COOBOWIE

Seawater Flooding Adaptation Pathways for Yorke Peninsula Settlements

Stage 2: Adaptation Options

Report by:

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Photograph of Coobowie seafront supplied by Coast Protection Branch.

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GLOSSARY

ADAPTATION

Adaptations are actions taken to help communities and ecosystems cope with actual or expected changes in climate conditions.

AHD

AHD is an acronym for Australian Height Datum. When a measurement is accompanied with the letters AHD it indicates a height above mean sea level. Mean sea level was adopted in 1971 by the National Mapping Council of Australia at 0.00 AHD. For example, 3.2m AHD is 3.2 metres above mean sea level. AHD tide levels are different to the fishing charts which are called Chart Datum (CD). A subtraction of 1.45 metres from tide chart will give the correct AHD height.

ARI

ARI is an acronym for Average Return Interval and is a theoretical calculation of the probability of the return of a particular event based on observations of the past. In relation to severe storm events the longer the interval the higher the storm surge height is predicted to be. For example, a 1 in 100 year storm surge would be higher than a 1 in 50 year or 1 in 10 year storm surge height. It is important to remember that this is just a theoretical calculation and there is nothing preventing a 1 in 100 year flood happening twice in one week.

DEM

DEM is an acronym for Digital Elevation Model. The digital elevation model used in this study was created from an aircraft that bounced millions of infra-red light beams to the ground and then created a digital topographical map from the reflected beams. This digital map is combined with aerial photography and can be used to display the height of land features. A Digital Terrain Model (DTM) is a type of DEM that has been specifically prepared for flood modelling.

EROSION

Erosion is where action of the sea moves sand and vegetation from the shoreline so that the dune system is weakened. When the frontal dune system is significantly weakened it may completely erode away and the shoreline moves inland.

STORM SURGE

A storm surge is usually the combination of the highest tide (king tide), the action of the waves, and the height the water is raised when pushed up the beach, especially when driven by a high winds. The combination of these factors is given a height AHD and used by planners to work out at what height buildings and infrastructure should be placed along the shore.

1. Introduction

In February 2015 the Yorke Peninsula Council commissioned Mutual Projects Pty Ltd T/A Integrated Coastal Management to undertake the *Seawater Flooding Adaptation Pathways* study, a project jointly funded by the Commonwealth Natural Disaster Resilience Program, the Coast Protection Board, and the Yorke Peninsula Council. The aim of the project is to identify the seawater flooding risks, assess current flood protection infrastructure and provide recommendations for future action to cater for seawater flooding. The project will also improve community awareness of the risks associated with current and future seawater flooding. The sites under investigation are Clinton, Price, Pine Point (Billy Goat Flat) and Coobowie which are all situated along the eastern coast of the Yorke Peninsula and are considered by Council to be locations of risk.

1.1 Investigative framework

This study utilises the *Local Government Association Coastal Adaptation Decision Pathways Investigative Framework* which was originally developed in 2012, and trialled at Onkaparinga and Mallala Councils. In 2013, the investigative framework was utilised in the *District Council of Mallala's Coastal Settlements Adaptation Study,* and subsequently amended to reflect the findings of that project. Each settlement is reviewed within the following framework:

1. Establish settlement history.
2. Analyse existing sea-flood protection.
3. Analyse the impact of sea-flood scenarios.
4. Analyse emergency access and egress.
5. Establish profile of the assets at risk.
6. Identify current policy framework.
7. Explore liability issues.
8. Propose adaptation actions.

1.2 Staging of the project

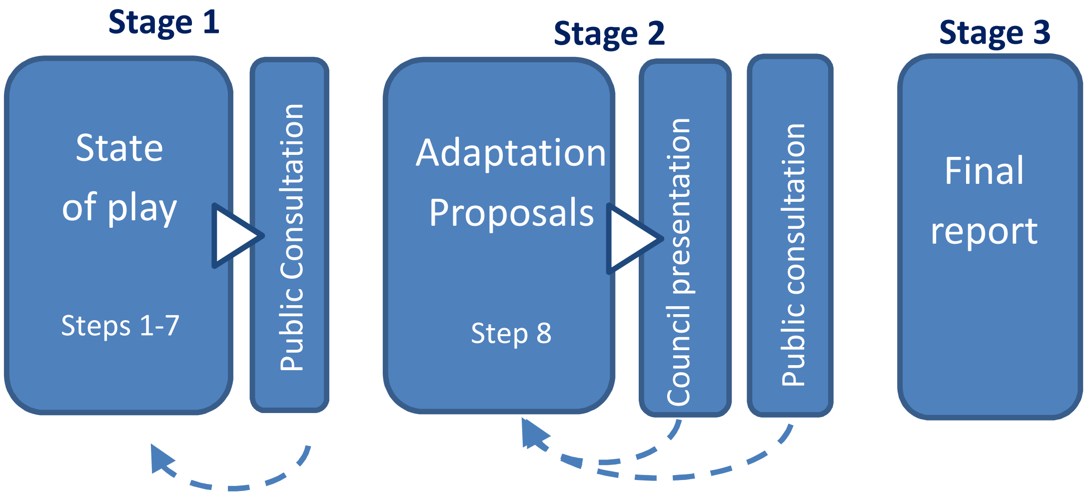
The process is to be undertaken in three main stages (**Figure 1:1**):

Stage 1: State of Play Report (Steps 1 – 7)

Stage 1 evaluates and reports the current and future threat. The community consultation process in Stage 1 reports *to* the community about the potential for sea level rise but also actively requests information *from* the community to create the full 'sea-flood risk picture' (See also Section 3).

