hour operation. The annual operational cost was estimated at $100,000 plus costs associated with land-based plant to load the hopper.

Offshore pumping unit

This consists of a buried vertical barrier with outlets through which water is pumped under pressure to fluidise the surrounding sand, which rises and is contained and transported as a slurry through an inverted channel to a pipeline for ultimate transport to the replenishment site. This system is suitable in locations where longshore drift is high, resulting in rapid infilling of the 'crater' created by the removal of sand. BMT WBM (2012) indicated that a propriety system, the 'Sand Shifter' (capital cost about $1.8 M), can transport around 20,000 m^3/year. The annual operational cost was estimated at $104,000. However, this system is susceptible to blockages by debris and seagrass which can escalate operational costs.

The pumping unit options have not been considered further as they are not cost-effective for Lucky Bay due to the high capital and operational costs and the relatively low volumes of sand required for ongoing beach replenishment. In addition, the offshore pumping unit is unsuitable due to the relatively low sediment transport rates and extensive seagrass beds and wrack at Lucky Bay.

Floating Plant

Two types of dredgers can be used for dredging and placing material for beach nourishment: Cutter Suction Dredgers (CSDs) and Trailing Suction Hopper Dredgers (TSHDs). Small CSDs are used at many small ports and estuaries around Australia for navigation channel dredging and associated beach nourishment works. Small dredgers can be transported by road and can work in water depths up to about 13 m. The suction pipe on a CSD generally has a diameter in the order of 250/350 mm and is capable of accommodating small debris/ rocks in the sandflow. The delivery pipeline to the shoreline can be floating or submerged and then overland to discharge directly to the nourishment site. Typical production rates for small CSDs are about 100 m^3/hr with production rates for fine sand being higher than for coarser material (BMT WBM 2012).

TSHDs are sailed to the dredging site with dredged material initially stored in a hopper. Discharge of dredged material can be by bottom dumping offshore from the nourishment site through the hopper floor, pumping the sand slurry through a pipeline to the nourishment site, or 'rainbowing' material onto the beach/ shoreline by pumping it through a nozzle at the bow of the dredger. Production rates are up to about 700 m^3/hr. Depending on the nature of the material being dredged, measures to manage turbidity may be required. Mobilisation/ demobilisation costs of TSHDs can be prohibitively high depending on the distance to the dredge site and the volume of material that needs to be dredged. Accordingly, they are typically used for large-scale offshore dredging operations (BMT WBM 2012).

3.2.3 Recommended Beach Nourishment Strategy

Figure 20 shows a diagram of the recommended beach nourishment strategy at Lucky Bay. The strategy consists of:

Step 1 – Beach nourishment area

Beach nourishment to be targeted to the Lucky Bay beach compartment (see **Section 5.1**), which is the 1 km of beach east of the Luck Bay Harbour eastern training wall. Sand would be placed along the beach against the existing foredune and in the hinddune area. Where possible sand placed in the hinddune area would be used to raise the level of the dune crest to 3.5 m AHD. Nourishment would taper off at the eastern end of the settlement where a wider sand buffer exists to the shacks. **Figure 20** shows the location for replenishment.

Step 2 – Mass Nourishment

Based on the 100 year ARI storm demand of 50 m^3/m and an additional contingency volume of 20 m^3/m, initial massive nourishment is recommended to provide a minimum of 70 m^3/m (above 0 m AHD) of beach seaward of the shacks. Initial estimates indicate that this would require around 25,000 to 30,000 m^3 of sand. This beach 'top-up' would establish an adequate buffer to mitigate storm erosion and should be conducted as soon as feasible. Based on the 2012 survey the contingency volume is required to build up the dune crest, protect against ongoing sediment losses until replenishment by harbour bypassing commences, and for the uncertainty in the estimate of storm demand.

The most cost effective option would be co-ordination with the capital dredging associated with the Lucky Bay Harbour channel deepening works, proposed for August 2014. **Section 2.3.3** provides some detail on this work. Use of dredged sand for beach nourishment would mean that the developers would not to dispose of the dredged spoil.

Costings completed here assume that sand for the initial massive beach nourishment would be provided free of charge to shack owners.

Step 3 – Establish Borrow Stockpile

Creation of a beach replenishment stockpile behind the dunes to the east of the shacks (See **Figure 20**). 40,000 to 50,000 m^3 of suitable sand-sized sediment would be placed in this area.

Sand harvesting for beach replenishment works has historically been difficult as expensive equipment is put at risk when scraping sand from below mean water (i.e. at low tide). Creation of the borrow stockpile would eliminate this difficulty and greatly increase the efficiency and reduces the cost of ongoing beach replenishment. It would also create an emergency supply of sand in the case of major storm erosion.

The borrow stockpile could be created using sand from the CUEF capital dredging works, or from sand accumulating on the western side of the training walls.

Step 4 – Sand Bypassing

Re-instatement of longshore drift by by-passing sand around the training walls. Provided sufficient sediment has accumulated on the western side of the harbour, the volume of sand should be at least 6,500 m^3/yr. This sand should be separated from seagrass wrack and either placed on Lucky Bay beach or within the borrow stockpile.

Based on the conditions of approval for the Lucky Bay Ferry Terminal (**Section 2.3.2**) it seems that SEA Transport have an obligation to relocate the sand trapped by the training walls to Lucky Bay beach.

Step 5 – Beach Replenishment

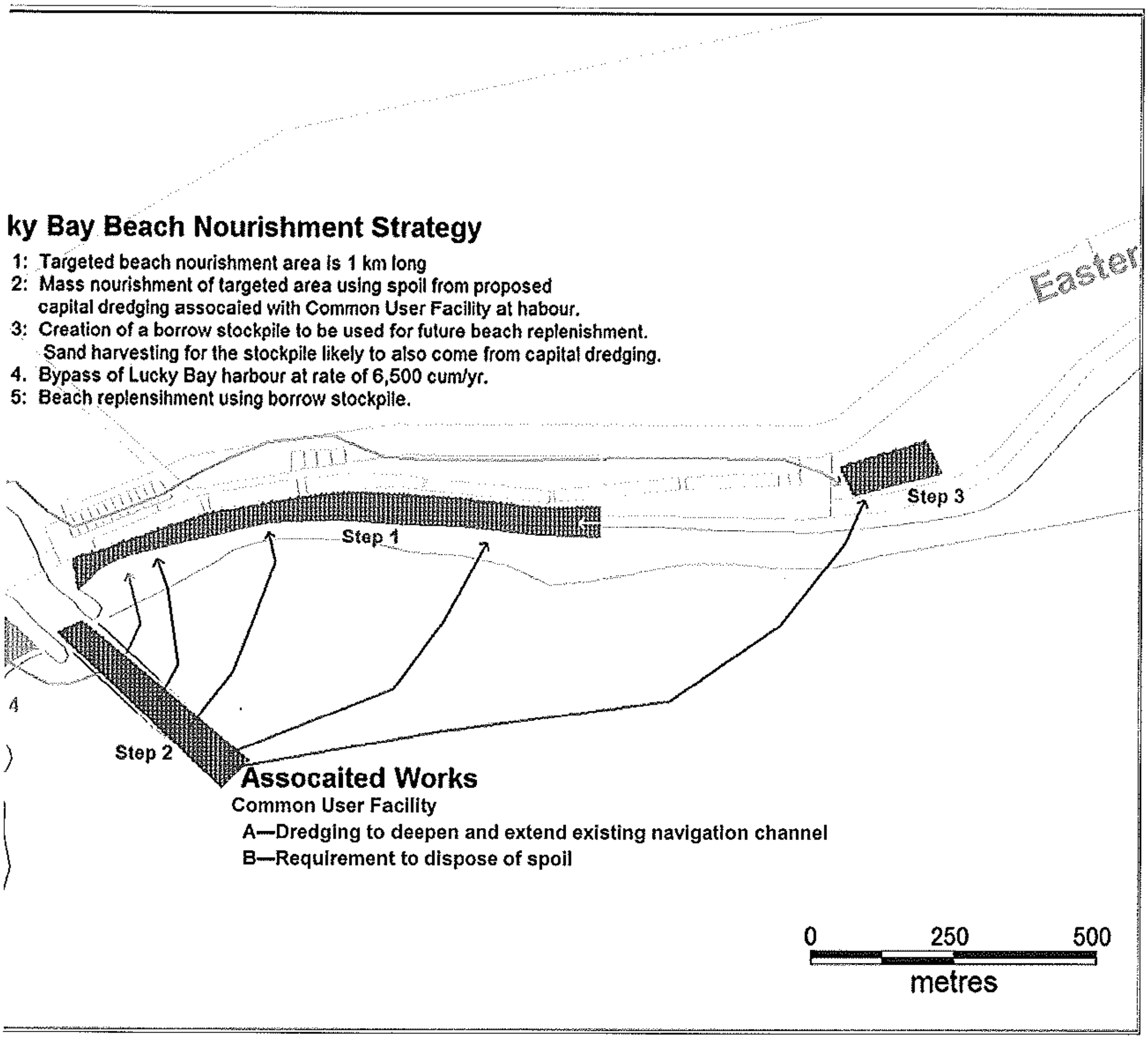
Ongoing beach replenishment using sand carting equipment that has already been used. The volume of any sand replenishment works should be assessed on a case-by-case basis but we have estimated a requirement of 2,200 m^3/yr. This includes an allowance to account for:

- long-term shoreline recession due net sediment loss (based on the long term recession of Lucky Bay shoreline (pre-harbour) of 2,000m^3/yr) and;
- sea level rise equates to an additional sand volume of 200 m^3/yr.

It is recommended that beach replenishment be undertaken on a regular basis to ensure that a sufficient sand buffer exists to allow for seasonal fluctuations in the shoreline position due to erosion events and subsequent recovery.

Step 6 – Dune Management

To stabilise sand used to replenish the dunes, the following works are recommended: installation of brush matting (e.g. collection and placement of dead branches from local trees), planting of colonising dune species, followed by other coastal species and fencing to protect these dune stabilisation measures. Locally indigenous species should be used where possible. If possible watering should be carried out to help in the establishment of vegetation, together with occasional fertilising and weeding. It would be beneficial to establish a local dune care group, if there is not already one.


ky Bay Beach Nourishment Strategy
1: Targeted beach nourishment area is 1 km long
2: Mass nourishment of targeted area using spoil from proposed capital dredging assocaied with Common User Facility at habour.
3: Creation of a borrow stockpile to be used for future beach replenishment. Sand harvesting for the stockpile likely to also come from capital dredging.
4. Bypass of Lucky Bay harbour at rate of 6,500 cum/yr.
5: Beach replensihment using borrow stockpile.
Easter
Step 1
Step 2
Step 3
Assocaited Works
Common User Facility
A—Dredging to deepen and extend existing navigation channel
B—Requirement to dispose of spoil
0
250
500
metres

ategy

3.2.4 Other Considerations

Approvals	Beach nourishment/replenishment would be on Crown land. It would require statutory approvals including environmental assessment. The CPB is likely to approve this option, at least in principle, as it essentially works with the natural processes. Beach nourishment is the adopted strategy for the protection of coastal properties and maintenance of beach amenity along the Adelaide shoreline.
Coastal Inundation	In order to protect shack sites from storm tide inundation, rising of the lot levels and the access road would also be required. This is further discussed in **Section 3.4.2** .
Possible relocation of Block 1, 4 and 5 shacks	Beach nourishment is anticipated to avoid the need for relocation of shacks. However, as sea levels rise, the demand for sediment and the lack of a buffer may necessitate relocation of the Block 1 shacks, along with the shacks in Block 4 and Block 5 that are closer to the shoreline. Planning for this should commence now, well before the end of the next lease period.
Boat ramp	Removing the existing boat ramp and replacing it with a boat ramp constructed adjacent to the Lucky Bay Harbour entrance would make carting sand along the beach front possible.
Adaptability	A cornerstone of any beach nourishment strategy is flexibility and adaptability. It is recommended that a rolling review of the strategy be undertaken as new information is available (beach processes, evaluation of nourishment effectiveness and lessons learnt from nourishment exercises (plant etc)).
Sediment Sources and Gain Sizes	There is a relative abundance of suitable sand sources for Lucky Bay nourishment. This concept level review has not considered the compatibility of borrow sand for beach nourishment. The sources suggested are expected to have compatible grain sizes but this would need to be confirmed, if this option is adopted.
Funding	The capital cost associated with initial beach nourishment would be need up-front. Council could establish a low-cost loan for these works which would be payed back by an annual contribution from shack-holders as part of their lease agreements, along with a small contribution as required for ongoing beach replenishment.
Constructability	Based on previous sand replenishment undertaken at Lucky Bay, sand harvesting is the most difficult and risky part of beach replenishment. Stockpiling of sand in the back beach area above high water is preferable. Beach carting requires removal of the existing boat ramp.
Stormwater	Blocking of any existing or future stormwater outlets by nourishment sand would need to be avoided. It is expected that stormwater would be best redirected to the tidal inlet landward of the shacks.

Beach Amenity Beach replenishment would maintain beach amenity providing a wider beach for recreational activities and eventually a vegetated dune (buffer) to the shacks. Dune management activities to maintain vegetation and control access would further enhance beach amenity.

3.2.5 Costs

This beach nourishment strategy is anticipated to have a capital cost **$1.3 million**, with an ongoing cost of around **$20,000/yr**. Mutually beneficial arrangements could be made between the shack owners and Iron Clad Mining and SEA Transport, who are developing the CUEF at Lucky Bay Harbour. Such arrangements would significantly reduce costs to the shackholders. If sand can be supplied free of charge, the capital cost reduces to around **$120,000** while the ongoing cost remains around **$20,000/yr**.

Based on previous experience at Lucky Bay and elsewhere in Australia, where sand is moved locally from one section of a beach compartment to another, costs are in the order of $5 to $25/m^3. From information provided by FHDC, costs associated with beach scraping to move approximately 4,000 m^3 of sand from south of the shack settlement to the boat ramp were approximately $5/m^3.

The cost to raise Lucky Bay Boulevard is estimated at **$700,000.**

3.3 Option 3: Relocation

The Lucky Bay Management Plan, prepared Council, was endorsed by the Minister of Lands in 1989. At this time, shacks 1 to 12 were identified as being at immediate threat from coastal erosion and shacks 13 to 26 were identified as possibly being at risk, see **Figure 15**, which shows Lucky Bay prior to construction of the ferry harbour.

The Management Plan recommended the following:

- As each site becomes untenable, and if the shack owners are willing to meet the cost, relocate to filled sites further inland, accepting that there is a possibility that these new sites will also be overcome by encroachment by the sea at some time during the next one hundred years.
- The relocation area was identified as the Recreation Reserve between Lucky Bay Boulevard and the access road adjacent to the existing shacks. It was noted that the existing structures would have to be demolished as they could not be moved. It was intended that relocation sites be developed just ahead of the anticipated need and that each site would have direct access to the beach without crossing a road.
- Site development included filling to a level of at least 3.3 m AHD to avoid inundation from flooding of the adjoining low-lying lands (associated with the tidal inlet) to the north, along with service relocation, water and power. In addition, a larger lot area of at least 600 m^2 was required to accommodate onsite effluent disposal to meet the SA Health Commission's requirements. A common septic disposal system servicing two lots was proposed. This requirement would mean that the overall area occupied by the shacks would extend further to the east and west of the existing area occupied by the shacks. While the first 1 to 12 sites extending partly west of the existing shack settlement could be accommodated within the Recreation Reserve, extension to the east would require acquisition of part of a perpetual lease. If an alternative effluent management system was available, e.g. packaged sewerage treatment plant, the lot sizes specified above could be reduced.

The Lucky Bay Master Plan (Masteplan SA Pty Ltd 2011a) included a number of options for development of the wider Lucky Bay area. As part of this, it included options for shack relocation as shown in **Figure 21**.

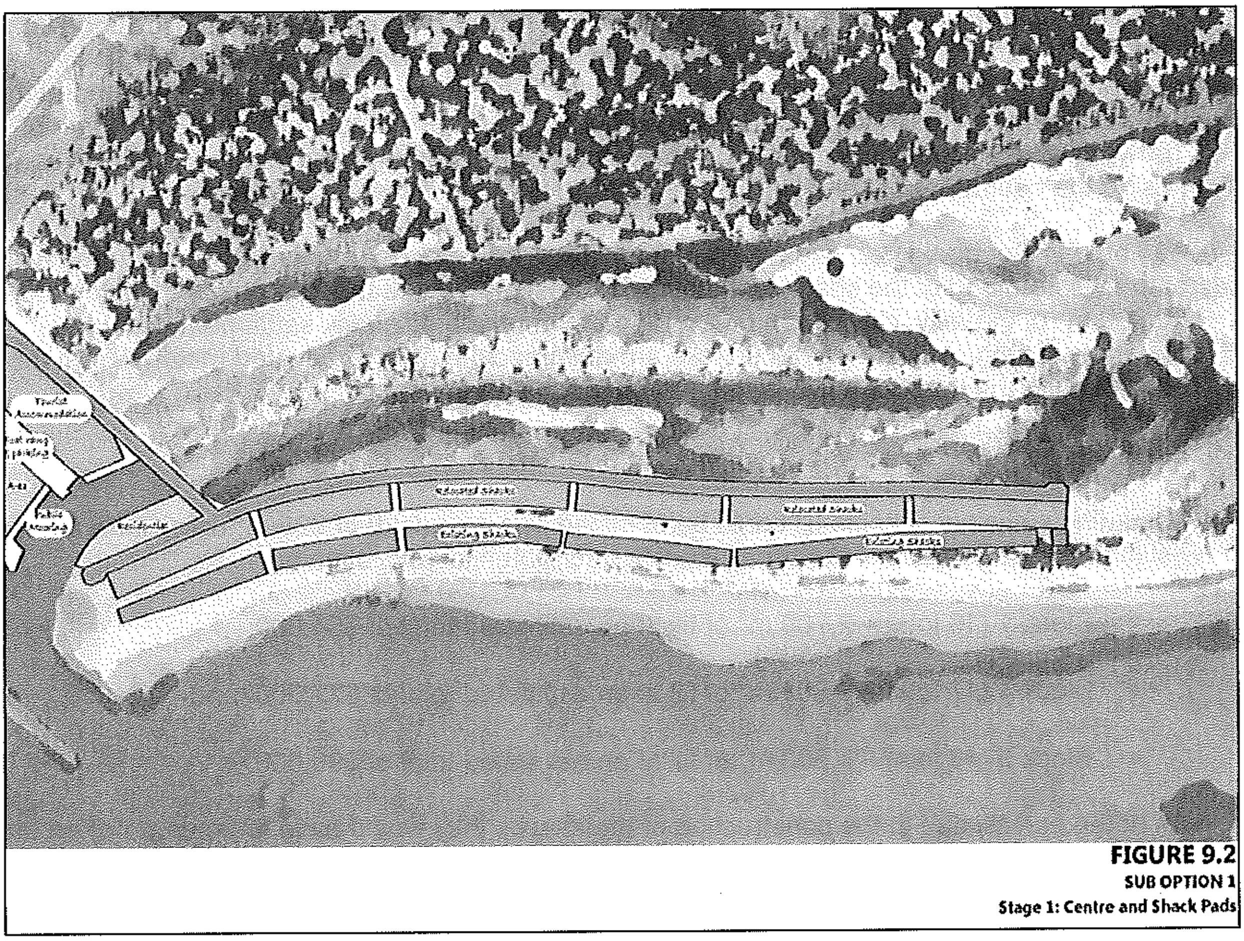


Figure 21 Shack Relocation (Masterplan SA Pty Ltd 2011a)

3.3.1 Relocation Philosophy

This option would see the staged relocation of Lucky Bay shacks (see **Figure 23**) from their present locations to the reserve immediately to the north. The relocation of 46 shacks recommended in this report is anticipated to have a cost of around **$1.4 million**. This cost is only for raising building platforms, so costs for construction of new shacks would be additional. It is likely that any staged relocation of shacks would be accompanied by beach replenishment.

Based on the hazard line presented in **Figure 5**, the shacks in Block 1 (see **Figure 15**) are at immediate risk from coastal erosion (although placement of sand on the eastern side of the harbour entrance means this is not the current situation). Provision has already been made for relocation of these shacks to the previously filled area on the northern side of Lucky Bay Boulevard. The next most at risk shacks are those located closer to the beach in Blocks 4 and 5. Given the current practice of beach replenishment (and the ongoing availability of sand from various sources) and the potential to undertake massive nourishment with material dredged for harbour development, this is considered a long term option, i.e. post 2050.

3.3.2 Relocation Strategy

As noted in **Section 2.2** , natural ground levels in the vicinity of the shack settlement are around 2.4 m AHD. The 2050, 100 year ARI still water level including an allowance for wave setup was estimated to be 2.6 m, see **Section 7.2** . These values include an allowance for sea level rise to 2050 of 0.3 m. An additional 0.7 m of sea level rise is recommended to be considered for the 2100 planning period. If new lots are to be created, it is recommended that the pads be raised to a level of 3.3 m AHD, this would raise the ground levels above that of the 100-year inundation level for the 2100 planning period. Consideration could then be given to raising the habitual floor level for dwelling to including an allowance for freeboard.

As noted in **Section 1.3.2**, excavated material from the ferry harbour is stockpiled to the north of the western end of the shack settlement. It is estimated that this comprises approximately 60,000 m^3 of gravelly, clayey sand. As filling of the relocated shack settlement could be undertaken progressively (not all shacks are at immediate risk), excavated material from the expansion of the harbour could also be used for this purpose.

3.3.3 Costs

Assuming sufficient suitable fill could be obtained at a cost (laid) of $25/m³ using local plant; the estimated cost for each of the areas identified for potential relocation are:

- Block 1 (16 lots) – 2,700 m^3 of fill at an estimated total of $54,000;
- Block 4 (17 lots) – 3,900 m^3 of fill at an estimated total of $77,000; and
- Block 5 (13 lots) – 4,500 m^3 of fill at an estimated total of $90,000

As noted earlier, due to the construction of the shacks they would have to be demolished and new shacks built. It is assumed that some materials may be able to be recycled for use in construction of new shacks and that demolition material could be disposed of at no cost at the Lucky Bay landfill. However, shacks are likely to contain asbestos and this material would need to be removed by a licenced contractor and disposed of to a licenced facility. It is estimated that demolition costs along with disposal of asbestos would be in the order of $20,000-30,000 per shack.

Service relocation would also be required for shack relocation. Given that a staged shack relocation is proposed, service adjustments may be able to be incorporated in maintenance or upgrading works for the wider Lucky Bay area.

These costs above do not include construction of new shacks as the 1989 Management Plan indicated that this would be at the shackowners' expense. Planning controls should be applied to future structures to allow for conditions beyond 2100, e.g. light weight, relocatable structures founded on piers.

It should be noted that the intertidal and low-lying area behind the relocated shacks will become more frequently inundated under future sea level rise and additional works associated with this option would include raising Lucky Bay Boulevard and riparian bank protection, as discussed previously. These costs are not included in the above estimates.

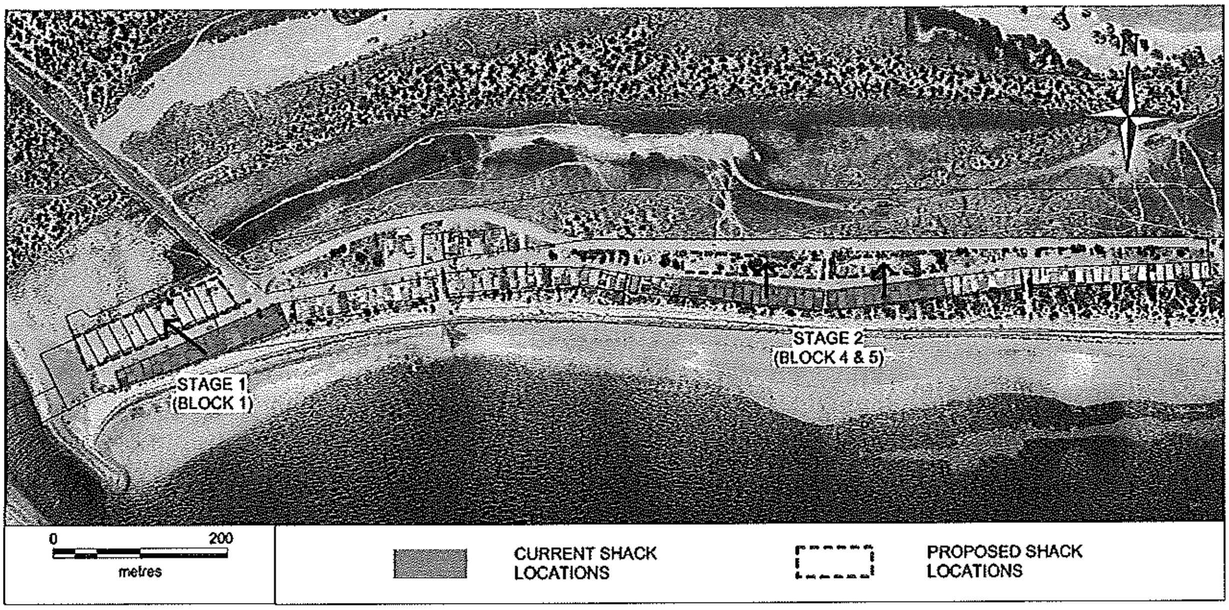


Figure 22 **Staged Shack Relocation Proposed at Lucky Bay**

3.4 Additional Measures

3.4.1 Dune Management

Regardless of the option selected, it is important to maintain or enhance the stability and health of the dune and beach barrier system. The following works are recommended: installation of brush matting (e.g. collection and placement of dead branches from local trees), planting of colonising dune species, followed by other coastal species and fencing to protect these dune stabilisation measures. Locally indigenous species should be used where possible. If possible watering should be carried out to help in the establishment of vegetation, together with occasional fertilising and weeding. It would be beneficial to establish a local dune care group, if there is not already one.

3.4.2 Raising Lucky Bay Boulevard

To mitigate the coastal inundation hazard it is recommended that Lucky Bay Boulevard be raised to a level of 3.3 m AHD. This measure would protect against flooding from the tidal waterway at the rear of the shacks. This level would need to be maintained all the way to the coastal dune area. Maintenance of a frontal dune system would also mitigate the risk of coastal inundation. As such, it is recommended that dune crest levels be maintained at or above present levels (or at least above 3.5 m AHD).

Figure 23 shows a typical profile for the raised road. It is estimated that 24,000 m^3 of suitable fill material would be required to raise the road. Assuming that fill needs to be trucked in, costs are estimated to be around **$700,000**.

Stormwater drainage would need to be provided between the shack area and the tidal inlet. Rubber duckbill values should be fitted to the end of stormwater outlets so that backflow from the inlet during times of storm surge and high tide is eliminated while allowing stormwater to drain at all other times. Consideration of expected rainfall/runoff volumes and durations, along with coincident flooding (i.e. rainfall and storm surge combined) would need to be considered in the detailed design stage to ensure drainage measures were adequate.

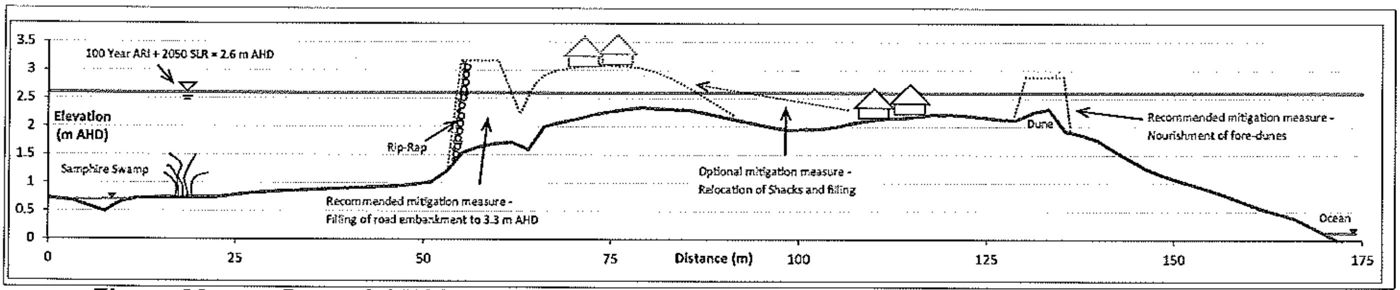


Figure 23 Potential Mitigation Measures

3.4.3 Boat Ramp Relocation

Moving the boat ramp would be required for both the rock revetment and beach nourishment strategy, however it is recommended for any option considered as, it is exacerbating erosion in the current location. A possible new location is adjacent to the eastern training wall. No costs have been included for the relocation of this infrastructure.

3.4.4 Beach Monitoring

The CUEF conditions of approval require pre and post harbour extension hydrographic surveys and ongoing hydrographic surveys at intervals not exceeding 5 years. This information will be useful in estimating the rate at which the navigation channel infills and the volume of material that may be available over a certain timeframe for ongoing beach replenishment, if this source is available for use at Lucky Bay beach.

To confirm ongoing nourishment requirements (volumes, frequency of replenishment), formal records should be maintained including information such as:

- date/ timing of nourishment activities
- preceding weather conditions, e.g. occurrence of storms/ erosion events
- beach condition, e.g. depleted, full
- nourishment volumes
- where material was placed

This information would be used to review the replenishment strategy on a regular basis, say every 5 years.

3.5 SWOT Analysis

A summary of the strengths, weaknesses, opportunities and threats associated with each of the options described above is provided in **Table 2**.

ɜ

‹nesses · Loss of the sandy beach as sea levels rise and the shoreline recedes – there will be no beach. · Requires beach nourishment to maintain beach amenity · Restricts pedestrian access down to the beach when exposed · Very high capital costs ($4M) and high ongoing maintenance costs particularly if beach nourishment is included · Would also require more works (raising road), potential relocation of western shacks · Cannot be built at individual property scale because the beach and land will continue to erode next to the revetment. Must be built along entire Lucky Bay shack settlement.	Opportunities - Pedestrian and maintenance vehicle access along the crest can be incorporated in the design - Design can include access points, e.g. timber platforms and steps, down to the beach to reduce the number of access points to the beach and eliminate informal access - Can be adapted to rising sea level, i.e. crest level can be raised	Threats - Overtime, loss of the sandy beach in front of the revetment due to scour at base and associated flattening of beach profile - End effects, scour/ erosion at eastern end of structure - Impacts on beach amenity when exposed - Development of the Lucky Bay CUEF will alter coastal processes and design requirements and may impact on revetment performance
‹nesses · Sand can be lost offshore during storm events and can be moved quickly alongshore · Needs to be continually repeated (i.e. every 2-5 years) · Higher volumes or more frequent nourishment needed as sea level rises	Opportunities - Mutually beneficial arrangements with other developments could significantly reduce costs and maximise benefits - Use of sand from western side of western training wall provides navigation benefits	Threats - Development of the Lucky Bay CUEF will alter coastal processes and may alter demands for sand nourishment

· Temporary impacts: beach use during works with plant travelling along the beach, noise		
‹nesses	Opportunities	Threats
· costs associated with demolition, rebuilding and servicing of shacks	- Crown land available within vicinity of existing shacks	- Relocation close to the foreshore may result in assets becoming at risk over the longer term due to sea level rise from both Spencer Gulf and tidal inlets to the north

4 RECOMMENDED OPTION

4.1 Coastal Management Strategy

Coastal protection works are likely to extend the life of the shack settlement, possibly out to 2100, but would not be permanent solutions. The lease arrangements at Lucky Bay offer flexibility to manage coastal hazards that are likely to become more severe in the future. Regardless of the coastal protection measure adopted, it is not recommended that the lots be converted to freehold title. However, feasible and cost-effective measures are available to enable the granting of the next long-term lease. In view of this, a combination of options and a stage approach is recommended to maximise the timeframe over which occupation of the shacks is viable. Ultimately the preferred solution to take forward falls to Council and the shack owners however, based on the finding of this investigation, the recommended Lucky Bay coastal protection strategy is:

- Implementing the Lucky Bay beach nourishment/ replenishment strategy as outlined in **Section 3.2.3** with an estimated capital cost **$1.3 million**, with an ongoing cost of around **$20,000/yr**. Beach monitoring should be used undertaken to inform the ongoing beach replenishment strategy.

- Raising Lucky Bay Boulevard to protect against coastal inundation as outlined in **Section 3.4.2** , at an estimated capital cost **$0.7** million

- Staged filling of the Recreation Reserve to provide an opportunity to build new shacks as existing shacks are damaged or become at risk post 2050.

- New shacks to be relocatable so that over the longer term they can be moved if/ when they become at risk.

The costs provided above do not account for a reduction in the costs that may be achieved if a suitable arrangement can be made with the developers of the Lucky Bay CUEF.

4.2 Other recommendations

Other recommendations are summarised below:

- Council to negotiate with harbour owners for suitable excavated material from development of the ferry harbour to be stockpiled and made available at no cost for use as fill for future shack relocation area.
- Seagrass wrack to be removed from sand transferred from the western side of the harbour entrance to the eastern side for beach replenishment.
- Beach nourishment dates and volumes to be formally recorded.
- Monitoring of shoreline position by CPB.
- Relocation of the boat ramp adjacent to the eastern harbour breakwater
- Rationalisation of pedestrian and vehicle access points
- Limiting four wheel driving on the beach to the area east of the beach replenishment area.
- Dune planting to stabilise the beach dune using locally indigenous species and ongoing vegetation management.

PART B

Supporting Assessment of Coastal Processes

5 COASTAL PROCESSES SUMMARY

Implementation of successful coastal protection measures requires an understanding of the coastal processes to ensure that a design option is selected that can work within the constraints of the local environment. Part B presents the technical investigations and findings relating to the conceptual understanding of beach processes at Lucky Bay.

It is not the intent of this study to reach an agreed position on the coastal processes at Lucky Bay, however, in the context of assessing long-term options for coastal protection, it has been necessary to consider the expected hydrodynamics and sediment transport patterns. In this regard, we have drawn from previous studies as well as our own investigations. This has included:

- review of previous studies relating to coastal and estuarine processes in the study area and wider Spender Gulf region have been reviewed (see Section 6.1 and Section 6.2).
- interpretation of recent and historical air photography (refer Section 6.3);
- volumetric analysis of beach profiles (refer Section 6.3.2);
- analysis of tide and extreme water levels (refer Section 7.2); and
- numerical wave modelling of swell and wind waves within Spencer Gulf (refer Section 7.3).

To provide on-going review of the conclusions drawn in this study, it is recommended that expanded monitoring of the coastal zone at Lucky Bay be undertaken in the future.

A summary of the key findings is presented in the initial sections of Part B, with the details of the supporting investigations presented in the remaining sections.

5.1 Coastal Compartments

To assist in describing the coastal processes at Lucky Bay, the shoreline has been separated into three main sections, as shown in **Figure 24**. While there is significant interaction between these compartments and adjacent sections of coastline, segmenting the shoreline assists in the description of coastal processes in the study area.

It is clear is that there is a dominant littoral drift (or longshore transport) of material from the south-west to the north-east along much of the Eyre Peninsula's shoreline. As such we order the compartments from west to east, in the direct of longshore sediment transport

- Western Sand Spit - this sand spit[3] extends from the northern shoreline of the entrance to Franklin Harbour, near Victoria Point, terminating at the tidal inlet that separates the spit from the western end of Lucky Bay Beach.
- Lucky Bay Beach - extends from the western tidal inlet to the eastern, and main inlet to the samphire flats. It is recognised that this compartments is somewhat arbitrary, but the eastern boundary marks a long term change in processes from shoreline

[3] This and other sand spits have been referred to previously as sand banks, however, here we use the term sand spit as that's what they are.

recession to shoreline accretion and is an important distinction for coastal management.

- Eastern Spit and Main Tidal Inlet - which extends from the eastern end of Lucky Bay Beach.

These areas are further discussed in Section 6.3 , in relation to a review of historical aerial and beach profiles.

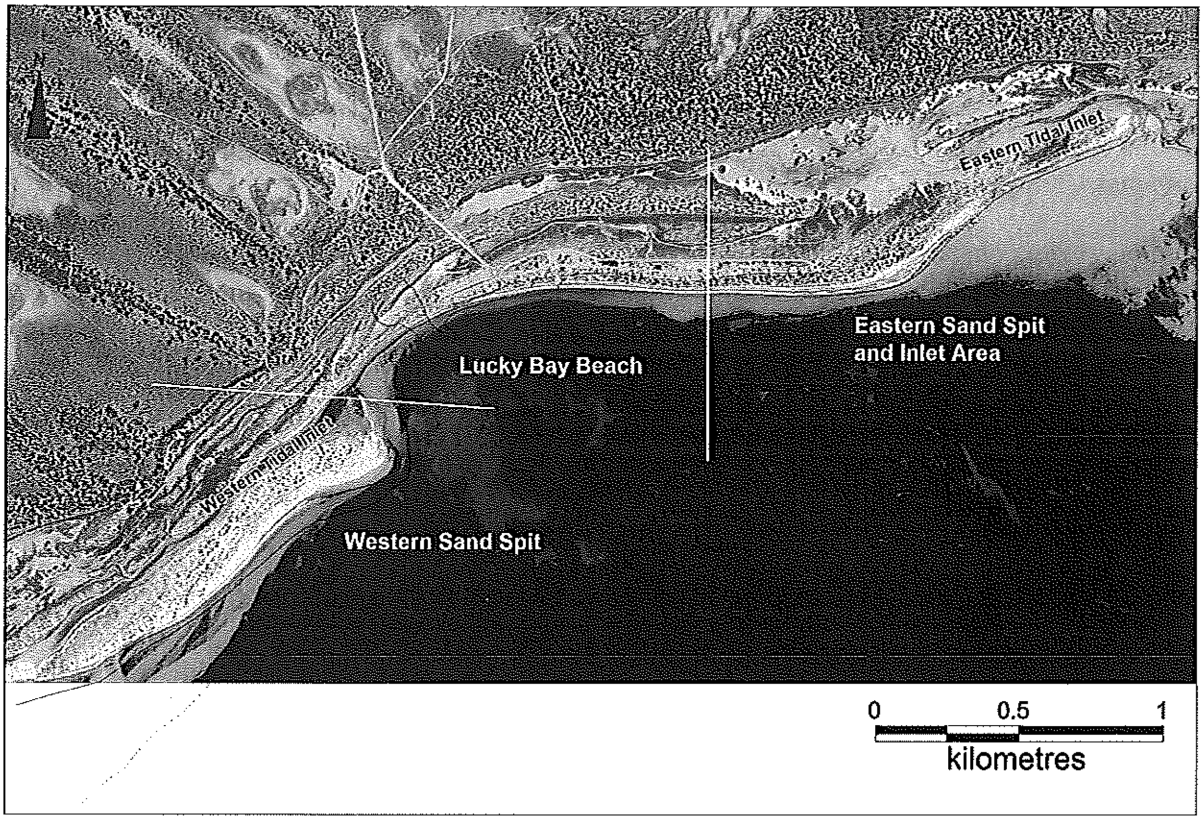


Figure 24 Lucky Bay Coastal Compartments

5.1.1 Coastal Setting and Metocean Forcing

The western shoreline of Spencer Gulf around Lucky Bay is characterised by low lying sand flats interwoven with wide Holocene dune ridges. Large dynamic sand spits are common as are small tidal inlets with shallow channels which provide tidal exchange with the intertidal sand flats. The sand flats and beaches grade into seagrasses.

The wave climate is generally of low energy but some ocean swells do penetrate to Lucky Bay, particularly in winter. The predominant wave direction is from the south to south-east and the net littoral drift is up the coast towards the north-east. Occasionally ocean swells and large local seas driven by southerly winds associated with the passage of cold fronts can cause significant storm waves. Episodic storm erosion has been observed along Lucky Bay and is associated with both ocean waves and larger local seas during the passage of cold fronts.

5.2 Conceptual Coastal Processes Model

Based on the outcomes of the coastal process and metocean forcings investigation, the coastal processes have been summarised in a conceptual model to demonstrate the current understand of coastal processes at Lucky Bay.

5.2.1 Natural State

Figure 26 shows the coastal processes model for the study area in a natural state. The effect of the Lucky Bay Harbour construction is also described below. In a natural state the coastal processes at Lucky Bay are described as:

Western Sand Spit

- A net longshore drift supplied sand from the west; the source is believed to be near Victoria Point. Episodic transport may be higher when 'sand slugs' migrate along the sand spit, as was observed between 1985 and 1995).
- This leads to a general accretion of the western sand spit of around 10,000 m^3/yr (based on the period 1985 to 2012).
- Accretion is concentrated at the end of the sand spit where a 'sand headland' forms and extends east as the sand spit accumulates sand:
- Net bypassing of the headland occurs along one of two pathways:
  - Along the shore, moving around the corner of the headland and bypassing the tidal inlet to move onto the Lucky Bay beach, this is likely to be the primary pathway for net transport. It is thought that net bypassing by this shoreline pathway is reduced as the angle made by the headland increases. The net littoral drift along this pathway is believed to be around 6,000 m^3/yr.
  - During larger coastal storms, likely associated with large waves and high water levels, a storm bypass pathway shortcuts much of Lucky Bay beach, rejoining the longshore drift about 200 m east of the existing boat ramp a location identifiable as a 'lump' in the seagrass/sandy seabed interface (see below).
- Sand slugs are likely to be associated with some large coastal storm events, likewise, it is postulated that the 'sand headland' can be rapidly eroded. That is to say that the 'sand headland' grows in mild weather years, fed partly by the migrating sand slug, but when a large storm surge and storm waves occur it is episodically washed into the Lucky Bay embayment. When a large storm surge occurs around a high tide, this 'sand headland' would be underwater and act as a mobile sand bar and could be easily transport at rapid rates. There is limited evidence of this in the available records, however, the eroded state of the 'sand headland' in 1985 along with simultaneous observations of the sand slug on the western sand spit suggests it may have been the same event that caused these features. What appeared to be a slow colonisation by seagrass of a sandy seabed in the storm bypass pathway also adds some support to this theory.

Lucky Bay Beach

- Mild recession (i.e. long-term erosion) of the shoreline between 1985 and 2006, is associated with a net deficient in alongshore drift rates. As sand accumulates on the 'sand headland', sand supply to Lucky Bay is reduced but net loss to the north is constant, resulting in a systematic loss of sediments from the shoreline. The rate of net sediment loss from this compartment is estimated at about 2,000 m^3/yr, based on beach profile data between 1986 and 2006 (see **Section 6.3.4**).

- As a secondary process to the net loss of sediments within this compartment it is possible that as the 'sand headland' extends east, the 'zeta' or log-spiral shape embayment in the lee of this headland changes (i.e. Lucky Bay beach shoreline) as per **Figure 25** below from Silvester *et al* 1978. This behaviour would result in a drift of the worst sort of erosion to the east for Lucky Bay, as has been observed.