Stage 1 is now complete and this report represents the findings of Stage 2.

Figure 1:1 The coastal adaptation study is conducted in three stages[1]



Stage 2: Propose adaptation options (Step 8)

Stage 2 proposes adaptation options in draft form and reports these to the Council, and then to the community by way of a second public meeting. Adaptation proposals are generally framed within the five broad ways human settlements can adapt to rising sea levels:

- **Protect:** use various means such as construction of sea walls, beach sand replenishment or installation of drainage swales to protect existing development;
- **Accommodate:** use means such as raising buildings or protecting buildings from flooding;
- **Retreat:** abandon settlements and move development inland in the face of rising sea levels. The concept of 'retreat' is also known as 'planned retreat'.
- **Defer:** threats have been assessed, and perhaps costs and options analysed but there are valid reasons to wait until to a later date to act.
- **Do nothing:** ignore the risks and do nothing.

Stage 3: Final reporting

Responses from the Council and the community from Stage 2 are taken into account for the final report. Stage 3 provides a final report to Council that includes an explanation of the adaptation options, a suggested prioritisation for action, and preliminary engineering solutions and estimated costs (where possible).

[1] Adapted from coastal analysis tool, *Dealing with the impacts of sea level rise on coastal assets (2012) (Western & Kellett)*

1.3 Reporting and consultation

While the scope of the *Seawater flooding adaptation pathways for Yorke Peninsula Cou*ncil covers the four settlements of Clinton, Price, Pine Point (Billy Goat Flat) and Coobowie, adaptation responses options available to each settlement are reported separately. This report contains the adaptation options for:

Coobowie.

Figure 1:2 Location Map: Coobowie, Yorke Peninsula[2]

In preparing the adaptation options in this report the following agencies and individuals were consulted:

- James Guy, Department of Energy, Water, and Natural Resources,
- Dwayne Werfel, Yorke Peninsula Council, Works Supervisor (North),
- Geoff Fisher, Australian Water Environments (AWE), on 2nd June, 2015 inspected Coobowie settlement and environs, also reviewed the adaptation proposals and offered technical advice on 26th August, 2015,
- Geoff Wilde, Managing Director, Geoff Wilde Earthmoving.

[2] http://www.naturemaps.sa.gov.au/maps/viewer.aspx?site=NatureMaps

1.4 Methodology

Adaptation responses in this study take into account: the nature of the threat, the protection of infrastructure, the safety of people, and the appropriate timing of response until 2100.

1.4.1 Adaptation responses that relate to the nature of the threat.

Other than depth of water, additional factors that influence the impact of a flood on a settlement are: the velocity of the water (speed), the duration of the flood (how long it lasts), and the topography of the settlement. How much warning is possible for possible flooding is a factor that enables the settlement to prepare for the flood more effectively. The general characteristics of a sea-flood in the Coobowie region are shown in **Table 1:1**.

Table 1:1 Sea flood characteristics for Coobowie coastal region.

Flood characteristic	Coobowie region
Depth of water	Shallow
Velocity of water	Low, due to tidal action and ocean terrain
Wave action	Minimal due to depth of water and sheltered from any westerly winds by the land
Direction of water	From the east
Duration of flood	Short 1-2 hours relating to combination of tide and storm surge
Warning	Predictable as flood will relate to tide.

To contextualise the flood risk in the Coobowie region, **Table 1:2** illustrates how insurance companies may discount their flood risk when adequate flood warning can be provided and the community is prepared to deal with a flood. For example, where the community is experienced and there is a greater warning time than 12 hours, the predicted actual cost of damages can be discounted by 0.4 (Victorian Government, 2000).

Table 1:2: Proposed ratios of actual:potential damages (Victorian Government, 2000)

Warning time	**Experienced community**	**Inexperienced community**
Less than 2 hour	0.8	0.9
2 to 12 hours	Linear reduction from 0.8 at 2 hours to 0.4 at 12 hours	0.8
Greater than 12 hours	0.4	0.7

Historically, storm surges that have threatened settlements in the Coobowie coastal region have been in conjunction with the highest astronomic tide (often referred to as a 'king tide') which would in the majority of cases, provide a greater than 12 hour warning period. In summary, and based on historical data, the flood threat is normally related to predictions of high tides, likely to be of low intensity in relation to velocity of water, and of short duration.

Finally, adaptation responses are proposed and analysed using the three one in one hundred ARI scenarios provided in the State of Play report (**Table 1:3**). These scenarios assist in providing the context from which to make decisions that relate to the viability and also the timing of responses.

Table 1:3 Coobowie- 1 in 100 annual return events, with allowance for sea level rise[3]

	2015	2050	2100
Storm surge (1990 levels)	1.9m	1.9m	1.9m
Wave set up	0.1m	0.1m	0.1m
Wave run up	0.1m	0.1m	0.1m
Sea level rise	0.1m	0.3m	1.0m
Totals (AHD)	**2.2m**	**2.4m**	**3.1m**

1.4.2 Adaptation responses that relate to infrastructure and people.

<u>Infrastructure</u>

In proposing adaptation responses, Councils are required to take the long view. For example, a house constructed today is likely to have a life span of 60 to 80 years, so future risks from actions of the sea are required to be taken into account in current planning policies. Councils are also required to take into account Coast Protection Board policy and advice. Such policy includes being able to demonstrate that development is capable of being protected for the sea-flood risk for the 1 in 100 ARI event adopted for 2050, but also that reasonable steps can be taken to adapt the development to the sea-flood risk for the 1 in 100 ARI event adopted for 2100 (Coast Protection Board, 2004).

<u>People</u>

Adaptation responses should also take into account the safety of people in a flood event. These include warning and emergency procedures, the ability of people to be able to move safely away from the flood, and the ability of emergency vehicles and personnel to move into the settlement.

1.4.3 Adaptation responses that take into account time

The *State of Play Report* (SOP) has already analysed the possible impact of the three 1 in 100 ARI flood scenarios (2015, 2050, 2100) upon the settlements. It is proposed here to draw upon that data and deal with adaptation responses in the following order:

- What level of protection can be realistically provided (at current threat, 2050 threat, 2100 threat).

[3] Since the completion of the State of Play report, DEWNR (Coast Protection Branch) has revised the sea-flood risk levels for Coobowie by increasing the allowance for storm surge, but also decreasing the amount allowed for wave action which has resulted in the same overall risk level.

- Where protection falls short, what accommodation responses can be employed?
- Where protection and accommodation strategies fall short, what longer term retreat options should be employed (if any)?

Finally, responses canvassed within this report may be implemented over the coming decades but also may be contingent on each other. For example, a protection strategy employed now may mean that other accommodation strategies are not required until a later date. The limitation of a protection strategy may mean that accommodation or retreat strategies are required to cater for that shortfall later in the century. **Figure 1.3** provides a pictorial overview of the adaptation strategy.

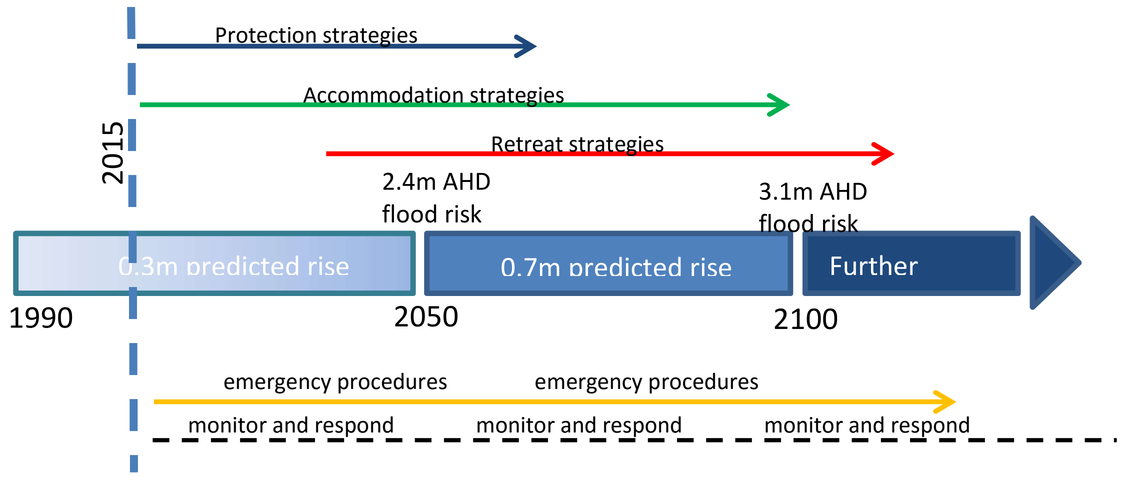


Figure 1:3 Adaptation responses are time related and sometimes contingent on each other but also contingent on the rate of sea level rise which is to be monitored over time (M. Western, 2015).

1.4.4 Adaptation responses that take into consideration possible costs:

The cost estimates provided with this report should be read with extreme caution and are only provided to give some context for priority setting. This is especially true for the Coobowie study for two reasons. First, the Digital Terrain Model provided with the study proved to be inaccurate and general height levels of foreshore areas were not able to be determined. The study relied on spot levels provided by Martin Ankor, Custom Spatial Solutions. Second, the existing and proposed defence systems highly varied and the proposals more complex (than other settlements in this study), and without further information from engineers and other designers, the price estimates are based on very basic information. All costs are given without GST.

1.4.5 Adaptation responses that do not take into consideration:

- The effect of rising sea levels on ground water within Coobowie,
- The potential for a rain flood event either combined or not combined with a king tide (although the State of Play report found that there was a low correlation between sea-flooding events and rain flooding events),
- The possibility of a sea-flood event caused by unforeseen event such as a tsunami.

2. Coobowie protection options

In brief the findings of the State of Play (SOP) report were:

- The topography of Coobowie limits sea flooding to a 700m length of the foreshore in parallel with Beach Road (**Figure 2:1**, and SOP, p19).
- Existing sea-flood protection is situated on the shoreline, is predominantly man-made, and is best categorised into five main sections (Table 2.1)(see also SOP, p 23-27).
- Several weak spots in the coastal protection exist. These include low height of walls or bunds and deteriorating infrastructure (See details in SOP, Appendix D).
- The highest known level of flood water is likely to have been in the 1981 flood event at height 1.80m to 1.90m AHD (including wave action). This date may also represent the highest levels experienced in Coobowie since 1940 (see SOP, pp 28-35).
- Consultation with residents suggest that there have been no major breaches of the protection works subsequent to the 1960s when protection systems were installed.
- The current 1 in 100 risk (2015) is 2.2m AHD[4] and if this event was to occur, defences would be seriously breached with water covering Beach Road at depth of 100-300mm. After such an event, water would lie between Beach road and the frontal protection works with no means of draining away.
- Available evidence indicates that the beach has a very low wave action, has been stable over a long period of time, and shows little sign of significant erosion (SOP, Appendix C).
- Coobowie is not likely to be vulnerable to lateral erosion which would undermine the integrity of the settlement, although the dunes in the west may show increased erosion should the sea continue to rise as predicted (see SOP, p21).
- Large over-land flooding is unlikely due to the installation of a detention and diversion system. However, rain events generate flooding into Giles Street West basin, and as yet, no solution has been identified for this flooding problem (see SOP p. 22, 35-36)[5].
- In rain events water accumulates along the foreshore in the vicinity of the hotel on the corner of Giles Street and Beach Road.
- The ground water is close to the surface[6] and the long term stability of the ground near the foreshore may be in question if the sea level rises as anticipated over this century.