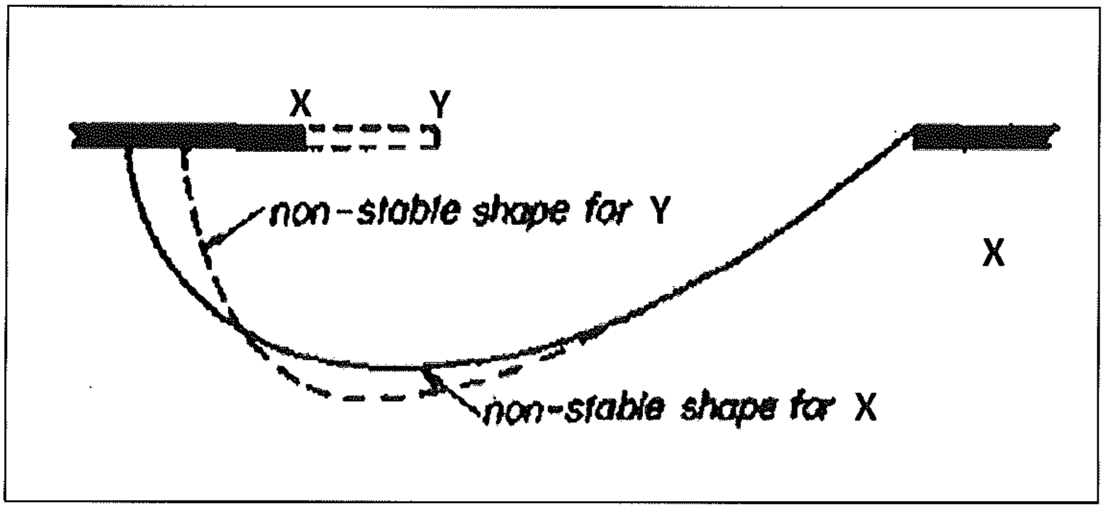
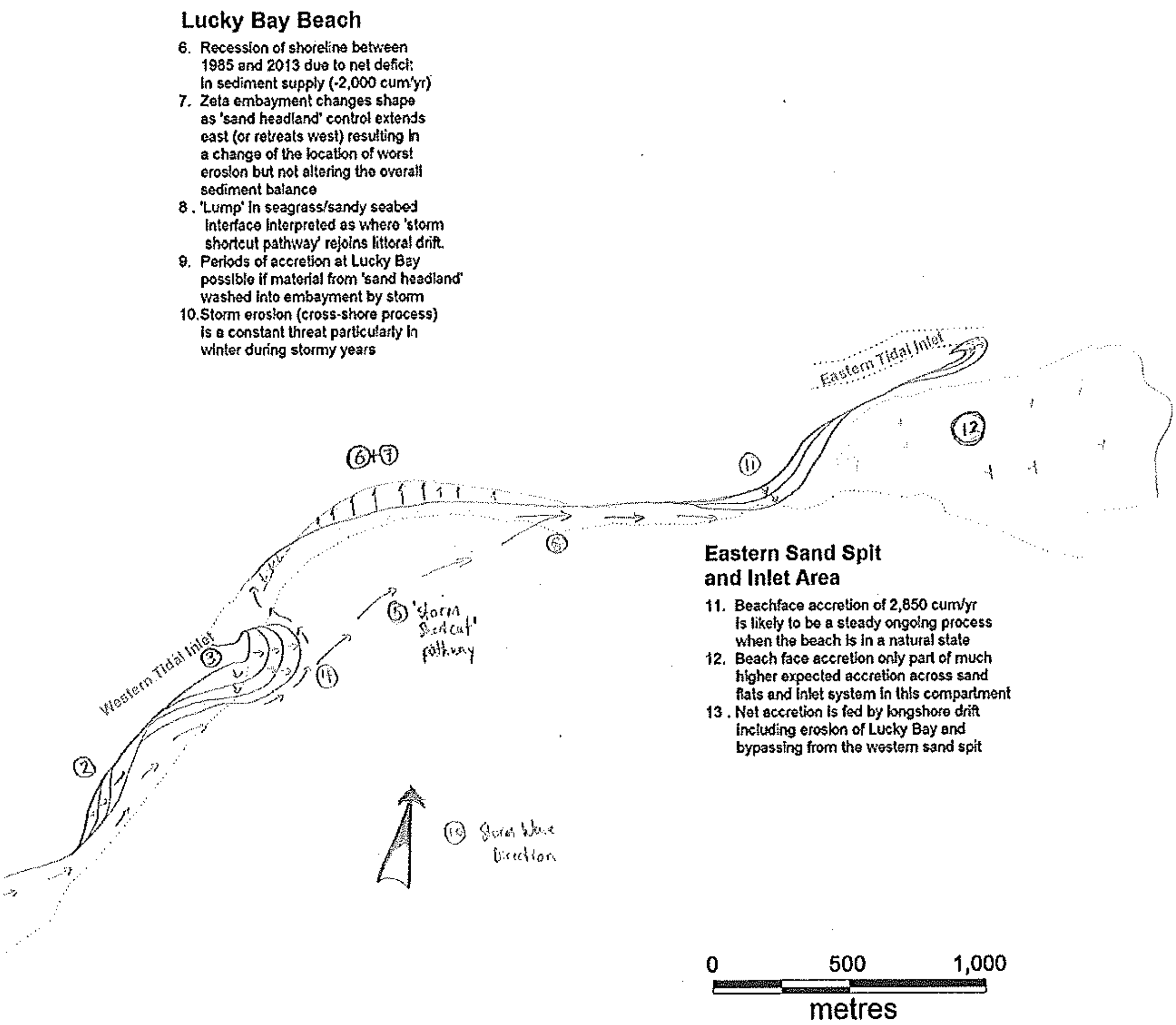


Figure 25 Effect on shoreline within embayment when headland control extends from A to B

- the 'lump' in the seagrass/sandy seabed interface observed in all historical aerial images is interpreted as where the storm shortcut sediment pathway rejoins the alongshore drift, which predominately occurs on the beachface.
- It is possible, although not directly observed in the available records, that if a mass sand transport event was to occur, (i.e. an event that washed the sand accumulated on the 'sand headland' into the Lucky Bay embayment), periods of accretion of the shoreline at Lucky Bay could result.

Eastern Sand Spit and Main Tidal Inlet

- This compartment was accreting at a rate of about 2,850 m^3/yr, based on observations between 1985 and 2012. When Lucky Bay was in a natural state, it is likely this was a steady ongoing process.
- Net accumulation of sediment is fed by the net alongshore drift, which is in turn is fed by both the bypassing of the 'sand headland' at the end of western sand spit, and by net sediment loss from Lucky Bay.



iment Transport at Lucky Bay

5.2.2 Effect of Harbour Construction

Based on review our review of aerial photography and recent observations following construction of the Lucky Bay Ferry Harbour in 2006, the following points can be made. For more details on the 2006 construction of the Harbour refer to **Section 2.3**, **Part A**. However, the main aspect from a beach processes perspective was the introduction of training walls across the beach and placement of an estimated 28,000 m^3 of dredge spoil as beach nourishment directly to the east of the eastern training walls. This resulted in:

- effectively blocking of the net littoral drift along the shore pathway, this is observed through the net accumulation of around 6,000 to 6,500 m^3/yr of sand between 2010 and 2013 on the western side of the training walls. The blocking of the littoral drift pathway would be expected to result in a 'wave' of erosion proceeding north-east along Lucky Bay.
- The placement of an estimated 28,000 m^3 of beach nourishment immediately adjacent to the eastern training wall has been effective in temporarily filling the longshore drift demand. This nourishment volume initially moved down the beach profile, spreading seaward to the end of the training walls and flattening the beach profile adjacent to the training wall. It then (after 2008) moved east resulting in rapid erosion in the area adjacent to the training wall estimated as 1,500 m^3/yr over the 170 m of shoreline east of the harbour. Indicating that 25% of nourishment volume has moved away from the eastern sector of the Lucky Bay compartment (identified as **Zone A** in **Figure 9**).
- The introduction of the training walls is expected to alter the zeta embayment shape as per **Figure 25** (after Silvester *et al*, 1978). It is likely that erosion in **Zone A** of Lucky Beach will start to slow as it reaches a new stable alignment, seaward of its previous (pre-construction) alignment, see area X below in **Figure 27**.

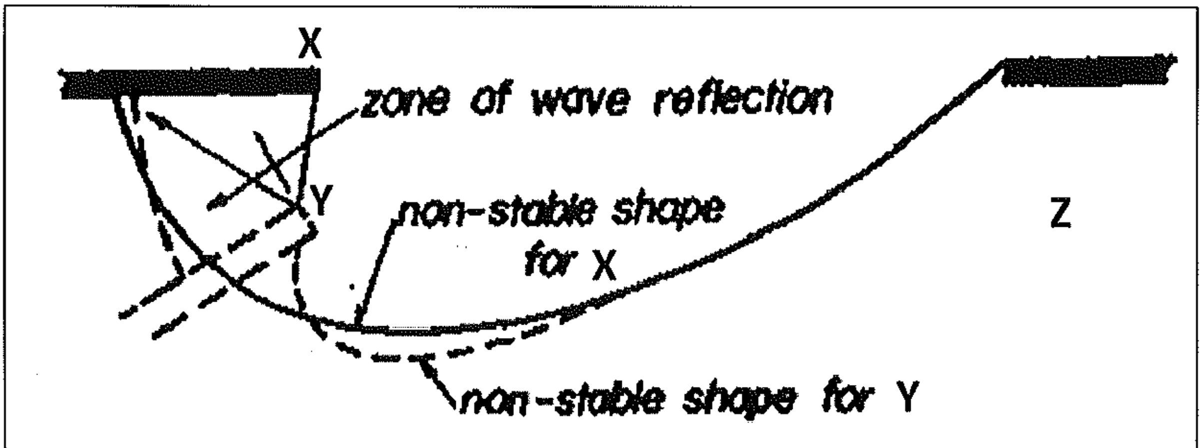


Figure 27 Effect on shoreline within embayment when a new structure, such as training walls, moves the control point from A to B.

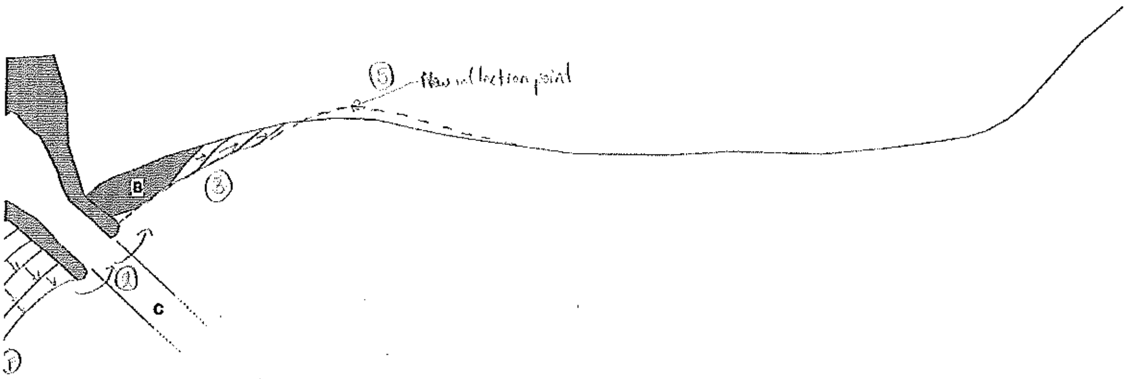
- As the nourishment material spread rapidly east it caused a change to the previously steadily eroding mid-section of Lucky Bay beach (**Zone B**) where it started to accrete. This is likely to be a temporary response, limited to the duration of beach nourishment. The most recent observation is that this area has already reverted to erosion and this would be expected to accelerate.
- Only limited impact has been observed further east (**Zone C**), however, there has been a very recent slowing of the erosion, which might be evidence of the nourishment sand spreading into this sector of the compartment.

- The impact on the other potential sediment transport pathway (the 'storm bypass shortcut') is unknown.
- The basic conclusion is that once the masking effect of the one-off beach nourishment diminishes, erosion along Lucky Beach will occur if nothing is done to feed the long shore drift which has been interrupted by construction of the training walls.

Impact of Lucky Bay Harbour Construction

1. The net alongshore drift (via the shoreline pathway) has been blocked since construction leading to material accumulating west of training walls at rate of 6,000 to 6,500 cum/yr.
2. Once the longshore drift fills the available space west of the harbour sand will start to bypass the training walls, infilling the navigation channel and eventually ending up on Lucky Bay beach.
3. Beach nourishment filled the area east of the harbour and temporary supplying the longshore drift demand with rapid erosion occuring as the profile readjusts to the nourishment.
4. The mid sections started to accert as nourishment material moves east, prior to construction it had been receeding. Without further nourishment it is expected to resume the trend of erosion again soon.
5. Training wall have changed the control points for the zeta-shape embayment. This is expected to stabalise the area immediately east of the harbour while leading to more erosion further east as the inflection point of the embayment moves east.
6. Only limited impact observed on beach processes further to the east.

Eastern Tide



Lucky Bay Harbour Construction

Constructed in 2006, from a beach processes perspective. the three main aspects were:

A - introduction of training walls as part of the harbour basin
B - beach nourishment of area to the east of the harbour
C - dredging of a navigation channel.

0 250 500
metres

act of Lucky bay Harbour on Sediment Transport within the embayment

6 COASTAL PROCESSES INVESTIGATIONS

6.1 Review of Previous Investigations

6.1.1 Lucky Bay Management Plan (1989)

This plan mentioned the relocation of the shack sites to inland locations. In relation to the coastal stability study by Fargher Maunsell (1985) it was noted that:

> *"...all shacks will be subject to significant unacceptable risks from seawater inundation over the next 100 years. These risks arise from a combination of coastal erosion, potentially high sea levels relative to shack levels and the flooding of access roads"*

6.1.2 Lucky Bay Master Plan (Master Plan, July 2011)

The Lucky Bay Master Plan was completed in 2011 and was produced in order to guide future development of the Lucky Bay area. The Master Plan included an ecological assessment, coastal processes investigation and wastewater treatment options investigation.

The following issues were identified as a priority for action:

- resolve tenure issues to secure the long term operation of the ferry; and
- some form of coastal protection is required to secure the long term future of the shacks.

Development plans were produced for a number of options, sub-options and permutations. Development potentially includes a:

- ferry terminal precinct with retail, boat ramp, public moorings, tourist accommodation;
- shack precinct;
- residential precincts – a western and eastern precinct;
- export facility; and
- other infrastructure and recommended vegetation offsets.

6.1.3 Coastal Process Investigation (Tonkin Consulting, 2010)

As part of the 2011 Master Plan a coastal processes investigation was undertaken by Tonkin. The purposes of the study were to:

- gain an understanding of the natural erosion and accretion cycles at Lucky Bay;
- assess the potential shoreline response to future sea level rise;
- assess the risk of coastal flooding both now and in the future
- suggest conceptual options for protection of the shacks from coastal processes

Through examination of historical aerial photographs and sand profile information Tonkin found that the shoreline adjacent to the shacks at Lucky Bay had generally accreted for the 30 years to 1985 before eroding, particularly around 1985 to 1995, resulting in a small net change between present day and when many of the shacks were first constructed (baseline data at 1953).

Through application of the Brunn Rule, assuming a sea level rise of 1.0,m for the year 2100 a 22 m buffer to account for shoreline recession as a result of future sea level rise was recommended.

The Tonkin report adopts a 100 year ARI elevated coastal water level of 2.4 m AHD. While it is not specifically specified it is believed that this was based on the water levels recorded at Whyalla during a 1981 storm coincident with a high tide (Short, Fortheringham and Buckley, 1986). Allowing for wave setup, wave run-up and 0.3 m of sea level rise to 2050, a minimum site level of 3.2 m AHD with a Finished Floor Level (FFL) of 3.45 m AHD was recommended, provided there are practical measures for protection against the 2100 prediction sea level rise; alternatively a site level of 3.9 m AHD and FFL of 4.15 m AHD was recommended.

Tonkin recommended two options for protection of the shack settlement. These were:

- **Option 1** - construction of a rock armour seawall extending from the eastern breakwater to the eastern end of the shack sites.

- **Option 2** - relocation of the existing shack sites landwards, providing a buffer of sufficient width for protection against coastal processes and to maintain beach amenity.

Both of these options would require the elevation of the shack sites through the placement of engineered fill material in order to comply with Principle of Development Control requirements

The coastal processes review noted that the construction of the breakwaters provides a barrier to the natural littoral drift to the north-east, although immediately east of the breakwaters, the beach have remained relatively stable. It also noted that "whilst over the last 30 years the coastline adjacent the Lucky Bay settlement has experienced significant periods of erosion, observed accretion trends between 1953 and 1985 have meant that the primary dune escarpment is similar to that which may have been observed when many of the shacks were first constructed".

6.2 Morphological Evolution

The following information is summarised from the *Morphodynamic, Hazard and Development Impact Assessment Eyre Coast Protection District* (Short *et al* 1986).

The Spencer Gulf consists of Cainozoic outwash deposits which, in places have been reworked into shingle storm beach ridges. The sandy sections include wide intertidal to subtidal sandflats; beaches and backing foredunes and transgressive dunes; and beach ridges.

Based on the combinations of the pre-Quaternary substrate and subsequent Quaternary deposits the coast can be divided into eight coastal Provinces. Lucky Bay falls at the southern end of Province 1 'Central Spencer Gulf' (McGregor Boundary to Lucky Bay) described by Short *et al* 1986 as 61 km in length and comprised of Holocene beach ridges and swales and intertidal and subtidal sandflats.

One of the key factors of the Quaternary evolution, relevant to this study, is the abundance of marine shell material that has provided a sediment source for much of the sandflat, shoreface, barrier and dune deposits of the present coast and shelf area. The sand barriers are wave-deposited sediments consisting of sandy shoreface deposits (nearshore, surf zone and beach) and usually backed by back or inter-barrier depressions filled by finer deposits. The study area is typical of the Eyre Peninsula barriers at the lower end of the energy scale, with beach ridge plains fronted by wide intertidal sandflats.

A typical beach ridge plain consists of swash deposited sand-shelly ridges separated by, and fronted on the seaward margin, wide intertidal sandflats. At Lucky Bay there are numerous ridges behind the current beach ridge. These ridges are relic beaches. In South Australia the beach ridges are composed of a sandy matrix with a high proportion of shell debris. As new ridges block the backing swale from wave attack, samphire vegetation covers the prior sandflats.

The Eyre Beach ridges have been emplaced since the Holocene stillstand. Most consist of several low (1-2 m) ridges a few tens of metres wide, separated by wider inter to supratidal swales. They usually extend a few hundred metres seaward and are always fronted by wide (100's m) intertidal sandflats. The mollusc-rich sandflats are the apparent source of ridge material. The evolution of the Eyre Peninsula Holocene beach ridges is depicted in **Figure 29**.

Figure 29 Evolution of Eyre Peninsula Holocene Beach Ridges (source: Short et al 1986)

The coastal geomorphology of Provence 1 is a distinctive section of the Eyre coast due to its uniform orientation and exposure to the predominantly low wave energy gulf, coupled with the low gradient Pleistocene calcareous surface mantled by east-west trending stable longitudinal dunes.

The coast follows the beach ridge evolutionary model as shown in Figure 1, particularly in cross-section. In plan, however, the partially drowned longitudinal dunes have imprinted a highly crenulated backshore and influenced the present morphology.

Figure 30 schematically illustrates the effect of the longitudinal 'desert' dunes on Holocene shoreline evolution in the Spencer Gulf:

a) Present stillstand, partially submerges a dune field forming 'headlands' and embayments and initiating shoreline development.
b) Beach ridges formed from quartz dune material and insitu marine cabonates
c) Beach ridge (BR), foredune (FD) evolve as well as recurved spits, with inter and back barrier depressions

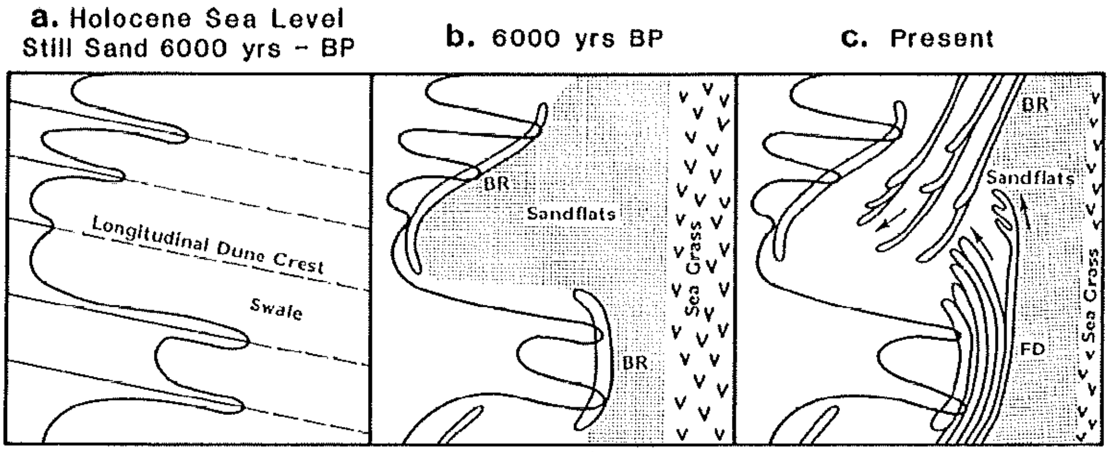


Figure 30 Spencer Gulf Shoreline Evolution (source: Short *et al* 1986)

In (a) the dunes were active during low sea level glacial periods, at the Holocene sea level stillstand the dunes extending into the gulf were drowned and their sediments reworked shoreward. The drowning of the dunes produces a crenulated shoreline with the swales forming shallow embayments and the ridges low headlands. Sediment swept shoreward and eroded from the dune headlands initiated infilling of the embayments and formation of beach ridges as shown in (b). Continued sediment supply to the coast by onshore and longshore (northerly) reworking of quartz dunal and in situ sandflat biotic material has resulted in the formation of multiple beach ridges. Inner ridges are composed of predominantly iron stained quartz, the outer by increasing percentages of shell debris, reflecting the changes sources. Progradation of the ridges seaward of the headlands has straightened the coast considerably.