Table 2.1: Types of and condition of protection works

Section	Height and Condition
Caravan Park	At 2.20m AHD, some erosion evident
Sea walling	Large variation in type, condition and height (1.85m to 2.10m AHD)
Earthen bund	Generally of solid constituency, well vegetated and at heights above 1.90m AHD
Shell grit bund	Generally narrow, in poor condition, and at heights above 1.90m AHD
Old Quarry - Dunes	Natural dune system with low points at 1.50m AHD

[4] Including wave run up (mapping in the SOP, excluded wave run up)
[5] Storm water flooding is outside the scope of this study but any adaptation option should also deal with storm water that collects in the Beach Road region. Note: Australian Water Environments (2009) study, SOP p. 35 suggested that rain events are independent of sea flooding. Residents in community consultation did not concur with this finding.
[6] Based upon several anecdotes of residents in community consultation meetings.

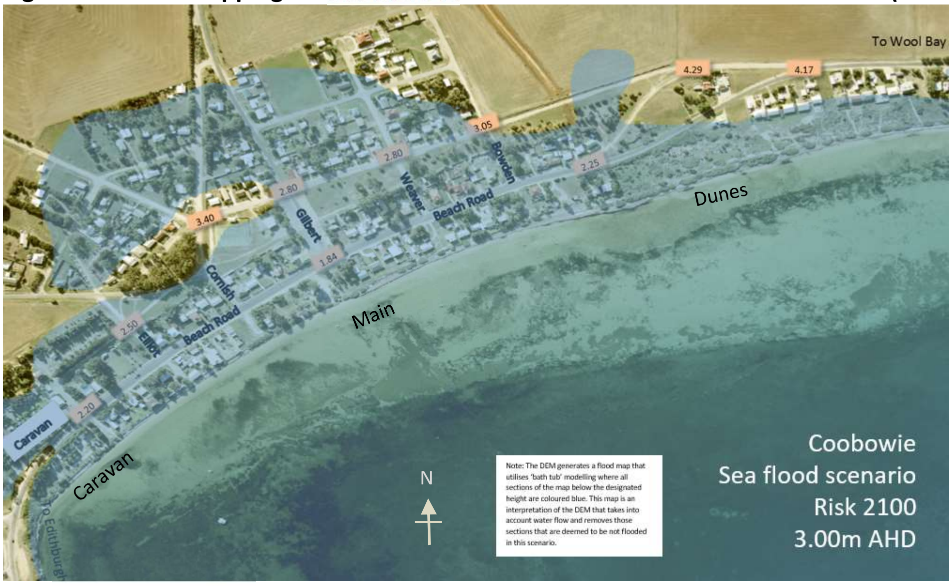
2.1 What level of protection can be realistically provided to cater for the sea-flood risk at 2100 (3.0m AHD)?

In brief, the State of Play report found if a 3.00m AHD[7] sea-flood of significant duration occurred, and not just a brief over-topping of defences, Coobowie would be significantly inundated:

- Beach Road would be inundated at depths of 1.0m to 1.2m.
- Water may traverse to Anesty Road (the upper ridge line at levels 2.8m to 3.0m AHD) and cross over this ridge line in places at levels up to 200mm and inundate the northern portion of Coobowie.
- Giles Street West may be inundated at depths of 1.3m to 1.5m.
- Water would remain trapped behind the frontal defence system with no means to drain water away after the flood event.

Furthermore, an increase of sea level by 1m over the course of the century is likely to raise the ground water within the settlement and the integrity of the ground south of Beach Road may be under increased threat.

Figure 2:1 Flood mapping for sea-flood scenario 1 in 100 ARI event of 3.0m AHD (2100 scenario).



Conclusion:

In pure engineering terms it would be difficult to construct levees to the Coobowie sea-front at elevation 3.0m AHD because the size of the required base would encroach significantly on to the beach area (approx 8-10 metres). Sea walls or rock revetment may be possible but these would protrude some distance above the natural ground level and the construction costs prohibitive.

As far amenity issue are concerned, protection works that obliterate the view of the sea will be likely to change the nature of Coobowie in an unacceptable manner. For example, a person

[7] Without 'wave run up' of 0.1m (but this decision relates to the changes in the way Coobowie sea-flood height is now calculated subsequent to the completion of the State of Play report).

walking towards the ocean at Beach Access 3 would be unable to see the ocean (**Figure 2:2**). The view from the beach would be also be compromised with protection works likely to rise 2.5m above the level of the sand.

Figure 2:2 Expected height of required protection works for 2100 sea-flood scenario.

Finally, if the sea level does increase as predicted, there is nothing to suggest that it won't keep rising past 2100, thereby rendering any defences at 3.0m AHD ineffective. The conclusion of this study is that protection options are not realistically viable to cater for the predicted rises of sea level at the end of this century and into the next.