In the southern section of Provence 1 (i.e. in the vicinity of Lucky Bay), the shoreline orientation swings to the east-west which means this section of the coast faces strong south to south-westerly winds and waves, as well as occasional ocean swell producing a higher energy shoreline with initial beach ridge development being replaced by foredune ridges as shown in Figure 3 (c). Steeper gradients can occur as the shoreline progrades seaward (into deeper water) and sediments are reworked landward (thus deepening the nearshore), with the latter being favoured in this location.

The modern shoreline therefore consists of a wide intertidal sandflat which grades into seagrass meadows. Reworking of the sandflat biota provides shell detritus for shoreline progradation.

At the shoreline the beaches have low reflective beach faces which are only active during strong onshore-alongshore winds. The beaches are capped by low vegetated dunes and backed by wide, low inter to supratidal flats covered by samphire vegetation.

Morphologically the coast is very stable. Locally, particularly in the southern section (i.e. in the vicinity of Lucky Bay) longshore drift of sediments and migration of large scale intertidal bedforms produce both shoreline erosion and accretion.

6.3 Review of Historical Aerials and Beach Profiles

A summary of the findings from a review of historical shoreline observations is presented for each of the beach compartments described above. This review is a key aspect informing the conceptual understanding of coastal processes at Lucky Bay.

6.3.1 Historical Aerial Photography

Historical aerial photography for the following years: 1956, 1964, 1978, 1981, 1985, 1995, 2004, 2008, 2008 and 2012 have been obtained from Council and DEWNR and used to inform the following review of observed foreshore changes in the study area. Where images were not provided as ortho-rectified, the images have been roughly located in real world co-ordinates using software package MapInfo. This resulted in reasonable positioning of aerials along Lucky Bay, with errors estimated to be around 3 to 8 m depending on the image. Greater spatial error is expected away from Lucky Bay.

6.3.2 Coastal Protection Board (CPB) Profiles

A volumetric analysis of all available beach profile data at Lucky Bay has been undertaken to analyse the short-term trends and fluctuations in the beach profiles and to assess the impact of the construction of the breakwaters.

Table 3 provides a summary of the beach profiles available in Lucky Bay and **Figure 31** shows the locations of these within the bay. A 27-year series of beach profile data is available to the east of the training walls, for profiles 01 to 04, from 1986 to 2013. To the west, profile 11 has useable data to inform recent changes due to the construction of the harbours training walls in 2006. While additional profiles (06-09 and 10) were analysed, they are not discussed at length here due to the short period of data (from 2000 to 2013).

CPB beach profile data has been analysed using a volumetric analysis to determine beach change over the time 27 year period of record. To ensure consistency in the comparison, it was necessary to normalise the profile chainages between the years of available data. Trends in historical beach volumes have been identified using a regression analysis. The results of the analysis are discussed below for the relevant beach compartments.

It should be noted that when interpreting discreet beach profile data sets, that they often mask the higher frequency beach changes associated with cross-shore sediment transport, such as episodic beach erosion events, and short time scale changes such as seasonal beach rotation.

Table 3 Summary of the beach profile data available for the study

Profile ID	Years
01	1986, 1992, 1993, 1994, 1996, 1997, 1998, 1999, 2000, 2003, 2005-2013
02	1986, 1992, 1993, 1994, 1996, 1997, 1998, 1999, 2000, 2003, 2005-2013
03	1986, 1992, 1993, 1994, 1996, 1997, 1998, 1999, 2000, 2003, 2005-2013
04	1986, 1992, 1993, 1994, 1996, 1997, 1998, 1999, 2000, 2003, 2005-2013
11	2010, 2012 (insufficient length), 2013

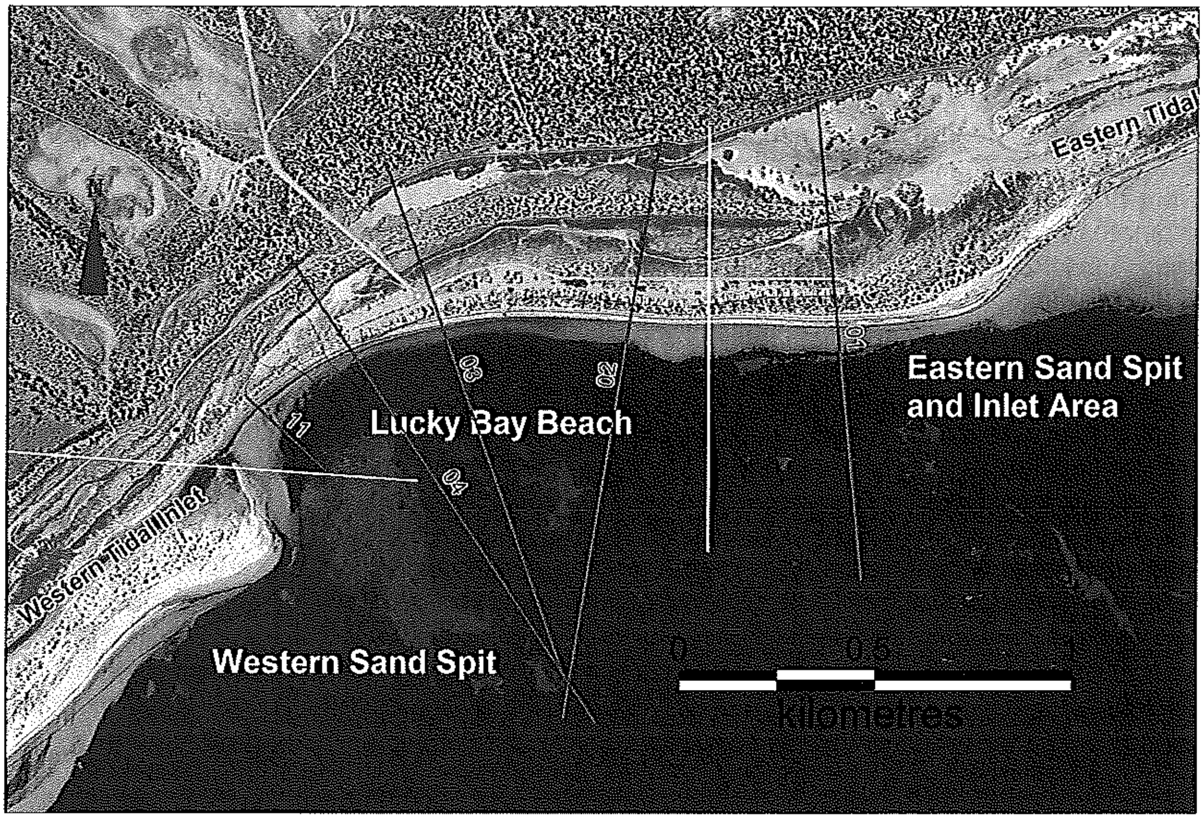


Figure 31 Location of the selected CBP beach profiles at Lucky Bay (2004 aerial in background).

6.3.3 Western Sand Spit

This sand spit separates Spencer Gulf from a narrow tidal inlet (or waterway) which connects with an extensive intertidal/wetland/low-lying area of samphire swamp. The sand spit is formed by the net east to west longshore drift that dominates along the Eyre Peninsula (Short *et al* 1986). The source of the sand that feeds the growth of the western sand spit is believed to be the sand shoals around the northern entrance to Franklin Harbour and the sand barrier system in the vicinity of Victoria Point. However, in this study we only consider the 2.2 km stretch at the eastern end of the sand spit. A detailed understanding of this sand source is outside the scope of the present investigations. As the ongoing supply of sand is likely to important to beach processes at Lucky Bay in the longer term, it is recommended that additional monitoring and assessment be undertaken in the future.

At the eastern end the sand spit is constrained by the location of a tidal inlet that provides for exchange to the samphire swamp.

A series of selected aerials of the western sand spit compartment is presented below. The lines annotated on the images are in consistent locations to assist in the interpretation.

Through inspection of these images, the following key observations can be made:

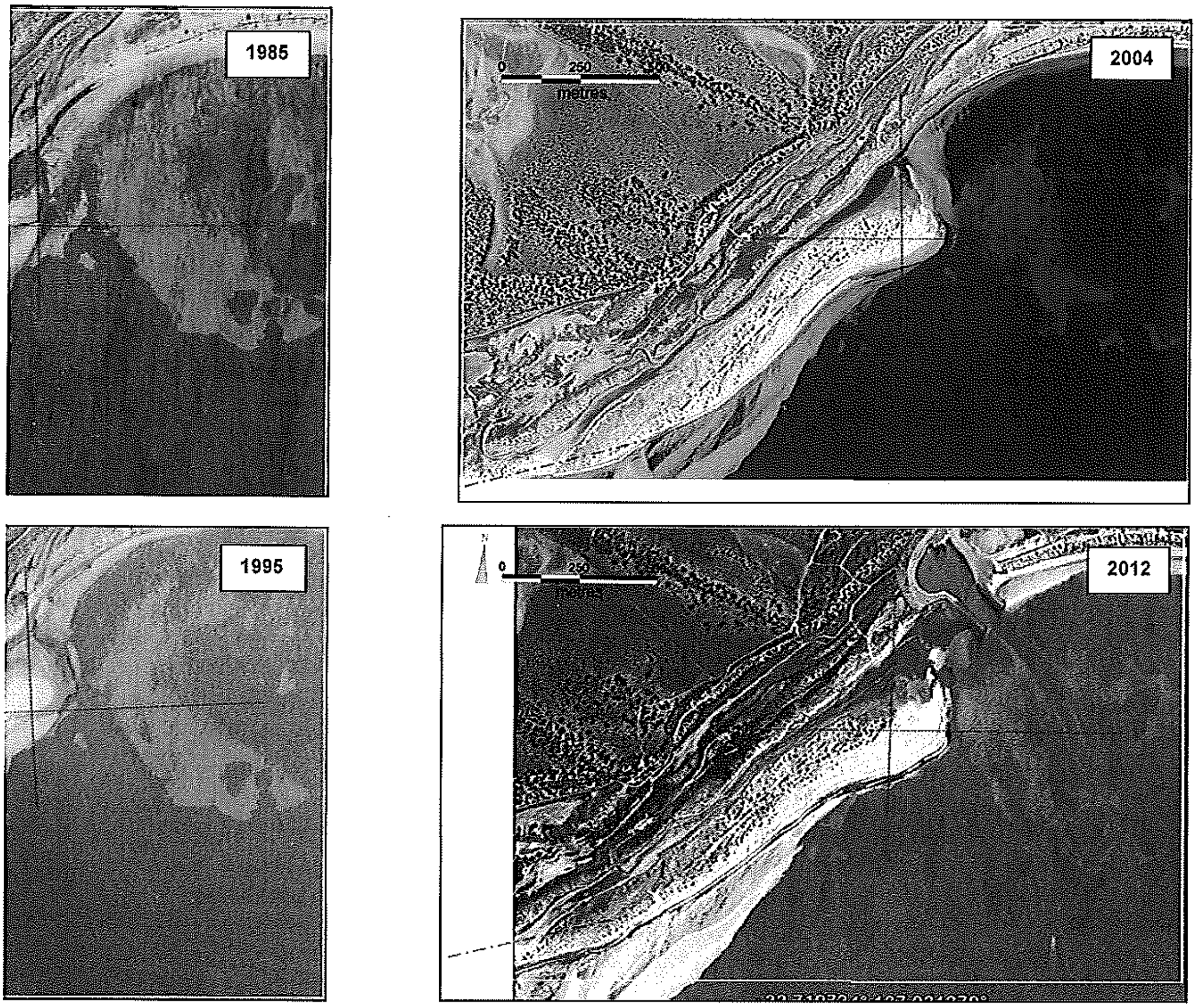
- A sand 'slug' observed along the spit in the 1985 aerial has moved around 300 m westward by the 1995 image, moving at an average rate of 30 m/year.
- In the 1985 image the shoreline along the western sand spit has two distinct alignments, in the west the alignment is more east-west, this is likely due to the sand slug.

- From 1995 to 2004 the sand slug appears to have moved some 700 m to become fused to the end of the sand spit forming what, in mild weather conditions, effectively acts as a sand 'headland' to the Lucky Bay embayment. The rate of movement during this period was 75 m/yr or greater. This more rapid longshore transport is likely due to this section of shoreline being more oblique to the dominant wave direction.
- The 'sand headland' at the eastern end of the sand spit grows considerable over the 27 year period, extending 195 m eastward, indicating an average growth rate of around 7 m/yr. The eastward extension of the headland has generally increased the angle formed between the end of the headland and the Lucky Bay embayment, this is particularly evident in comparing the 1985 and 2004 aerials.
- By 2012 the alignment of the western sand spit shoreline is more uniform and more perpendicular to the dominant wave direction.
- Over the period there appears to be a slow colonisation by seagrass of what was a rather large area of bare sand in 1985, between the end of the western sand spit and Lucky bay. Seagrass colonisation appears most rapid between 1985 and 1995. (refer to **Figure 33**).
- It is difficult to say from the aerials alone but the construction of the training walls does not appear to have had much of an impact, as yet, on the western sand spit. This might be expected as the spit is updrift and separated somewhat by the tidal inlet.

Based on further analysis of the change in the area of the sand spit observed in the aerials combined with some assumptions on the height and volume within the beach profile, it has been estimated that the overall volume accretion along the 2.2 km of sand spit was in the order of 270,000 m^3. This equates to an average rate of 10,000 m^3/yr. Averaged across the length of the spit this would be an accretion of 4.5m^3/m/yr.

One possible explanation of the growth of the headland is that it will get knocked down by the lest large storm when large waves combine with . Perhaps this explains the bypass pathway from western sand spit to Lucky bay

The above observation indicates that the western sand spit is active, has substantially accreted and that the eastern end of the sand spit has extended eastward significantly form what is termed here a 'sand headland'. Furthermore, movement of a large sand slug eastward along the sand spit has been a significant feature.



.ucky Bay (Western Area)

6.3.4 Lucky Bay Beach

The Lucky Bay beach compartment consists of an embayed shoreline extending from the western tidal inlet to the eastern sand spit. The shoreline is predominately aligned east-west but curves toward the south in the western sector when it was in a natural state (i.e. pre-harbour).

A series of selected aerials of the Lucky Bay beach compartment is presents below. Through inspection of these images, the following key observations can be made:

- Pre-harbour construction there is a zeta-shaped curve at the western end of the Lucky Bay beach compartment, this is associated with the sheltering from wave energy afforded by the 'sand headland' that forms on the western sand spit.
- About three quarters of the way along the compartment a consistently wider sub-aqueous beach is observed in all aerials. This has been inferred from the observed seaward 'lump' in the seagrass/sandy seabed interface. East of this lump, the sandy beach part of the profile is consistently wider than to the west of the lump.
- The 1995 image shows a buildup of sand on the updrift (western) side of the boat ramp, suggesting that the net easterly drift is maintained along the Lucky Bay beach compartment.
- By comparing the 2004 and 2012 images, it is clear that the 2006 construction of the Lucky Bay Harbour has had a significant impact on the shoreline of Lucky Bay beach, particularly in the western sector. The training walls and associated nourishment has resulted in significant accretion of the area immediately east of the training walls. Immediately to the west of the training walls the shoreline appears to have moved seaward some 140 m between 2009 and 2013.
- Following harbour construction, there has been an easterly movement of the point at which more severe erosion occurs. Prior 2006 this point was in front of the Block 1 shacks, now it is near the boat ramp.

CBP beach profiles are available for the Lucky Bay beach compartment and significantly add to the understanding of shoreline dynamics within this compartment. **Table 4** presents the key observations of the CBP beach profile assessment in the Lucky Bay beach compartment. Observations are presented in the direction of net sediment transport (i.e. west to east).

As the construction of the Lucky Bay Ferry Harbour has had a significant impact in beach processes in this compartment, the analysis, pre- and post-construction has been separated. For more details on the 2006 construction of the Harbour refer to **Section 2.3**, **Part A**. However the main aspects from a beach processes perspective, was the introduction of training walls across the beach and placement of an estimated 28,000 m^3 of dredge spoil as beach nourishment directly to the east of the eastern training walls.

Table 4 Key Observations of the CBP Beach Profile Assessment in the Lucky Bay Beach Compartment

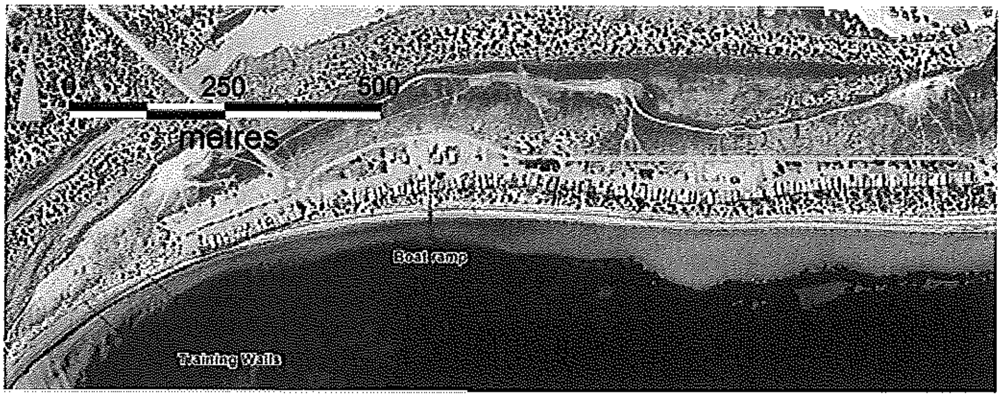
CPB Profile, location (see Figure 31), Figure references and data coverage	Pre-Harbour Construction (1986 -2005)	Post-Harbour Construction (2006 -2013)
CBP-11 – located immediately west of training walls, **Figure 34**. Data coverage 2009 and 2013	No data	Between the available profiles in 2010 and 2013, the data shows a 120 m^3/m to 130 m^3/m build-up of material within the lower beach face (0 to -1.5 m AHD). Extrapolating this across the shoreline between the tidal inlet and the western training wall it is estimated that 18,000 to 19,500 m^3 of material was trapped. This equates to an average rate of between 6,000 and 6,500 m^3/yr. It is likely that at least some of this material is seagrass wrack. The -0.5 m AHD contour accreted about 145 m seaward at a rate of 48 m/yr.
CBP-04 – western section of Lucky Bay beach compartment immediately east of training walls, **Figure 35**. Data coverage 1986 to 2013.	Eroded at a rate of 1.5 m^3/m/yr. The beach face (based on the 1 m AHD contour) receded about 9 m at an average rate of 0.5 m/yr.	Renourishment added some 155 m^3/m to this profile between 2006 and 2008, extending the beach face seaward by some 48 m. Since 2008 the volume of the beach profile has rapidly reduced, losing some 8.6 m^3/m/yr, as the renourishment material is transported to the east. The beach face receded about 19 m between 2009 and 2013, at an average rate of 4.8 m/yr.
CBP-03 – middle section of Lucky Bay beach compartment, between the harbour and the boat ramp, **Figure 36**. Data coverage 1986 to 2013.	Eroding at an average rate of 2.3 m^3/m/yr, but as high as 4.0 m^3/m/yr from 1997 to 2005. The beach face receded about 15 m at an average rate of 0.8 m/yr.	This area started to accrete at the relatively high average rate of 4.5 m^3/m/yr. The beach face moved seaward about 9 m at a rate of 1.3 m/yr. The rate of accretion has been variable, as seen by the poor straight line fit in **Figure 36**. This accretion was reversed

		between 2012 and 2013 when the profile eroded 10 m^3/m.
CBP-02 – eastern section of Lucky Bay beach compartment, east of boat ramp immediately east, **Figure 37**. Data coverage 1986 to 2013.	Eroding since 1986 and is continuing to erode Pre-construction of the training walls (2006), the volumetric rate of beach recession has been -1.6 m^3/m/yr. The beach face receded about 20 m of the entire 27 years, the average rate was 0.7 m/yr.	There is not a significant difference in the rate of recession between the pre- and post-training wall construction rates. Although there may have been a more significant slowing of the rate since around 2009 (erosion rate = 1.1 m^3/m/yr). It is possible the slowing erosion rate was due to small scale beach replenishment that added around 4,500 m^3 to this area in the last four years.

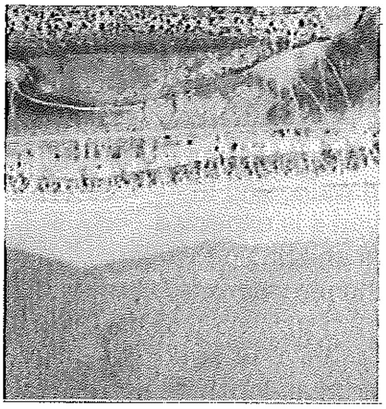
Following construction of the breakwaters this material is no longer transported to the east by the prevailing longshore transport and so the area west of the harbour is now silting up. The area will continue to silt up until material can start bypassing the training walls, and then it would be deposited in the dredged channel. At the rates of build up observed it is expected the sand will start to bypass the breakwater in the very near future, 1-2 years and begin to infill the navigation channel. This is likely to represent a real problem from the ferry service in the here future.

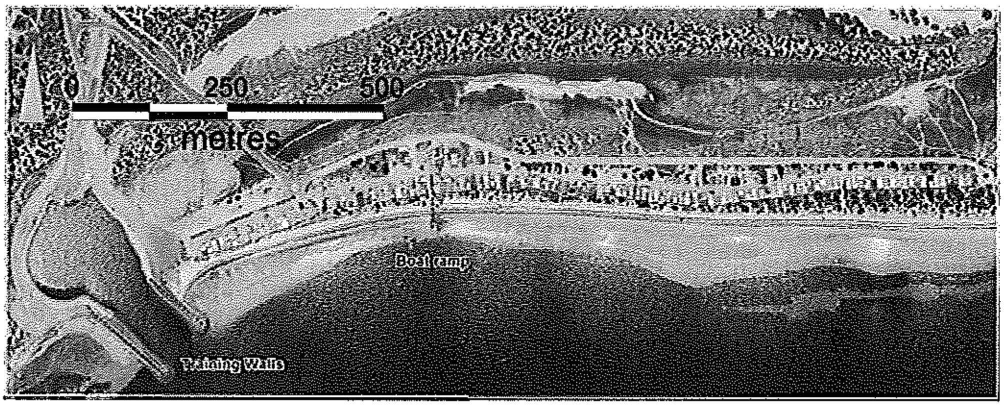
CBP-04 is expected to continue to erode but the shoreline with reaches equilibrium location shoreward of what it was before the training walls were introduced. This is because the training walls have resulted in a small sheltered area in their shadow and created a new control point for the zeta embayment which will hold sand in this zone. However, the blocking of the natural sediment supply from the west will continue to cause

The recent accretion at CPB profile 03 is evidence of the material placed as part of the renourishment has been moving east, changing the trend of this area of the beach from eroding to accreting. The renourishment will continue to move to the east and will start to result in accretion at the mid-section of Lucky Bay over the next few years. Recent erosion (2012-2013) could be the way of the future as the capital nourishment has run its course and the trend of erosion is likely to restart, possibly at a more rapid rate than before construction.



2004





2012

/ Beach)

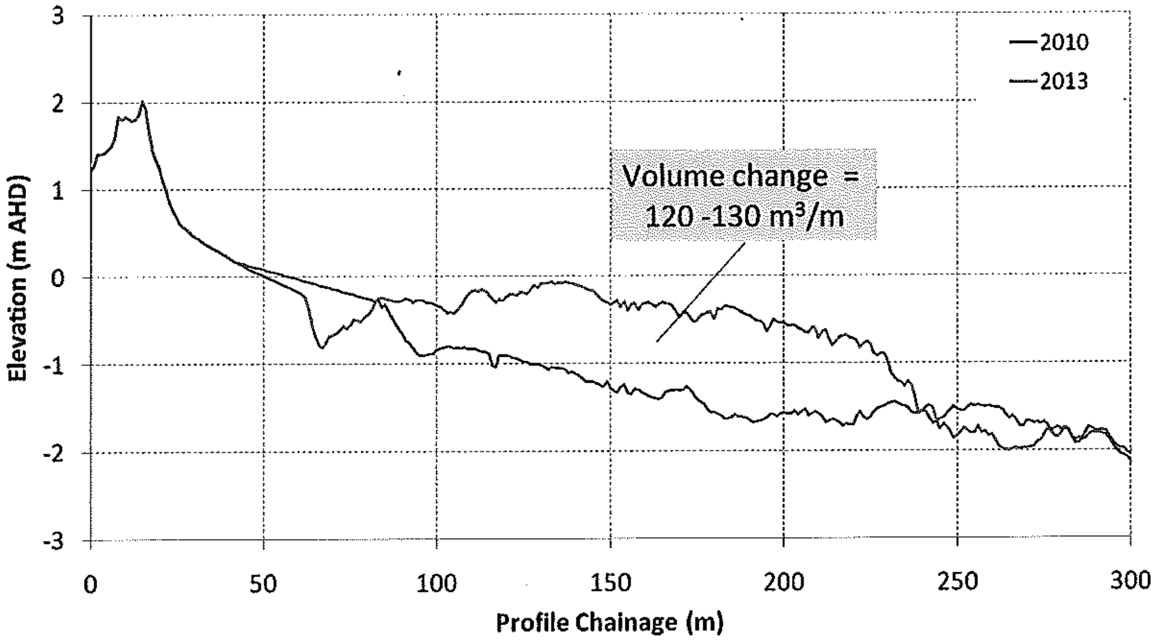


Figure 34 CBP-11 Plotted for 2010 to 2013

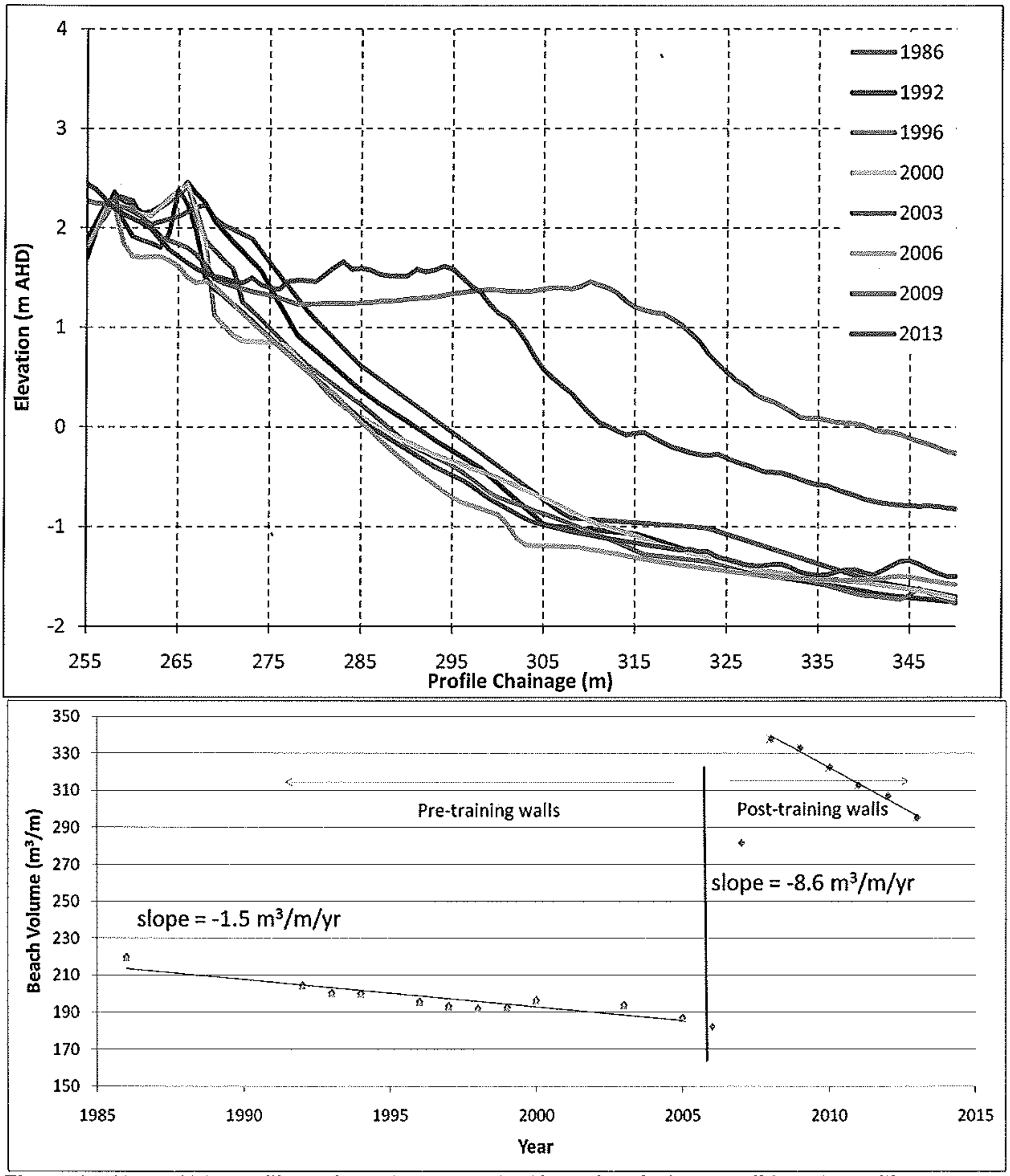


Figure 35 Top - CPB profile 04 from 1986 to 2013. Note: for clarity not all beach profiles are plotted, Bottom - Beach volume trend for CPB profile 04.

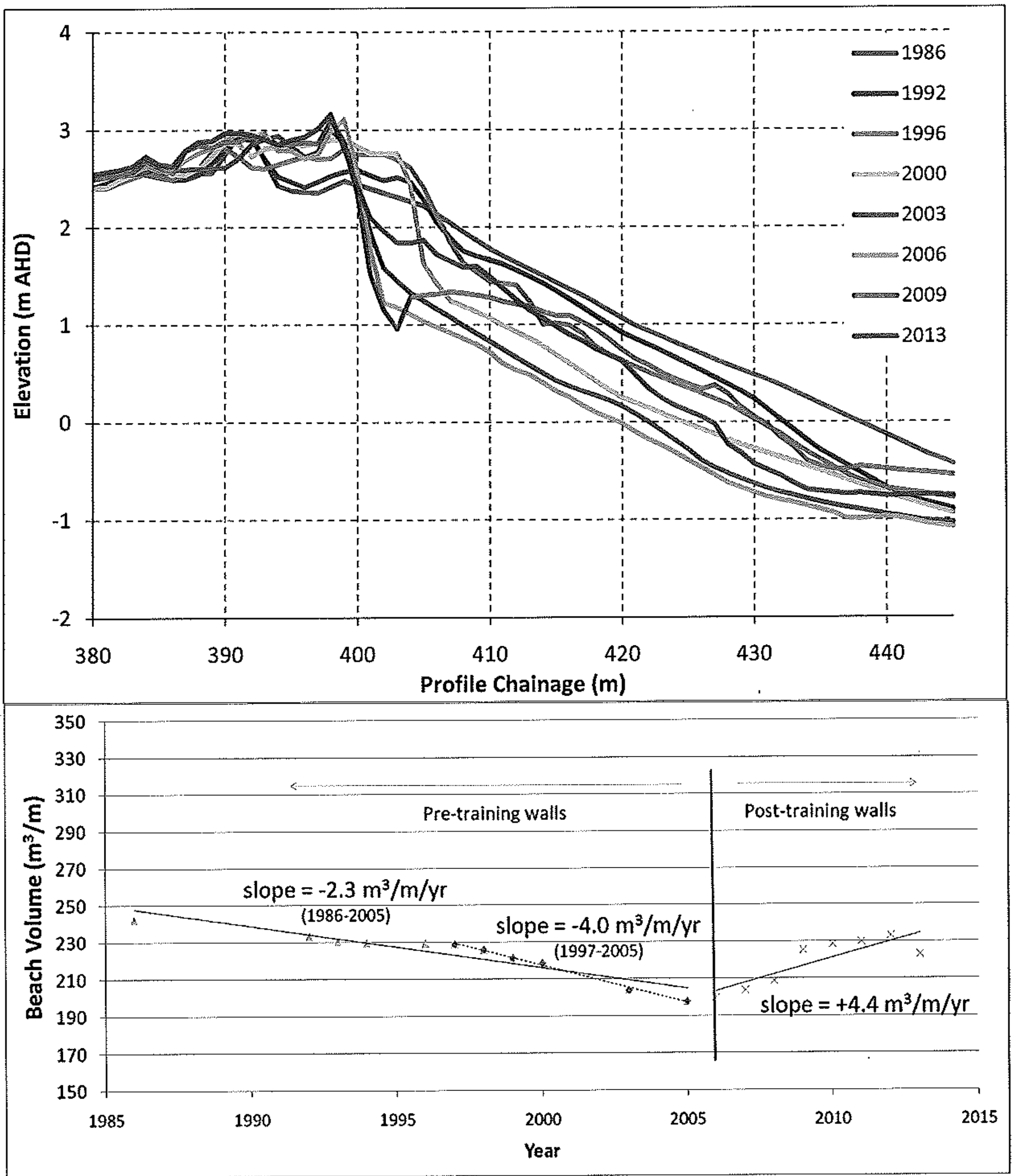


Figure 36 Top - CPB profile 03 from 1986 to 2013. Note: for clarity not all beach profiles are plotted, Bottom - Beach volume trend for CPB profile 03.

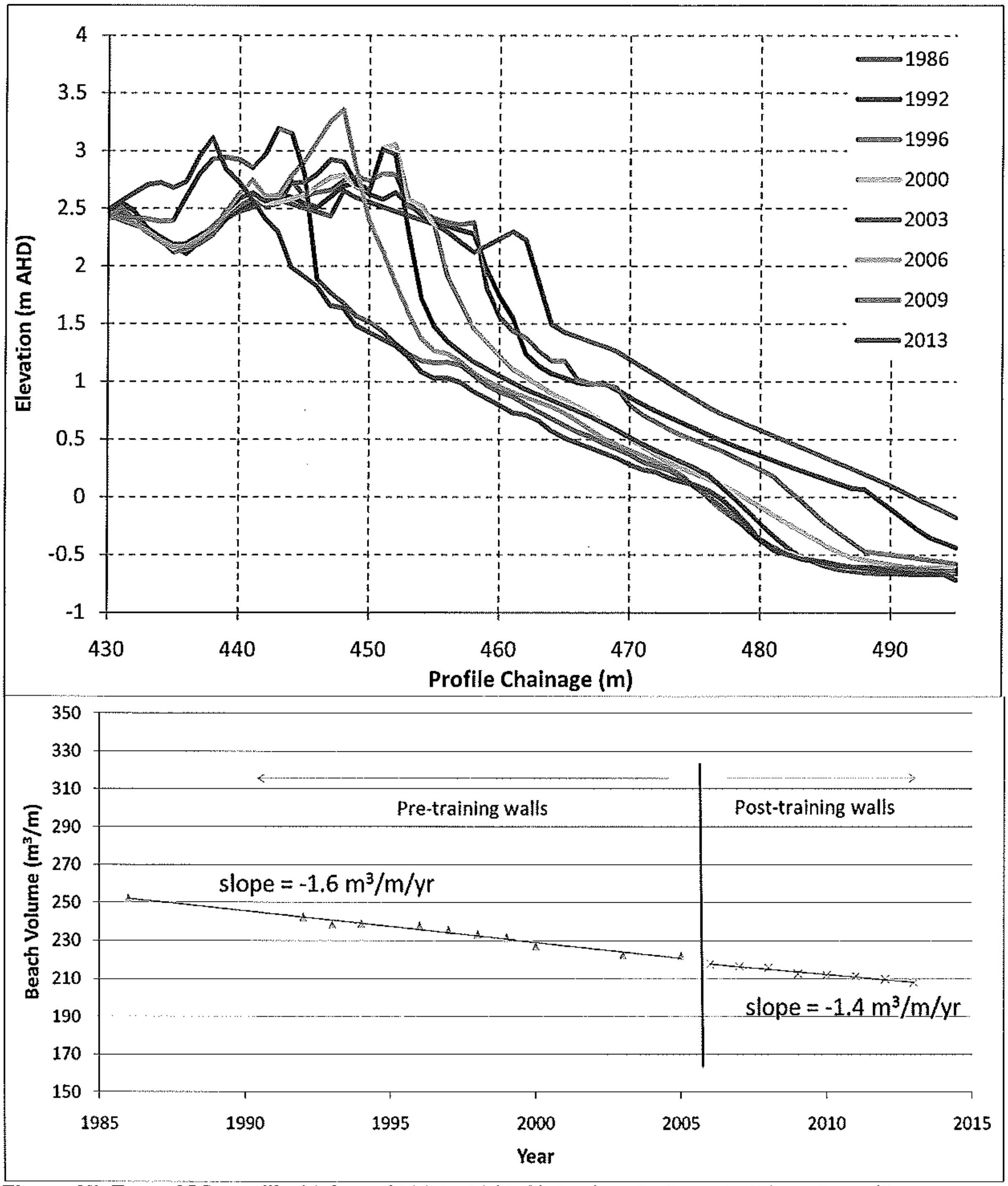


Figure 37 Top - CPB profile 02 from 1986 to 2013. Note: for clarity not all beach profiles are plotted, Bottom - Beach volume trend for CPB profile 02.

6.3.5 Eastern Sand Spit and Main Tidal Inlet

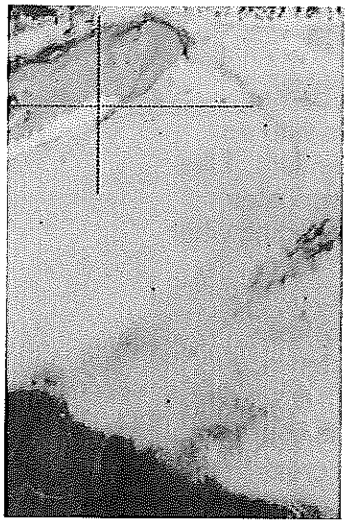
This sand spit continues on from the Lucky Bay beach compartment, forming a barrier between the Spencer Gulf and a narrow tidal inlet (or waterway) which connects with an extensive intertidal/wetland/low-lying area called samphire swamp and samphire flats. Like the western sand spit, it is formed by the net east to west longshore drift that dominates along the Eyre Peninsula. Alongshore drift feeds the growth of the sand spit, including what is has been historically eroded from Lucky Bay.

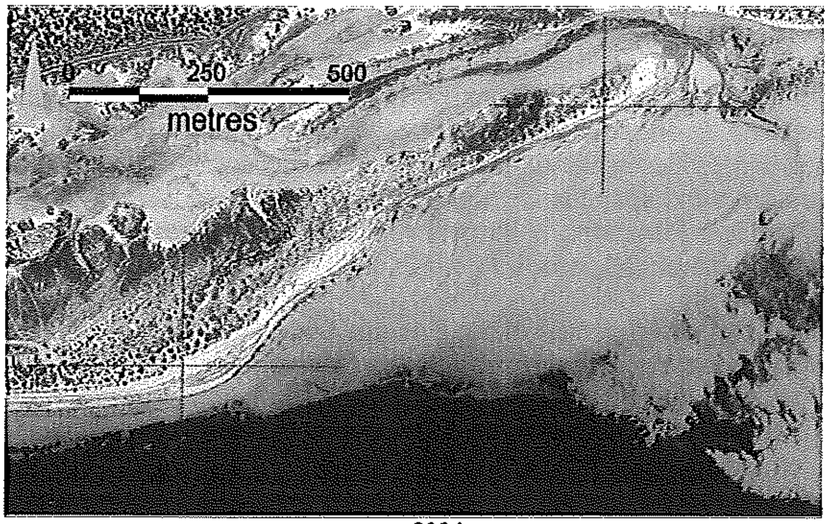
A series of selected aerials of the Eastern Sand Spit compartment is presents below. Through inspection of these images, the following key observations can be made:

- There has been a net accretion on the eastern sandspit, for example, the shoreline has extended 50 m to the east in the area around the first (western) red cross in the aerial images.
- The eastern end of the sand spit also appears to have been extending to the north east, in the area mark by the second (eastern) red cross in the aerial images.

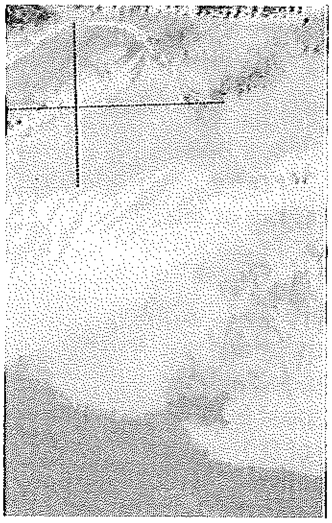
Based on further analysis of the change in the area of the sand spit observed in the aerials combined with some assumptions on the height and volume within the beach profile, it has been estimated that the overall volume accretion along the 1.6 km of sand spit was in the order of 77,000 m^3. This equates to an average rate of volumetric accretion along the entire eastern sand pit of about 2,850 m^3/yr during the period from 1985 to 2012.

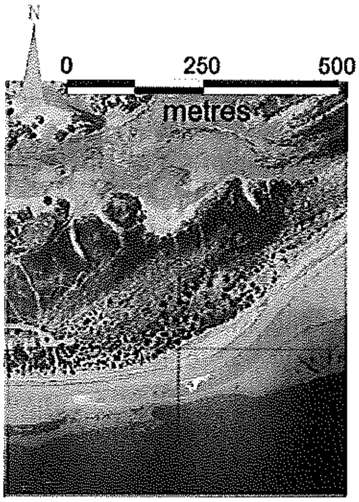
CBP-01 beach profiles are located at the western part of the compartment. **Figure 39** presents the plotted beach profiles and beach volume trends. CPB profile 01, has been accreting at a steady rate of around 0.9 m^3/m/yr from1986 to 2009. From the beach volume data it is likely that this trend of accretion may have been recently reversing (i.e. post 2009) and that this area is now starting to erode, albeit at a very slow to negligible rate of 0.1 m^3/m/yr. The most plausible explanation for this is the discontinuation of much of the longshore drift following the introduction of the training walls.