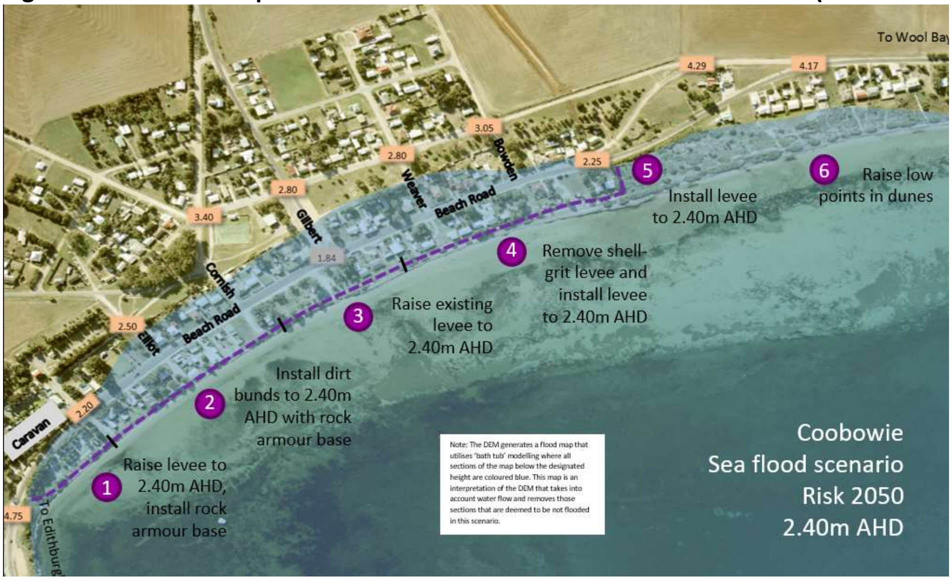
2.2 What level of protection can be realistically provided to cater for the sea-flood risk at 2050 (2.5m AHD)?

In contrast to the 2100 flood scenario, protection options for Coobowie should be considered for the 2050 1 in 100 ARI flood risk (2.4m AHD) for the following reasons:

- Protection measures are feasible and likely to be effective (**Figure 2:3**);
- Protection of development to cater for the 2050 flood scenario (2.4m AHD) is Coast Protection Board policy;
- Installation of protection measures now will provide a 30-40 year time in which data can be tracked over time to assess the rate of change in sea level.
- Installation of protection measures now will provide a 30-40 year time frame in which accommodation measures can be implemented to cater for sea level rises past 2050.

2.3 Protection options for Coobowie

Figure 2:3 Protection options to cater for 1 in 100 ARI event of 2.4m AHD (2050 scenario).



Rendition of Sea-flood scenario based on DEM (M. Western, 2015)

In relation to who should be responsible to pay for the protection works that are installed to the front of private property:

- The long standing policy[8] of the Coast Protection Board has been to not provide funding to protect private property unless certain conditions are met (such as their being simultaneous protection of public property, or where large numbers of dwellings may obtain a benefit).
- Where esplanade roads and associated infrastructure are situated on the shore line, Councils may make decisions to protect their own assets, and often these protection strategies provide a dual benefit of protecting private properties.
- Where settlements were founded prior to Councils being required to take into account rising sea levels (pre 1990s), there is not likely to be any legal responsibility for Councils to implement protection to protect private properties.
- In relation to the works proposed to private properties in this study, the main benefit is to the property owners as they will benefit from increased protection from flooding, and will enjoy an upgrade of existing works, which are overall in poor condition. However, the implementation of the works to private properties also provides protection for the settlement as a whole as well.
- Therefore, the preliminary conclusion of this study is the cost of implementing the works to private property should be shared equally between the Council and the property owners.

[8] Since 1980, See Coast Protection Board Policy Document, revised 22 May, 2012.

1(a). Install rock armour to base of 45 LM of existing caravan park bund.

The caravan park bund is currently at sufficient height to cater for the current sea-flood risk of 2.2m AHD but erosion is threatening the base of the bund (**Figure 2:4 and 2:5**). The purpose of these works is to halt the erosion.

Figure 2:4 Existing caravan park bund at height 2.2m AHD.

Photograph (M.Western, 2015)

Figure 2:5 Caravan park levee showing signs of erosion.

Photograph (M.Western, 2015)

Proposal:

Install rock armour to base and back-fill behind line of rock. Vegetate to match existing vegetation either side of the proposed works (see **Figure 2:6**).

Figure 2:6 Install rock armour base and backfill.

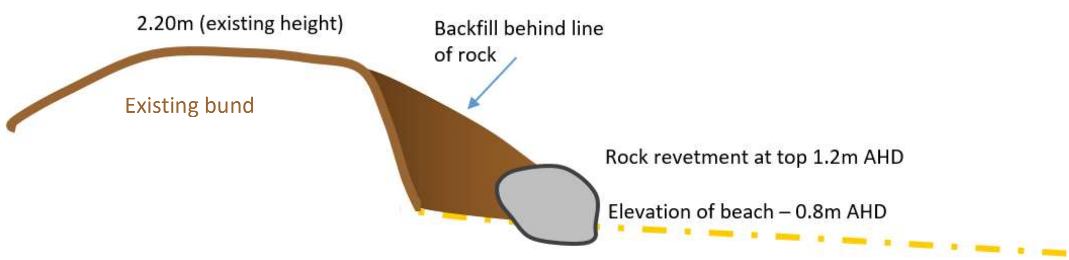


Illustration (M.Western, 2015)

Preliminary cost estimate:

43 m x $380 /LM = $16,000[9]

1(b). Raise caravan park levee from 2.20m to 2.40m AHD.