2004





2012

y Bay (Eastern Area)

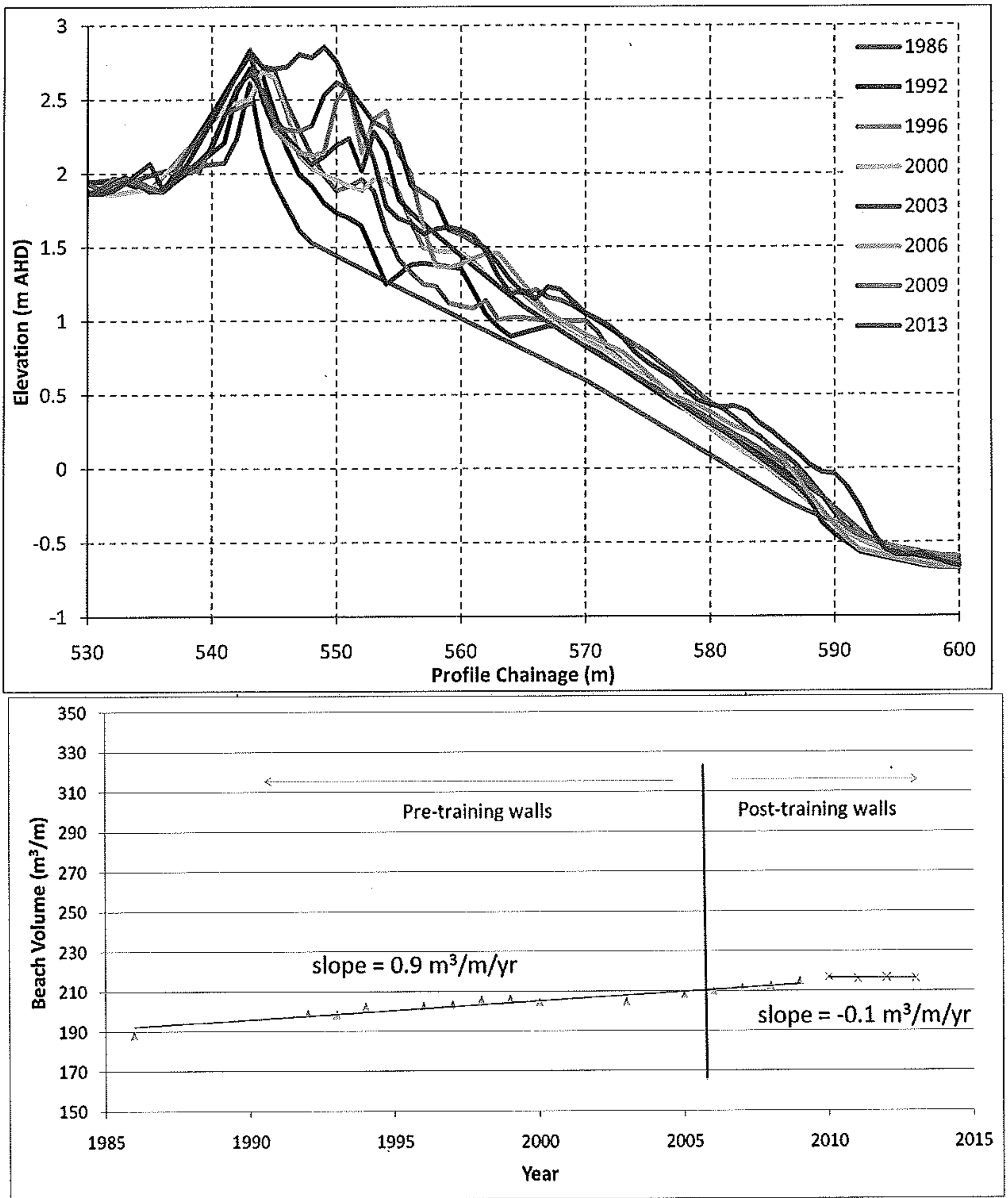


Figure 39 Top - **CPB profile 01 from 1986 to 2013. Note: for clarity not all beach profiles are plotted,** Bottom - **Beach volume trend for CPB profile 01.**

6.4 Sediments

Short et al (1986) analysed sediments from a number of sites around the Eyre Peninsula, collected on 28 February 1984. Results for Lucky Bay are shown in Error! Reference source not found..

Table 5 Lucky bay Sediment Analysis (Short et al, 1986)

Table 5 Lucky bay Sediment Analysis (Short et al, 1986)

Location	Carbonate %	Mode / s	Phi	Mean Phi	Sorting	Skewness	Kurtosis
Dune	1.8	1.5	2.75	1.67	0.55	0.68	3.17
Beach	1.9	1.75	2.25	2.00	0.60	-0.08	2.84
Swash (3°)	96.3	2.75	-	2.58	0.27	-0.17	4.49

7 METOCEAN FORCING INVESTIGATIONS

7.1 SMEC Metocean Data Collection

As part of this study, SMEC were commissioned by Council to undertake a wave and water level measurement program at Lucky Bay. The scope of this program included measurements of directional wave data at one site and water level measurements at two other sites for a period of 6 weeks. The location of these three measurement sites are presented in **Figure 40**:

- Sites LB_01 – directional waves; and
- LB_02 and LB_03 – water levels.

The data has been used to provide valuable information to inform the investigation of coastal processes, concept option development and assessment, and design criteria. This section presents a review of the metocean measurement program, further application of the data is discussed in **Section 7.2** (water levels) and **Section 7.3** (waves).

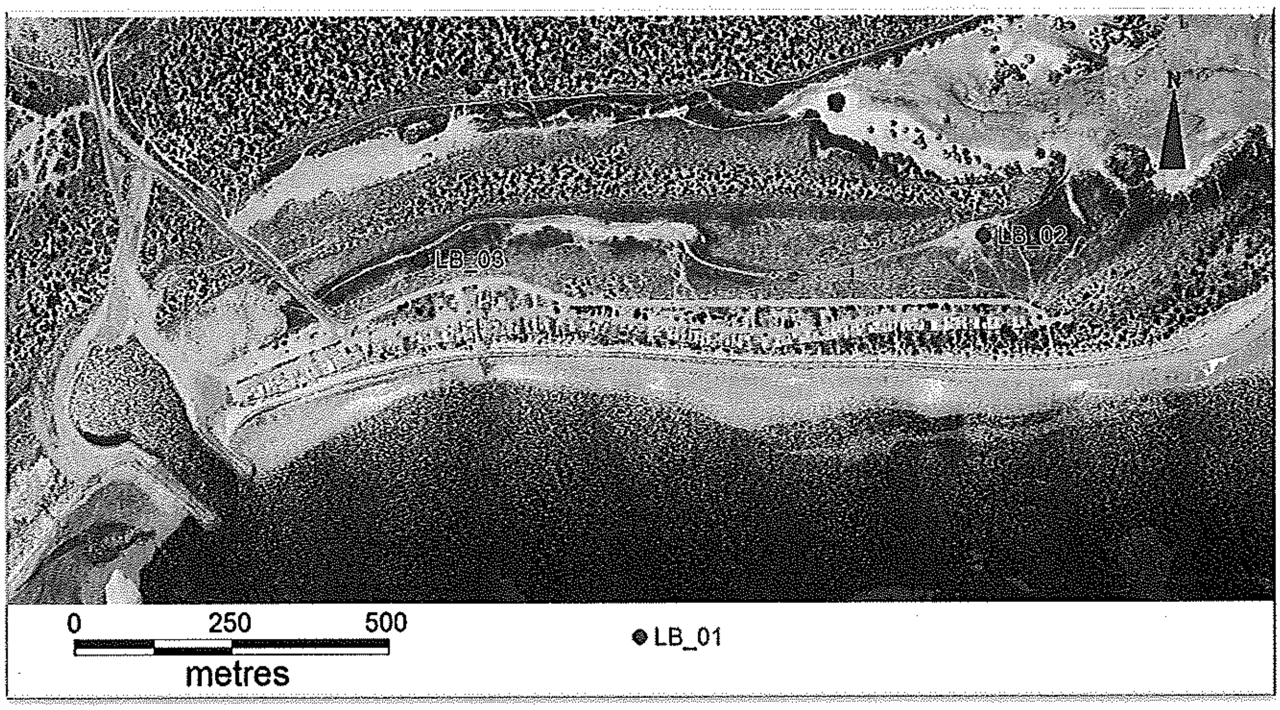


Figure 40 Lucky Bay measurement site locations

7.1.1 Field Operations

The deployment was undertaken on the 26 September 2013 and retrieval carried out on the 7 November 2013, all instruments were successfully retrieved without incident. **Figure 41** presents some images from the metocean data collection work.

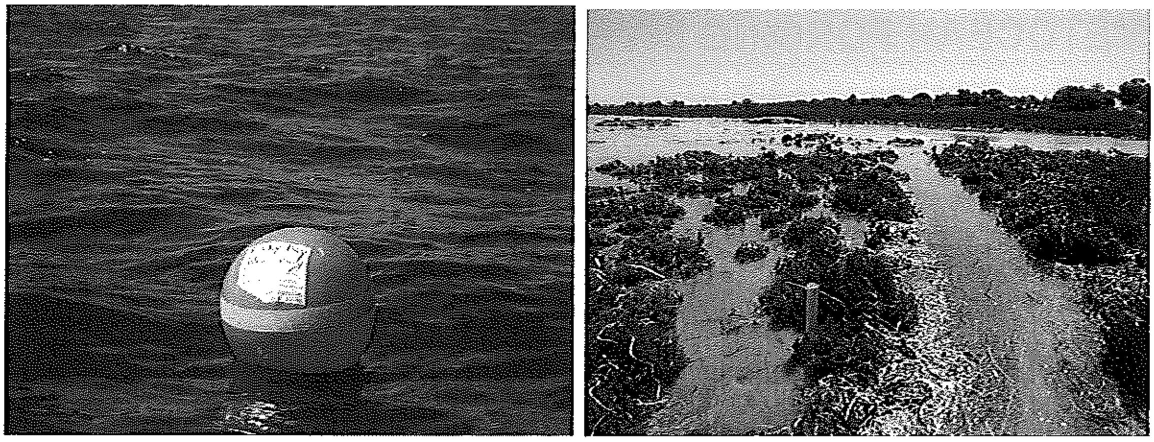


Figure 41 **Lucky Bay Wave Gauge (marker) and Samphire Swamp Water Level Gauge**

7.1.2 SBPA – Directional Wave Gauge

Directional measurements at Site LB_01 were collected using a short based pressure array (SBPA), of a type similar to that described by Howell (1998). Sensors were configured to record pressure data at 1Hz at bihourly intervals, with each measurement consisting of a 17 minute burst (1024 samples at 1Hz).

Waves (i.e. the height, period and direction of individual waves) and wave climate data parameters (significant wave eight (H_s), peak period (T_p) and mean wave direction (MWD)) were then determined from the data. Local information on waves was then used to assess the local wave climate, alongshore littoral drift rates, and design wave heights for rock armour design.

It is noted that raw data files can also be obtained from SMEC should Council (or other authorised party) wish to use this data.

7.1.3 Water Level Gauging

Water level was recorded at Sites LB_02 and LB_03 using specialised pressure transducers, set-up in PVC stilling wells.

Pressure data was processed to give the water levels using local atmospheric pressure information sourced from the Bureau of Meteorology. The gauges were not surveyed so the levels provided are relative to other local data only. The data was used in an attempt to understand the tidal behaviour of the eastern samphire swamp as this area is a concern for coastal inundation.

7.2 Water Levels and Extremes

Water level data for tide gauges in the Spencer Gulf was provided by the National Tidal Centre (NTC), the data was recorded every 5 minutes and the duration of the data available varied. Details of the tide gauges which have been used for the study are provided in **Table 6**, with their locations shown in **Figure 1**, see **Part A**.

The tide gauges at Franklin Harbour are located closest to Lucky Bay and as such this location is considered to represent water levels at Lucky Bay. There is only two months of measured water level data available at Franklin Harbour and for an extreme water level assessment a long duration data set of measured water level is required (at least in excess of 10 years). Therefore data from the Port Lincoln, Wallaroo or Port Pirie tide gauges was used to represent the extreme water levels at Lucky Bay. Water levels at these sites are plotted along with Franklin

Harbour in Figure 42, showing that of the three sites, the water levels at Wallaroo best represent the levels at Franklin Harbour. The water level at high tide at Wallaroo can be up to 0.3 m lower than at Franklin Harbour during spring tides; this could be a local amplification of the water level within the harbour which might not occur on the open coast at Lucky Bay. A large surge event occurred on 22/05/2011 (**Figure 42**), which resulted in the largest measured water level at Wallaroo over the 16 year period (see **Table 6** and **Figure 42** for details of the magnitude of this event in terms of water level and surge height). It is important to note that the maximum water level measured at Franklin Harbour and Wallaroo was similar, indicating that surge events behave the same at both sites and that for this extreme water level analysis Wallaroo can be considered approximately representative of Lucky Bay. As such, an assessment of historical extreme water levels due to residual surge at Wallaroo was undertaken to determine extreme water levels at Lucky Bay.

Table 6 Water level data used for the study within Spencer Gulf as provided by the NTC.

Location	Start Date	End Date	Duration (years)
Port Lincoln	05/08/1996	31/12/2012	16.4
Franklin Harbour Jetty	05/05/2011	08/06/2011	0.1
Franklin Harbour Entrance	18/04/2011	08/06/2011	0.1
Wallaroo	20/12/1996	31/12/2012	16
Port Pirie	06/01/1999	31/12/2012	14
Whyalla	24/11/2004	31/12/2012	8.1

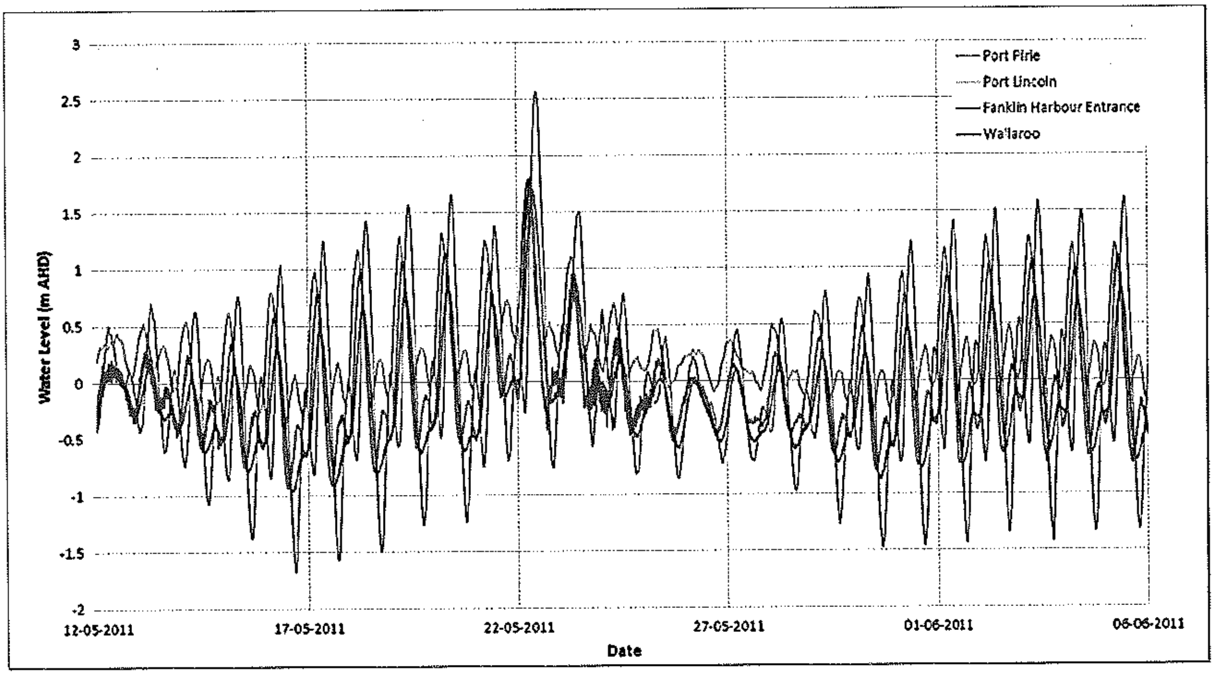


Figure 42 Measured water levels at Port Lincoln, Franklin Harbour, Wallaroo and Port Pirie.

Tidal constituents for water levels at Wallaroo were calculated based on harmonic analysis on the measured water level data to determine the harmonic constituents which make up the tidal signal. The tidal level was predicted for the same period as the measured data and from this a residual surge height was calculated for the period.

Generally, the highest measured water levels over the 16 year period were shown to be the result of a large residual surge (greater than 1 m) coinciding with high water on an average spring tide. The highest measured water level consisted of a predicted water level of 0.475 m AHD combined with a residual surge of 1.221 m giving a total measured water level of 1.696 m (refer Event 1 in **Figure 43**. **Figure 43** shows the measured and predicted water levels and the residual surge levels for the five highest water level events.

Univariate extreme values analysis (EVA)[4] has been performed for rare occurrences of both water level and residual surge. This utilised the 16 years of available measured water level data at Wallaroo. The purpose is to derive an estimate of the Average Recurrence Interval (ARI) levels for water level and residual surge. **Figure 44** shows a summary of the results from the EVA and **Table 7** provides the design still water level offshore for wave breaking for various ARI events at Lucky Bay. It is noted that 0.1 m was added to Wallaroo estimates to account for differences in tide level expected at Lucky Bay.

Table 7 Extreme Water Levels Predicted for Wallaroo.

ARI (years)	Design Still Water Level (m AHD)	Allowance for Wave Setup
10	1.8	0.2
50	1.9	0.2
100	2.0	0.3

[4] Univariate EVA referrers to examination of one parameter (in this case water level or residual), it does not take into account statistical dependences between variable (e.g. extreme residual levels and rainfall).

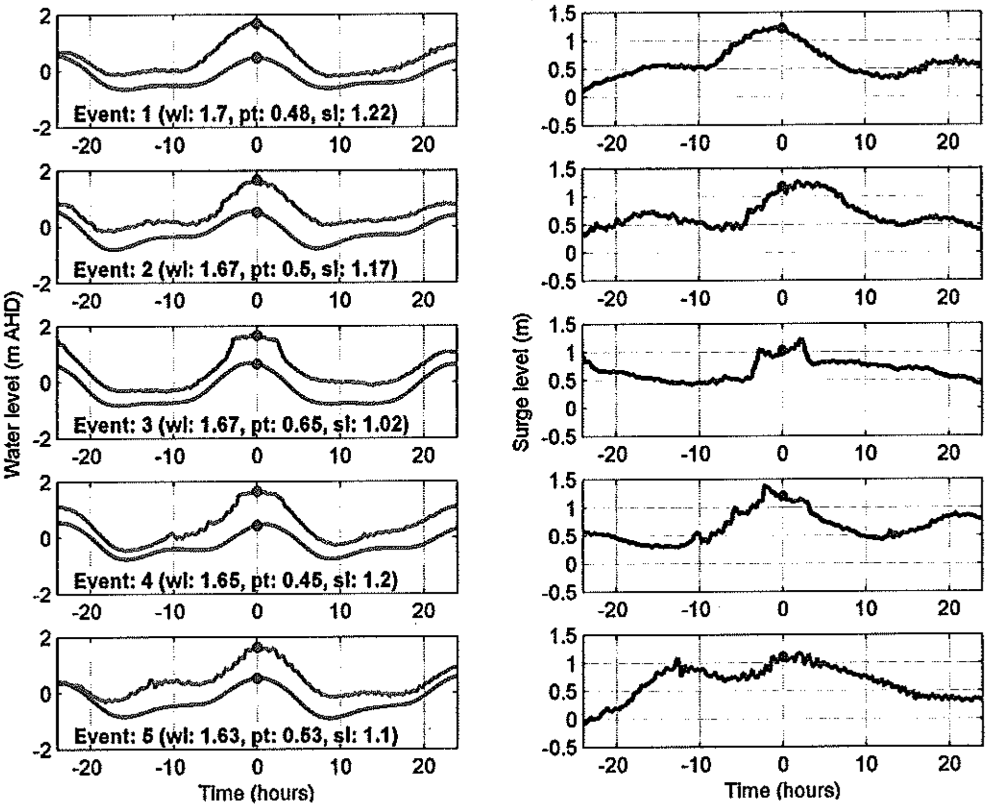


Figure 43 The five highest water levels recorded at Wallaroo tide gauge between December 1996 and December 2012. Note: blue line = measured water level (wl), red line = predicted tidal level (pt), and black line = surge level (sl).

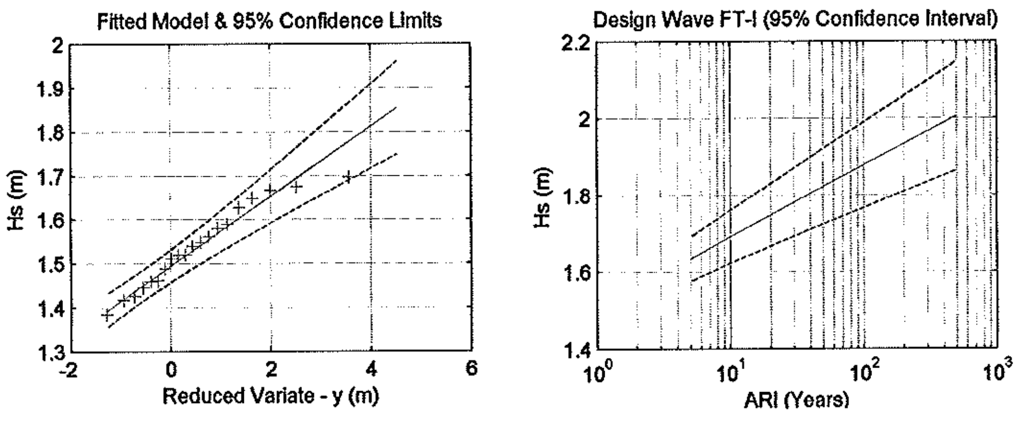


Figure 44 Fitted Extreme Value Model (left) and Water Level Design Curve (left) for Wallaroo Site (1996 to 2012).

Historically the highest storm surge tide level recorded within Spencer Gulf was on the 1 June 1981. At the Port Lincoln tide gauge this was 2.82 m (1.12 m above that predicted) and at the Whyalla tide gauge this was 4.14 m (1.44 m above that predicted). The highest recorded storm surge at Thevenard, near Ceduna, was 3.26 m on the 14 March 1934 (1.68 m above that predicted) (Short *et al* 1986).

7.2.1 Propagation of Tidal and Surge into Samphire Inlet

Based on the water level data collected at sites LB_02 and LB_03, this investigation has determined that high tides freely propagate into this area.

7.3 Wave Climate and Extreme Wave

7.3.1 Lucky Bay Wave Measurements

All data presented has been subject to quality control procedures. Erroneous data have been excluded from all plots and calculations. All plots in this section include a key that details the location, time period and number of observations that the plot is based upon.

Figure 45 displays a time series plot of the main wave parameters:

- The first (upper) panel is of the significant wave height (H_s) and maximum wave height (H_{max}).
- The second panel is of the peak period (T_p) and zero-crossing mean period (T_z).

The average H_s during the deployment period was only around 0.1 m and the maximum recorded was 0.4 m. At least six separate wave events occurred during the deployment. They and were dominated by short period wind waves. Most of the wave energy was concentrated between 3 and 4 seconds.

The wave measurement data collected at Lucky Bay has been incorporated into the wave hindcasting and extreme wave assessment, described below, and in the assessment of coastal processes described in Section 5 .

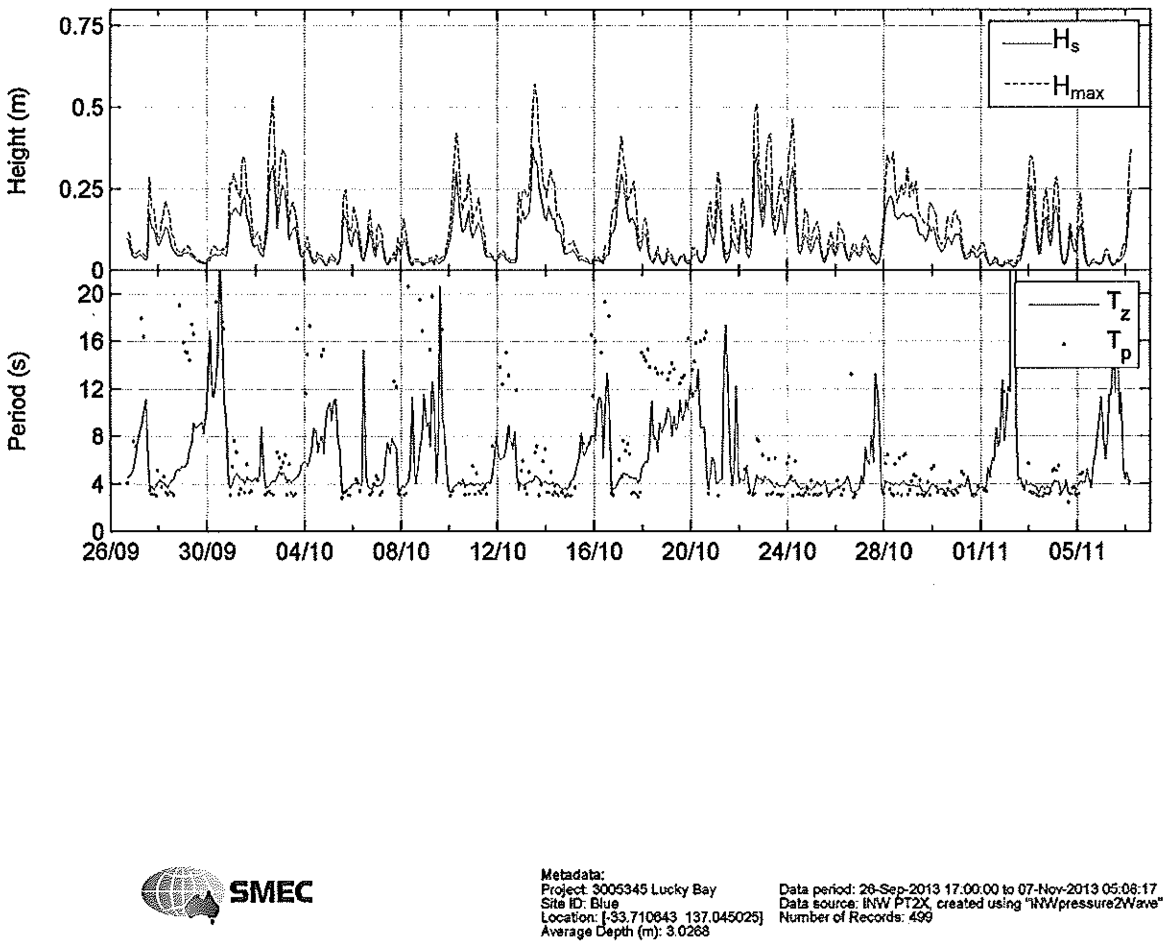


Figure 45 Site LB_01 wave parameters.

7.3.2 Other Wave Climate Assessment in Spencer Gulf

There is very limited measured wave data available within Spencer Gulf and no known wave data near Lucky Bay. A wave buoy is operated at an ocean-open site at the entrance of Spencer Gulf at Cape de Couedic, Kangaroo Island. This buoy is operated by the BoM, and has been utilised in this study. SMEC are aware of two recent wave, current and water level measurement exercises undertaken within Spencer Gulf. These were both associated with port development projects and are summarised in **Table 8**.

Table 8 Summary of Spencer Gulf wave measurements

Area	Period(s)	Location(s)	Project	Consultant
Whyalla	06/04/2004 to 12/05/2004	No 1 [-33.039 137.630] and No 2 [-33.039 137.61]	OneSteel Project Magnet	Lawson and Treloar
Port Spencer	Oct 2009 to Mar 2010 Aug 2010 to Sep 2010	[-34.250, 136.272]	Centrex Port Spencer	ASR

Based on reporting of the two measurement programs, seasonal variations in wave climate at Port Spencer can be described as follows.

- Winter is characterised by larger waves with more open swell penetration and local seas. Wave heights (H_s) are typically less than 1 m with events up to 1.8 m, with a mean peak period of 9 seconds and a peak wave direction predominantly from the south-east.
- Summer is predominantly onshore south-east winds that result in a more local sea dominated wave climate with a mean peak wave period of 4 seconds.

At Whyalla the wave climate is generally small with events up to 1 m associated with periods of strong local winds.

7.3.3 Wave Hindcast Modelling

The SWAN (**S**imulating **WA**ves **N**earshore wave – Cycle III version 40.11) wave model was used to provide a numerical hindcast of the wave climate at Lucky Bay. Measured waves, collected at the site, also supported the wave climate development.

The SWAN model was developed based on bathymetry data from:

- soundings and contours from the Admiralty Chart Aus 344, Spencer Gulf, South Australia scale 1:300,000; and
- soundings and contours from the Admiralty Chart Aus 345, Gulf of St Vincent and Approaches, South Australia scale 1:300,000.

The domain of the wave transformation model covers Spencer Gulf and extends to Kangaroo Island in the south and includes part of Investigator Strait (**Figure 46**). The model extends to depths of about 150 m. This region was schematised onto a rectilinear grid derived from the detailed soundings and contours. The lateral boundaries were also located far from the region of interest to prevent inaccuracies in boundary conditions affecting the calculations in the area of interest.

Both ocean swell and locally generated wind waves were investigated using the SWAN model.

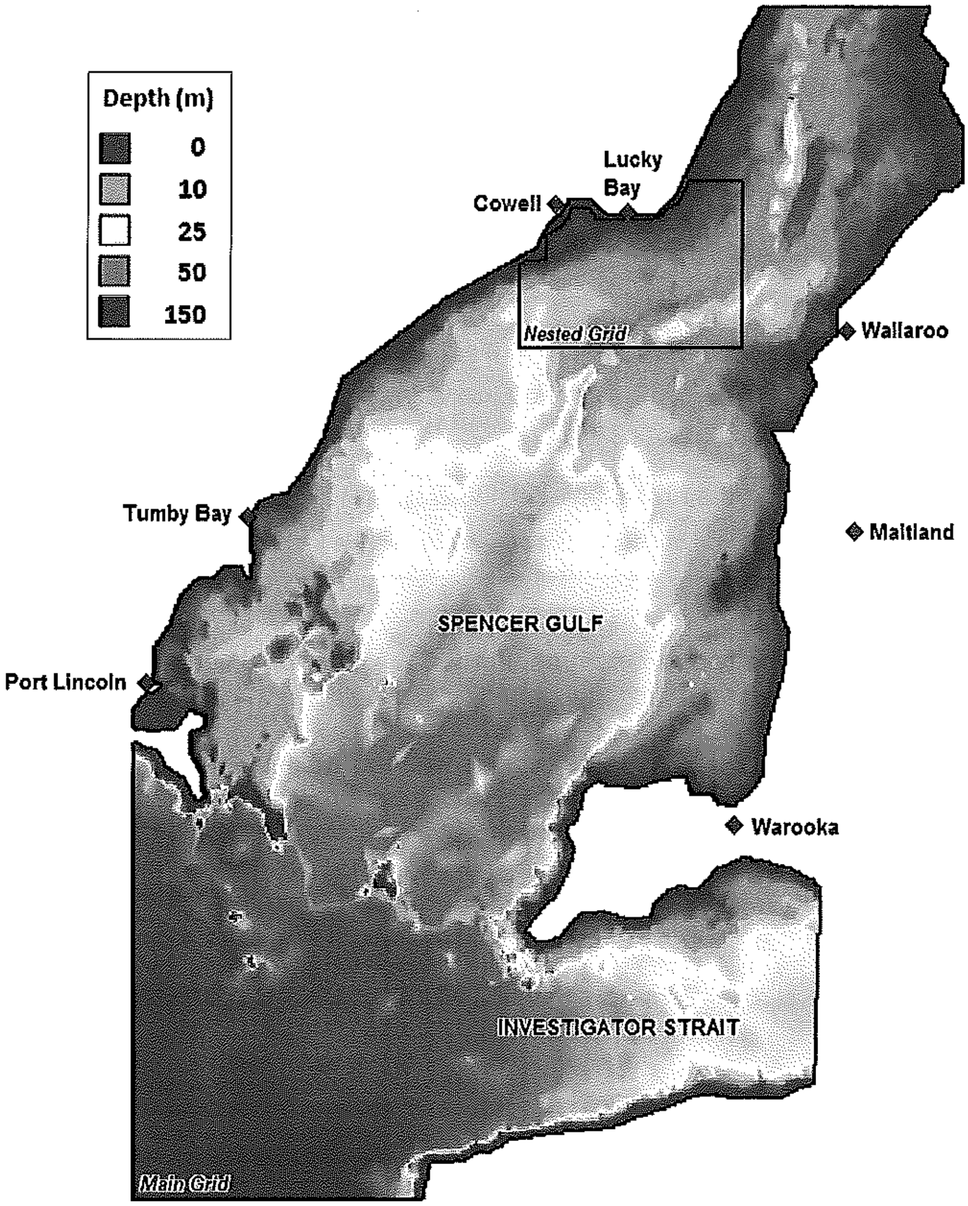


Figure 46 SWAN Model Extent and Bathymetry

Transformation of open-ocean swell waves was undertaken using the Delft3D-WAVE (SWAN), to determine the percentage of ocean swell that reaches the Lucky Bay site.

A range of scenarios with 13 different wave periods and six wave directions were simulated. Modelled wave periods ranged from 8 to 20 s and the swell waves with ocean swell directions ranged between 157.5°TN (SSE) and 270°TN (W). A significant wave height (H_s) of 1 m was used for all scenarios. The results were thus presented as refraction coefficients that could be applied to open-ocean swells to determine wave heights at Lucky Bay.

Results were extracted at various locations within the model including one representative of the wave gauge site (LB_01 – see **Section 7.1**) directly south of Lucky Bay beach. **Table 9** to **Table 11** present the results of swell simulations at the LB_01 location and an example model output for a swell case is presented in **Figure 47**.

Table 9 **Refraction co-efficients (H_s) for various offshore swell conditions at LB_01**

LOCAL SIGNIFICANT WAVE HEIGHT COEFFICIENTS						
Wave Period (s) \ Direction	SSE	S	SSW	SW	WSW	W
8	0.14	0.22	0.25	0.21	0.13	0.05
9	0.12	0.19	0.22	0.18	0.11	0.05
10	0.11	0.17	0.19	0.16	0.10	0.04
11	0.10	0.15	0.17	0.15	0.09	0.04
12	0.09	0.14	0.15	0.13	0.09	0.04
13	0.08	0.12	0.14	0.12	0.08	0.04
14	0.08	0.11	0.13	0.11	0.08	0.04
15	0.07	0.11	0.12	0.11	0.08	0.04
16	0.07	0.10	0.11	0.10	0.07	0.04
17	0.06	0.09	0.11	0.10	0.07	0.04
18	0.06	0.09	0.10	0.09	0.07	0.04
19	0.06	0.08	0.09	0.09	0.06	0.04
20	0.05	0.08	0.09	0.08	0.06	0.04

Note: for example, using the coefficents in Table 7, a 5 m offshore H_s from SW would result in a 1.05 m H_s at Lucky Bay.

Table 10 **Refracted wave periods (T_p) for various offshore swell conditions at LB_01**

LOCAL WAVE PERIOD DISTRIBUTION (seconds)						
Wave Period (s) \ Direction	SSE	S	SSW	SW	WSW	W
8	5.60	5.62	5.67	5.71	5.85	6.42
9	5.93	5.92	5.95	6.03	6.23	7.02
10	6.25	6.21	6.25	6.37	6.64	7.68
11	6.62	6.54	6.60	6.76	7.14	8.47
12	7.02	6.91	6.97	7.17	7.74	9.40
13	7.43	7.28	7.34	7.62	8.36	10.34
14	7.97	7.76	7.84	8.20	9.15	11.40
15	8.53	8.25	8.35	8.80	9.96	12.44
16	9.15	8.80	8.91	9.47	10.81	13.40
17	9.79	9.37	9.49	10.15	11.67	14.34
18	10.44	9.96	10.10	10.84	12.50	15.15
19	11.00	10.47	10.62	11.43	13.21	15.86
20	11.61	11.03	11.18	12.05	13.91	16.51

Table 11 Refracted Mean Wave Directions for various offshore swell conditions at LB_01

LOCAL WAVE DIRECTION DISTRIBUTION (degrees)						
Wave Period (s) \ Direction	SSE	S	SSW	SW	WSW	W
8	187.94	188.30	188.54	188.84	188.94	188.40
9	187.54	187.88	188.12	188.30	188.32	187.59
10	187.16	187.51	187.72	187.84	187.77	186.95
11	186.79	187.11	187.30	187.36	187.18	186.32
12	186.42	186.72	186.89	186.85	186.60	185.74
13	186.08	186.36	186.47	186.42	186.10	185.28
14	185.69	185.96	186.13	185.94	185.58	184.87
15	185.35	185.61	185.66	185.53	185.15	184.56
16	185.03	185.27	185.45	185.30	184.78	184.32
17	184.74	184.97	185.16	185.00	184.47	184.12
18	184.51	184.73	184.92	184.76	184.24	183.99
19	184.41	184.62	184.82	184.65	184.12	183.91
20	184.30	184.50	184.71	184.54	184.02	183.85

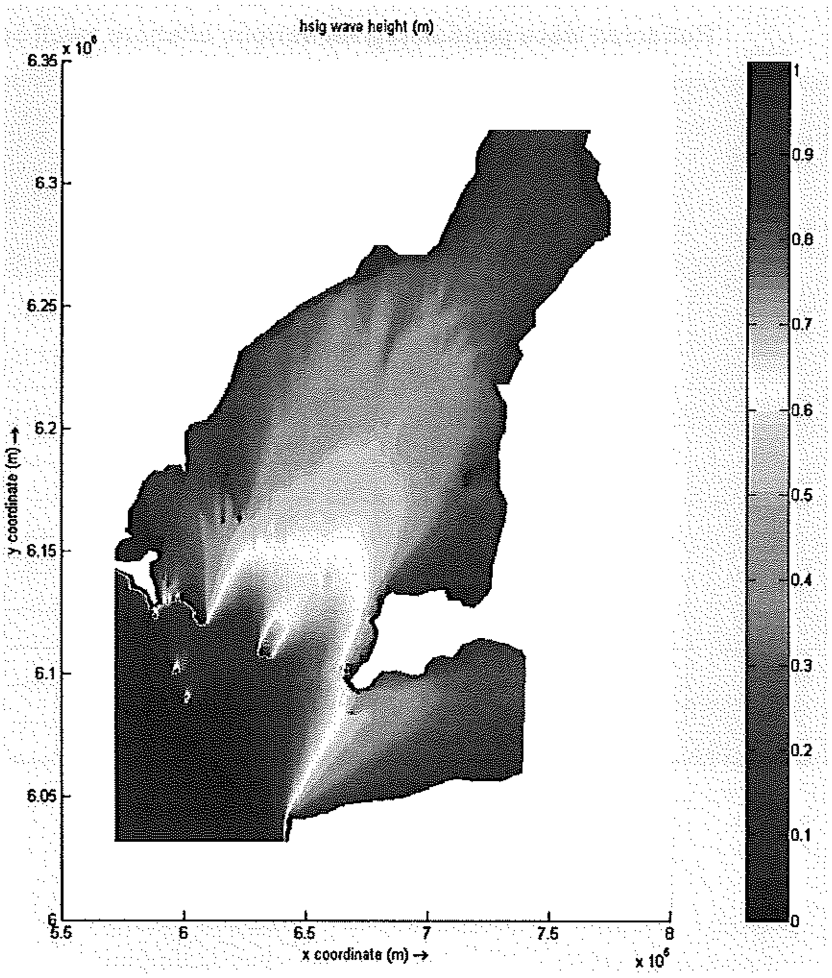


Figure 47 SWAN results for H_s = 1m, T_p = 8s and Dir = 202.5°TN (SSW)

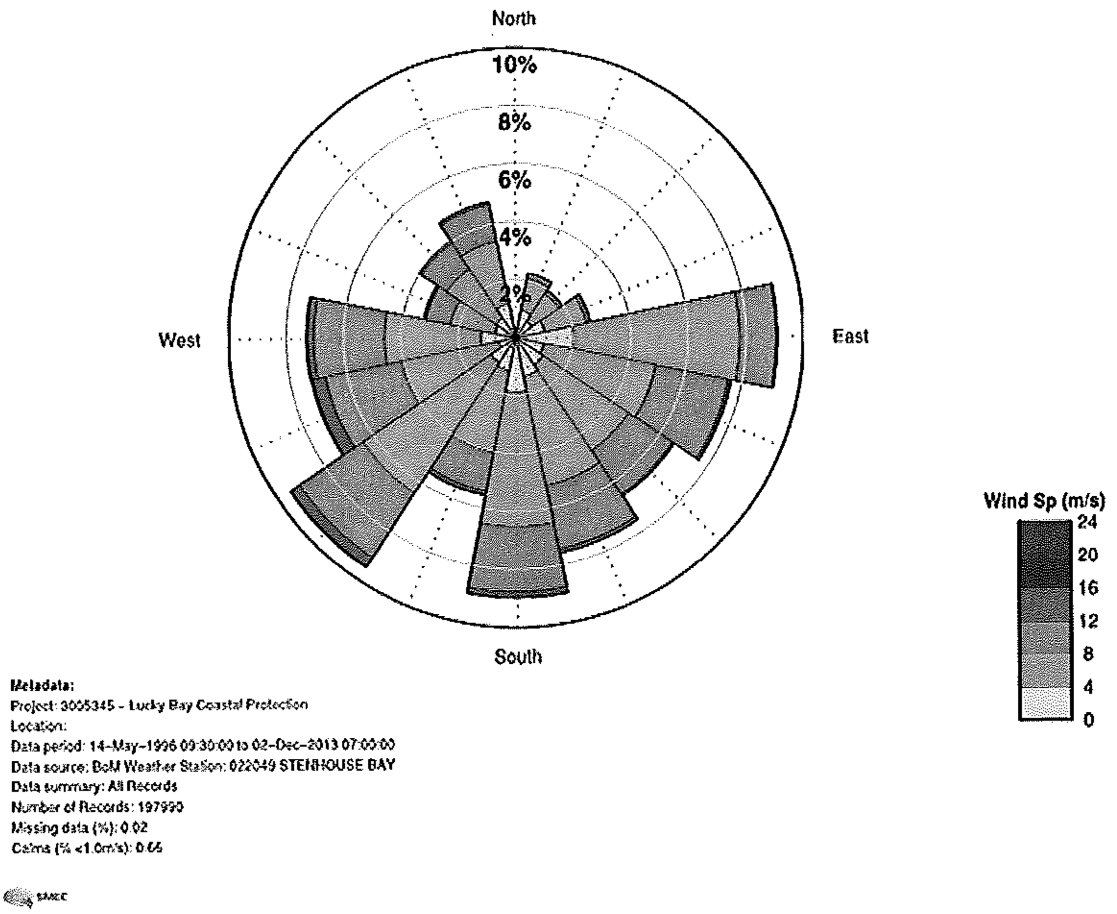
7.3.4 Locally Generated Seas

An assessment of the wave climate due to waves generated locally along Lucky Bay was also made. Waves generated by local winds depend on the fetch length, depth of water and the wind speed, direction and duration. Wind waves are generally relatively small in height with a wave period of 1 to 6 seconds.

Figure 48 presents a wind rose at Stenhouse Bay. Based on local wind measurements at this location, a range of scenarios with 13 different wind speeds and nine wind directions were run to determine the wave climate at the site. The modelled wind speeds ranged from 4 to 26 m/s and the wind directions that would have an impact on the site ranged between 45°TN (NE) and 225°TN (SW).

As locally generated waves have a much shorter wavelength than e offshore swell waves, they would undergo less severe refraction on the nearshore zones along Lucky Bay. The locally generated wave height and direction at Lucky Bay was transformed using the SWAN model by driving the model with winds applied as the boundary conditions.

The wind-wave climate derived by the SWAN model for a range of wind conditions is shown in **Table 12** to **Table 14** and an example of locally wind-generated wave scenario is presented in **Figure 49**.