To cater for the 2050 risk, raise 160 LM of the existing bund by 0.2m. The existing width of the bund would suggest that this could be accomplished with an earthen addition that was appropriately keyed into the existing top.

Figure 2:7 Use earth to raise existing levee by 0.2m with appropriate 'keying' in.

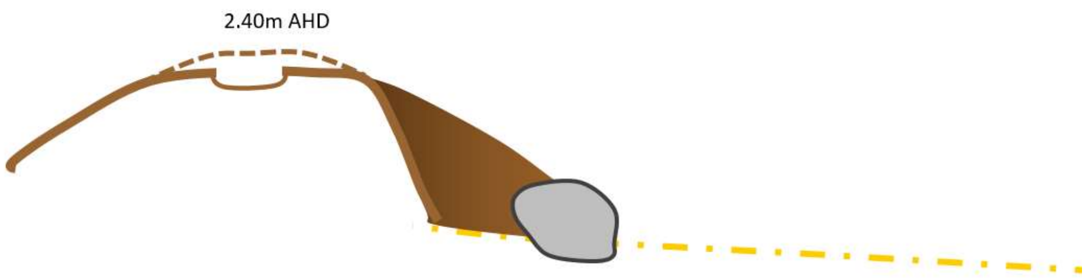


Illustration (M.Western, 2015)

Preliminary cost estimate:

160 m x $40 /LM (or 50m^3 dirt approx) = $5,500

[9] Geoff Wilde earthmoving (based on Pine Point per lineal metre rate for similar height rock revetment)

2. Install earthen bund with top at height 2.4m AHD

The existing protection in this location is an array of sea-walls of varying heights and integrity that belong to 13 private properties and 2 beach access points (See SOP, Appendix D for photographs of all properties). The aim of this protection strategy is to provide an option that is capable of encompassing all of the variations, as well as maintaining the existing character of Coobowie foreshore, which currently consists of vegetated bunds.

Note: The location of the seaward line indicates that this area of beach is lower than areas further to the east (dunes end).

Figure 2:8 Location of adaption option 2 – install earthen bund at 2.4 AHD

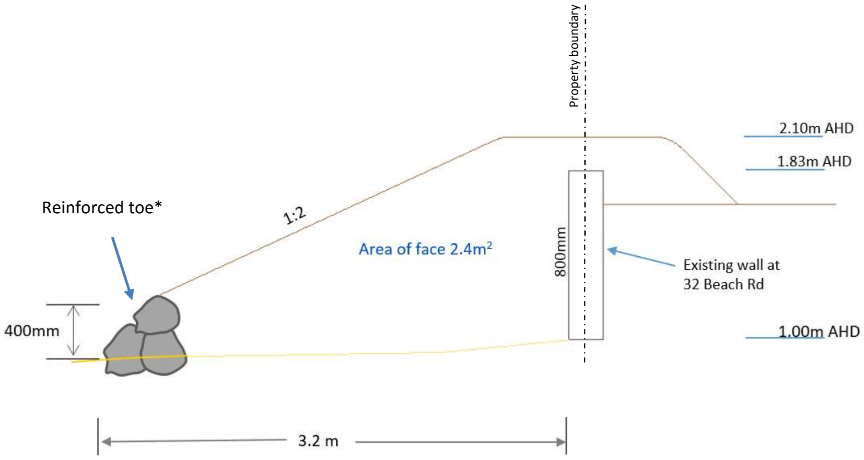
Digital Terrain Model (M.Western, 2015)

Proposal:

Stage 1:

Install an earthen levee with a top that bridges the boundary line of foreshore properties at height 2.1m AHD. This height approaches the current sea-flood risk of 2.2m AHD (including wave heights) and also equals the height of seawall protection at 32 Beach Road, which is the only property in which it would not be possible to use a dirt bund over the boundary line. **Figure 2:9** illustrates how the proposal would work at 30 Beach Road.

Figure 2:9 Concept - install dirt bund to encompass existing range of sea-wall types.



*An alternative way to reinforce the toe of the bund may be to use gabion methodology where a gabion basket is half buried in the sand and half protruding into which the earthen mound can butt. Supply of 1m long by 600mm high by 400mm thick = $40 per unit (gabion1.com.au)

Figure 2:10 Concept for reinforced toe – use gabion baskets

Figure 2:11 Existing sea-wall at 32 Beach Road

Photograph (M.Western, 2015)

Stage 2:

To achieve the height required for the 2050 sea-flood risk scenario of 2.40m AHD, the earthen bund could be raised with gabion rock basket (or use other means such as concrete plinth, concrete blocks). There are a number of reasons for adopting an alternative approach to achieve the final 0.3m in required height:

- To reduce the amount of distance required to encroach into the beach reserve. For example, with an incline of 1:3 of the bund, an extra 0.3m height would require almost another 1m of beach space (also meaning higher impact from action of the sea).
- To reduce the appearance of bulk of the bund. Assuming the bund is vegetated (at least on the ocean side), the plinth is unlikely to be visible.
- The approach is likely to be more cost effective.
- The installation can be undertaken in two stages (reducing up-front costs).

Figure 2:12 Concept - install upper addition to create 0.3m height

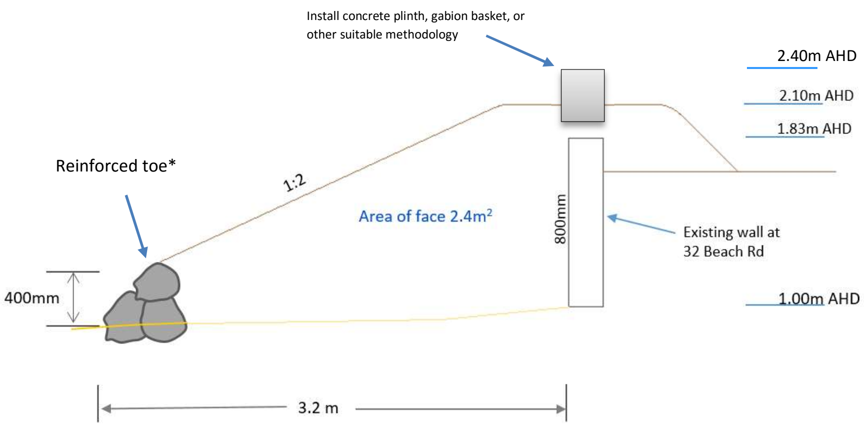


Table 2:2 Preliminary cost calculation: Install earthen bund at 2.40m AHD

2. Preliminary cost calculation: Installation of earthen bund foreshore (per property)							
Location	Item	Property width	Height	Area of profile face	Volume m^3	Cost per m^3	Cost (approx)
Per property	Install Bund	20m	1.4m	$2.4m^2$	$48m^3$	$\$90/m^3$	$ 4350[10]
Per property	Reinforce toe	20m	0.4m			$ 300/LM	$ 6000[11]
Per Property	Install additional 0.3m height	20m	0.3m			$ 120/LM	$ 2400

<u>Preliminary cost estimate:</u>

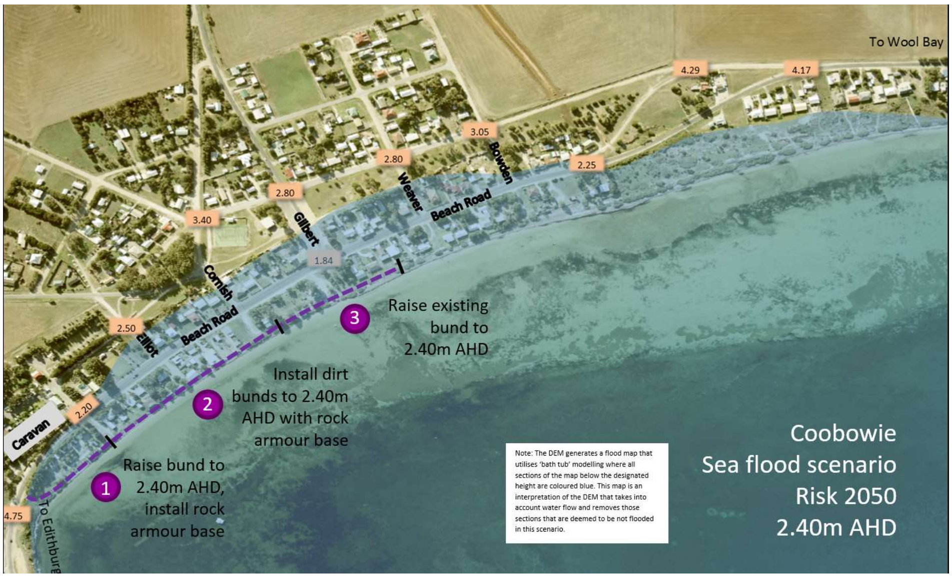
The cost per property to install bund with reinforced toe is estimated at $10,350 per property.
The cost per property to add 0.3m height to the bund is estimated at $2,400 per property.
To reinstate wooden crossovers at two beach access points allow $2,500 per access point.

The contribution expected from each private property owner is estimated at $6,600.

[10] Geoff Wilde Earthmoving priced bund at $6300. Yorke Peninsula Council is able to supply and deliver dirt from Port Julia at $20 per m^3. Council supply and installation rates of bunds at Port Clinton and Pine Point ranged from $40 to $70. Due to the complexity of this location, $90 per m^3 is utilised.

[11] Geoff Wilde Earthmoving priced rock revetment at $8,225 ($410 / LM) for reinforcing on a very low action beach (unlike Pine Point). This appears to be too high, and $300 per LM has been budgeted. Gabion baskets could be supplied for $50 -60 per lineal metre which could be half buried and half exposed.

3. Raise existing earthen bund to 2.40m AHD.



DEM, Mark Western (2015)

The existing bund in this section is at height 1.90m AHD to 2.20m AHD, of solid construction, wide and well vegetated. Note that the location of the bund between Beach Access 3 and Beach Access 4 is contained within the cadastral boundary of the allotments in the playground area.

Figure 2:13 Location of adaptation option 3 – raise existing bund to 2.4m AHD

DEM, Mark Western (2015)

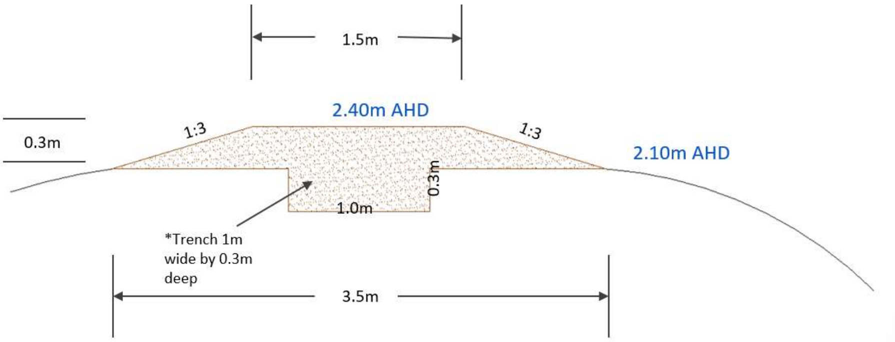
Figure 2:14 Nature of the existing bund (in front of playground area)

Photograph, Mark Western (2015)

Proposal

Raise existing bund by 0.3m to 0.5m (average 0.4m). To ensure that the raised portion is 'keyed' into the existing bund, a channel approximately 0.5m wide by 0.3m deep should first be cut into the top of the existing bund*.