Wind data provided by BoM

Figure 48 Wind Rose at Stenhouse Bay, Lower Spencer Gulf, typical of Lucky Bay fetches

Table 12 **Hindcast local sea waves (H_s) at LB_01**

LOCAL SIGNIFICANT WAVE HEIGHT DISTRIBUTION (m)									
Wind Speed (m/s) \ Direction	NE	ENE	E	ESE	SE	SSE	S	SSW	SW
4	0.17	0.19	0.22	0.24	0.26	0.27	0.28	0.27	0.26
6	0.27	0.32	0.38	0.43	0.48	0.52	0.52	0.50	0.49
8	0.38	0.41	0.54	0.62	0.70	0.75	0.82	0.81	0.77
10	0.51	0.62	0.65	0.87	0.96	1.11	1.18	1.15	1.09
12	0.63	0.77	0.81	1.09	1.23	1.41	1.46	1.46	1.39
14	0.77	0.94	0.98	1.29	1.46	1.54	1.57	1.57	1.53
16	0.88	1.08	1.26	1.45	1.57	1.62	1.64	1.63	1.60
18	1.01	1.24	1.31	1.53	1.63	1.68	1.69	1.67	1.64
20	1.11	1.35	1.48	1.57	1.67	1.72	1.72	1.70	1.67
22	1.18	1.42	1.52	1.60	1.70	1.75	1.73	1.71	1.68
24	1.10	1.47	1.56	1.63	1.73	1.76	1.74	1.73	1.70
26	1.34	1.51	1.58	1.65	1.76	1.77	1.75	1.74	1.71

Table 13 **Hindcast local sea waves (T_p) at LB_01**

LOCAL WAVE PERIOD DISTRIBUTION (seconds)									
Wind Speed (m/s) \ Direction	NE	ENE	E	ESE	SE	SSE	S	SSW	SW
4	1.32	1.41	1.51	1.62	1.68	1.74	1.75	1.74	1.71
6	1.55	1.73	1.92	2.14	2.30	2.39	2.43	2.41	2.33
8	1.77	2.04	2.25	2.62	2.89	3.10	3.08	3.11	3.02
10	2.00	2.31	2.74	3.04	3.47	3.69	3.78	3.83	3.71
12	2.23	2.59	3.09	3.45	3.98	4.27	4.45	4.54	4.36
14	2.43	2.85	3.39	3.84	4.43	4.80	5.05	5.18	5.03
16	2.60	3.09	3.55	4.22	4.84	5.23	5.51	5.64	5.53
18	2.78	3.35	3.92	4.51	5.12	5.56	5.83	5.96	5.89
20	2.93	3.58	4.16	4.73	5.32	5.81	6.00	6.11	6.08
22	2.99	3.78	4.36	4.84	5.54	5.96	6.12	6.19	6.16
24	3.06	3.95	4.55	4.92	5.62	6.10	6.16	6.15	6.21
26	3.25	4.08	4.64	4.98	5.73	6.11	6.11	6.07	6.18

Table 14 Hindcast local sea waves (*MWD*) at LB_01

LOCAL WAVE DIRECTION DISTRIBUTION (degrees)									
Wind Speed (m/s) \ Direction	NE	ENE	E	ESE	SE	SSE	S	SSW	SW
4	82.51	97.06	110.14	126.14	143.92	163.06	180.57	195.04	207.50
6	84.34	102.95	116.51	132.07	149.64	166.85	180.38	190.80	200.43
8	88.73	109.83	120.44	138.71	154.88	169.12	179.64	188.54	195.60
10	92.06	110.83	129.85	141.85	159.84	170.36	179.14	186.16	192.26
12	95.09	114.48	133.45	145.36	162.39	170.91	178.88	184.46	189.68
14	97.56	117.94	136.10	148.92	163.33	171.62	178.70	183.57	187.82
16	100.09	121.01	135.26	151.23	164.09	173.01	179.01	183.15	187.03
18	102.61	124.05	139.45	152.86	166.03	175.31	180.02	183.23	186.60
20	104.87	126.75	140.13	154.07	167.89	177.40	180.97	183.48	186.58
22	104.11	128.80	141.42	154.75	169.41	178.84	181.74	183.87	186.81
24	105.90	130.29	142.57	155.56	172.14	179.94	182.36	184.90	187.11
26	108.44	131.38	143.03	155.76	173.78	180.57	182.83	185.45	187.63

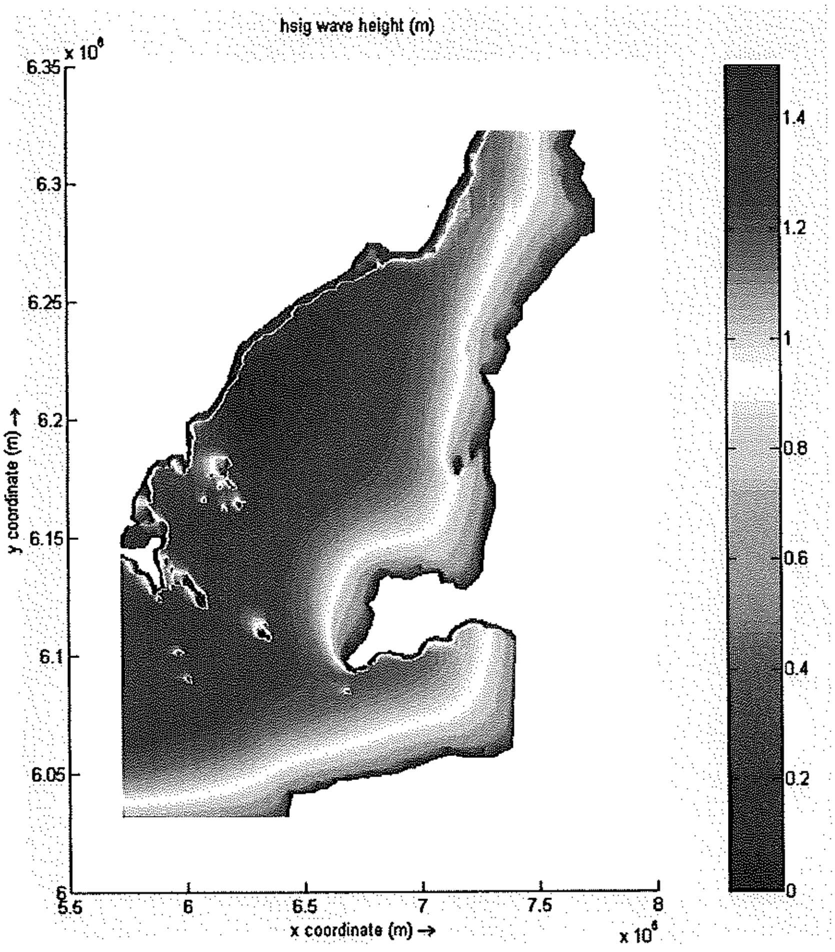


Figure 49 SWAN output for a wind speed of 10 m/s and a wind direction of 135°TN (SE)

7.3.5 Extreme Wave Analysis

Based on the measured data and result of modelling, an assessment of extreme waves was completed with the results as follows:

- 100-year ARI H_s = 3.0 m likely associated with a peak period (T_p) around 10-12 seconds.
- The dominant and net wave direction is from the South.

7.3.6 Summary of Wave Climate

Waves affecting the study site comprise locally generated, short period, steep waves and swell waves that propagate from the Southern Ocean in to the Spencer Gulf. During the summer months the dominant onshore south-easterly winds result in a more short period wave climate. Whilst, during the winter months, the winds result in a more active open-ocean wave climate increasing the occurrence of long period swell waves.

Unfortunately, the wave monitoring did not pick up a long period swell event and we were not able to exclude swell waves on the basis that this was a short deployment period. Numerical wave hindcasting, however, was able to reproduce the measured wave heights and this has been used to extrapolate out to design conditions.

Extreme wave heights (H_s) for the 100-year ARI condition were estimated to be 3 m and likely to be associated with a peak period (T_p) around 10-12 seconds.

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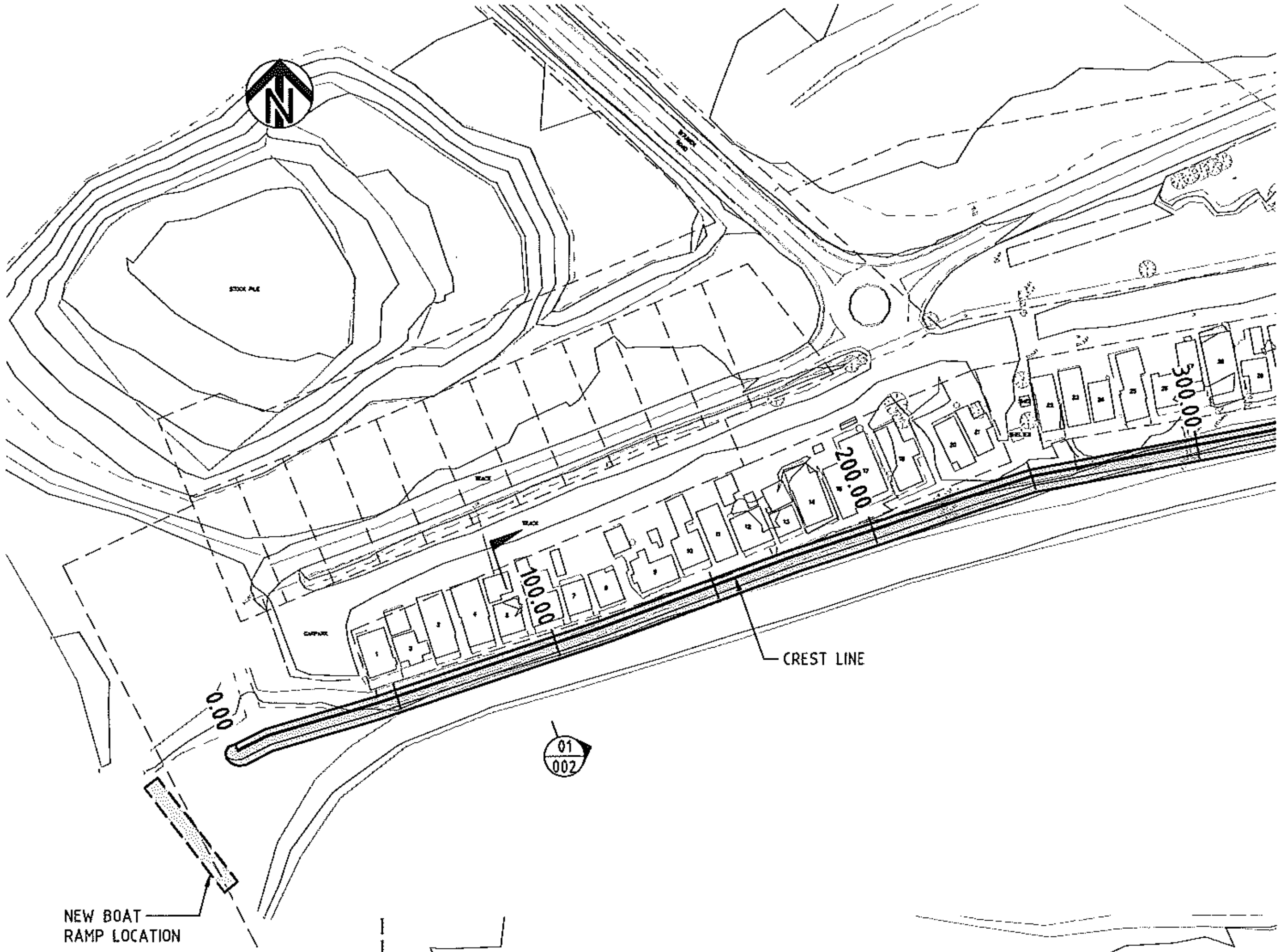
APPENDIX A DRAFT MINUTES OF INCEPTION MEETING

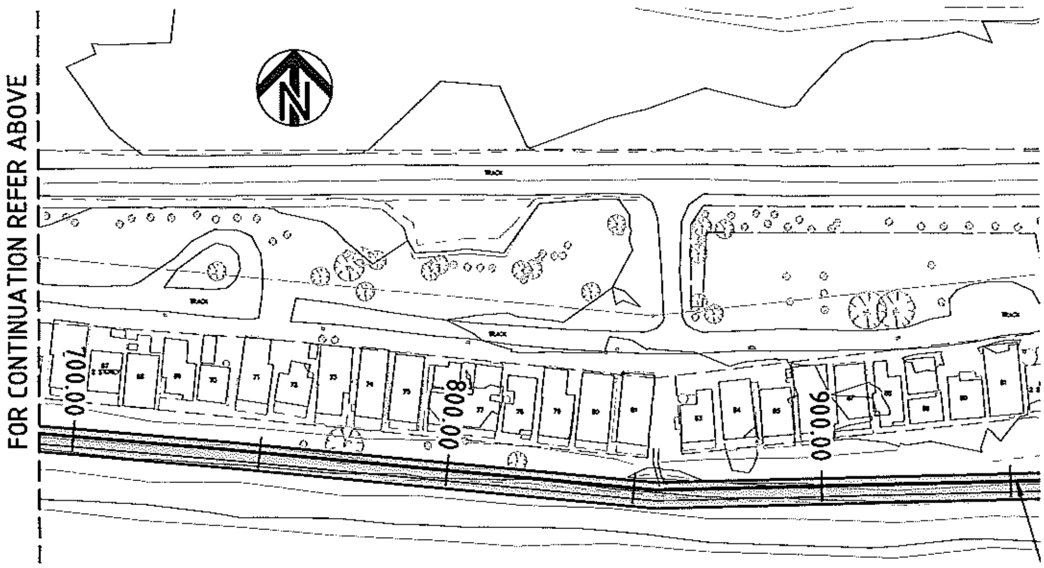
Minutes of *SMEC's Lucky Bay Coastal Study – Inception Meeting*	
Objective	Initiation of coastal review and design options project for Lucky Bay shack settlement
Date	15-May-2013
Time	**From:** 1:00 p.m. **To:** 2:00 p.m. (SA Time)
Location	District Council of Franklin Harbour (Council), Terry Barnes's Office
Convener (s)	Michael Richardson and David Probert
Attendees	Terry Barnes (CEO – Council), Eddie Elleway (Mayor – Council), Darren Zechner (Works Manager – Council), Michael Richard (Senior Planner– MasterPlan), David Probert (Manager Mining Infra & Envr – SMEC), Dan Messier (Manager Ports and Marine – SMEC) and Evan Watterson (Senior Coastal Engineer – SMEC)

S.No.	Discussion Items	Comments / Actions
1	TB outlined that the study is driven by State Gov't requirement for permanent coastal protection of Lucky Bay shacks that is technically and financially feasible. The study needs to output a design and costings such that the on-going feasibility of the township can be determined.	Council would like a positive outcome for the Lucky Bay shack owners. **ACTIONS** None.
2	Study data requirements. • Recent aerials were provided to SMEC by DZ. • Liaison with Coastal Protection Board (CPB) to be arranged by Council with follow up discussion between SMEC and CPB. • Possibility of shared funding for additional metocean data collection from IronClad. • Possibility of additional data from Port Spencer from Centrex. • Any gaps identified by SMEC in required data would be presented in Project Return Brief	**ACTIONS** • Council to identify contact in CPB and initiate contact for SMEC to follow up. • DP and MR to discuss metocean data requirements with IronClad. • DP to follow up a contact at Centrex for metocean data availability. • Project Return Brief being prepared by SMEC to include review of data including additional costs of data collection if deemed required.
3	Historical events and anecdotal evidence surrounding coastal instability issues at Lucky	**ACTIONS** • MR to scan historical photo's,

	Bay was discussed. EE mentioned the current and previous boat ramp in relation to beach erosion. TB provided a copy of 1989 Management Plan including past photos. TB suggested additional photos may be able to be sourced from shack owners. EE noted sand nourishment in 2010 was somewhat effective in protecting from storm erosion in the same year. DZ mentioned beach scraper works by Council. TB mentioned that there is some motivation within the current State Gov't for the retention of the Lucky Bay shacks including the acceptance of relocatable homes. EE noted tidal waterway at rear of shacks in relation to coastal inundation.	share electronic images with project group and return original to Council. • TB to attempt sourcing additional photos from shack owners and locals • DZ to pass on any existing records of scraper beach works (e.g. volumes, scraper hours etc from invoices) along with a contact of the contractor to SMEC.
4	Project Return Brief (PRB). DP explained the contents of the PRB including review of existing material, revised methodology and data gap analysis. Any additional costs for data collections would be included and justified in PRB. TB informed he would take any additional costs to the shack owners committee for their review.	**ACTIONS** • PRB to be prepared by SMEC and delivered to Council over next few weeks.
5	Project contract.	**ACTIONS** • DP and MR to discuss based on PRB and finalise for final Council approval.

APPENDIX B OPTION 1 CONCEPT DESIGN





NOT FOR CONSTRUCTION

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LUCKY BAY COASTAL F

OPTION 1 - ROCK REVET

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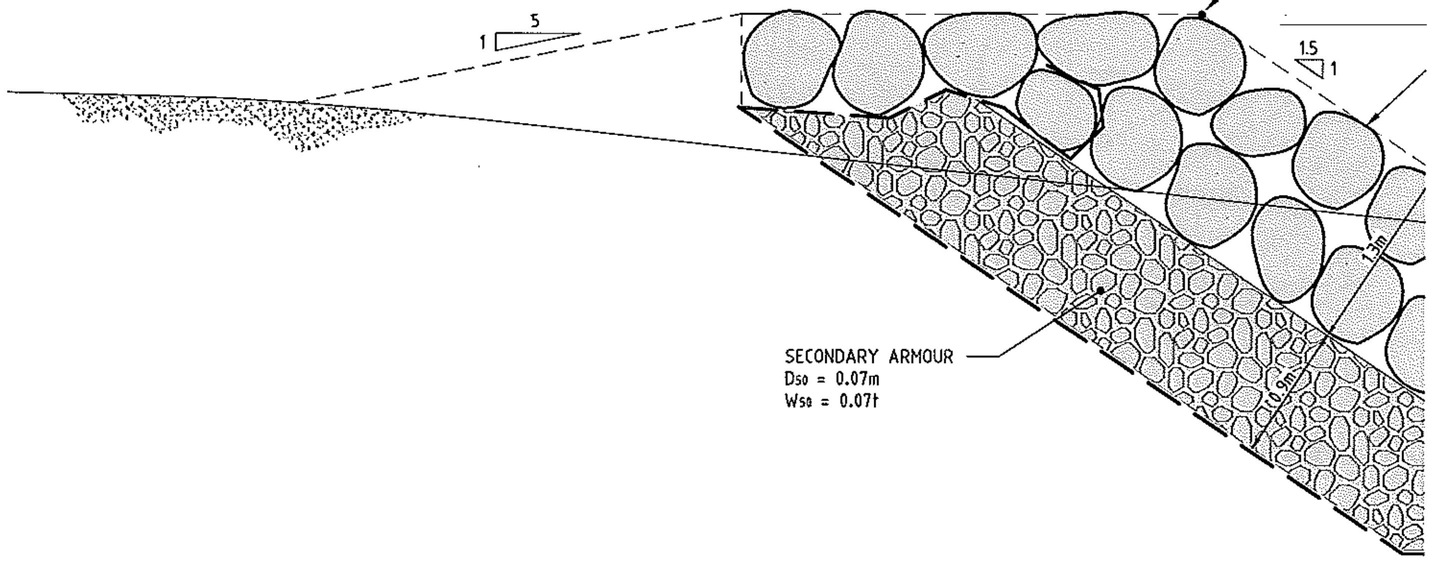

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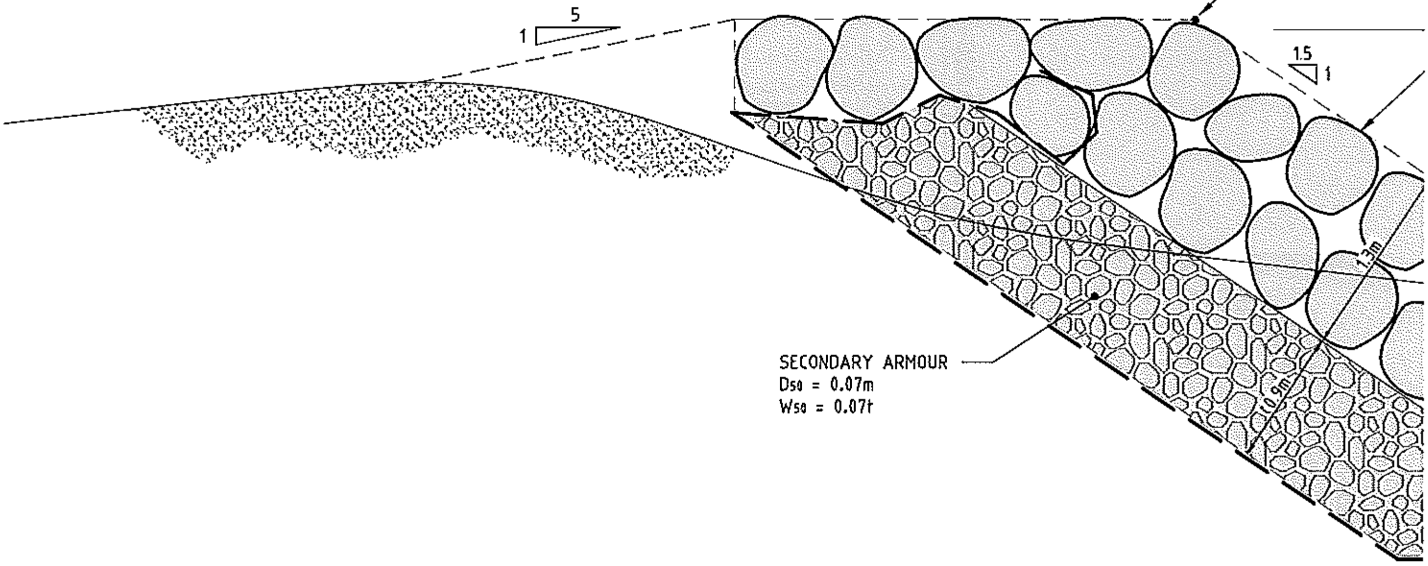

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LUCKY BAY COASTAL F

OPTION 1 - ROCK

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