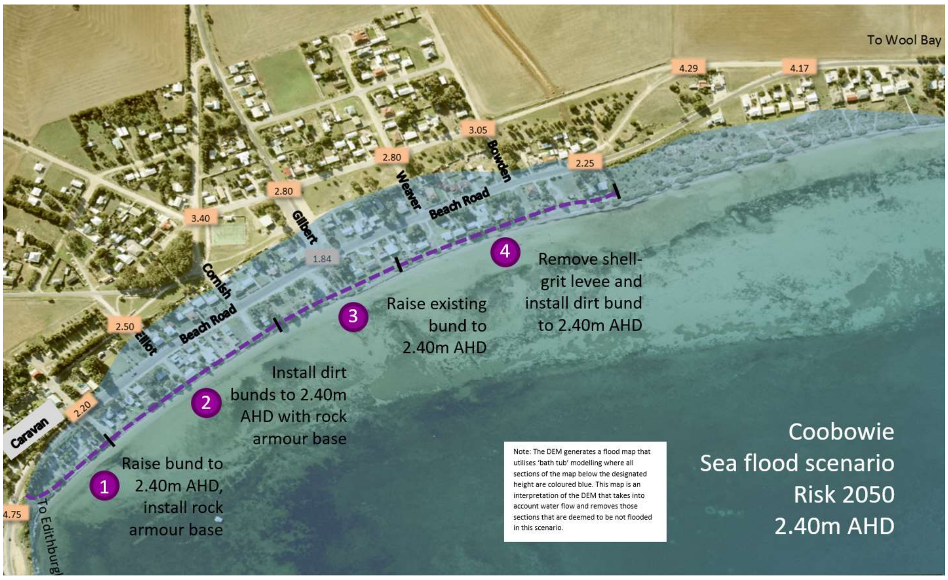
Figure 2:15 Concept – raise existing levee to 2.40m AHD



3.Preliminary cost calculation: raise existing levee to 2.40m AHD[12]								
Location	Existing elevation	Raise	Length	Width	Area of profile face	Volume	*Unit cost	Estimated cost
Levee (Part A)	1.90m	0.5 m	102m	1.5m	1.55m²	152m³	$ 80	$ 12,160
Levee (Part B)	2.10m	0.3m	96m	1.5m	1.05m²	101m³	$ 80	$ 8,080
Estimate:					Total	253m³		$20,240

[12] Geoff Wilde Earthmoving (using very basic information) quoted this section of work between $208 and $232 per lineal metre (but this equates to $173 per m³ which seems too high for the location). The upper m³ rate has been used from Yorke Peninsula Council's quotes for works in Clinton and Pine Point.

4. Remove shell-grit bund and replace with earthen bund with top at 2.40m AHD.



The existing bund in this section is predominantly at heights 2.00m to 2.20m AHD, with some lower points at 1.90m AHD. This bund was constructed in the 1960s from beach sand and is now in poor condition. Generally this area of land is more elevated than further to the west (caravan park end) as indicated by the location of the seaward line (**Figure 2:16**) which is now much further away from the private property boundary (compare with **Figure 2:9**).

Figure 2:16 Location of adaptation option 4 – raise existing bund to 2.4m AHD

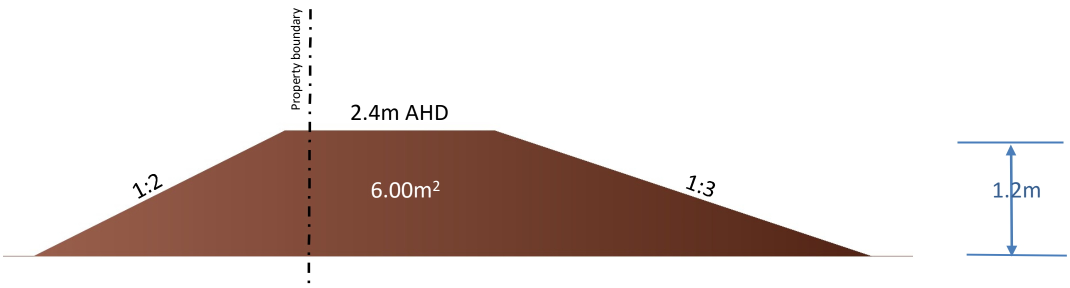
<u>Proposal</u>

Remove existing shell grit levee and relocate to the dunes section and install dirt bund with top at 2.4m AHD. It is unknown how much of the existing levee may need to be removed before being able to construct the new levee. If the base of the existing levee is solid and well compacted then the entire structure may not need to be removed. A height of 1.2m has been chosen for costing purposes but this selection may prove to be arbitrary.

Figure 2:17 Example of existing shell grit bund

Photograph: Mark Western (2015)

Figure 2:18 Suggested profile of dirt bund



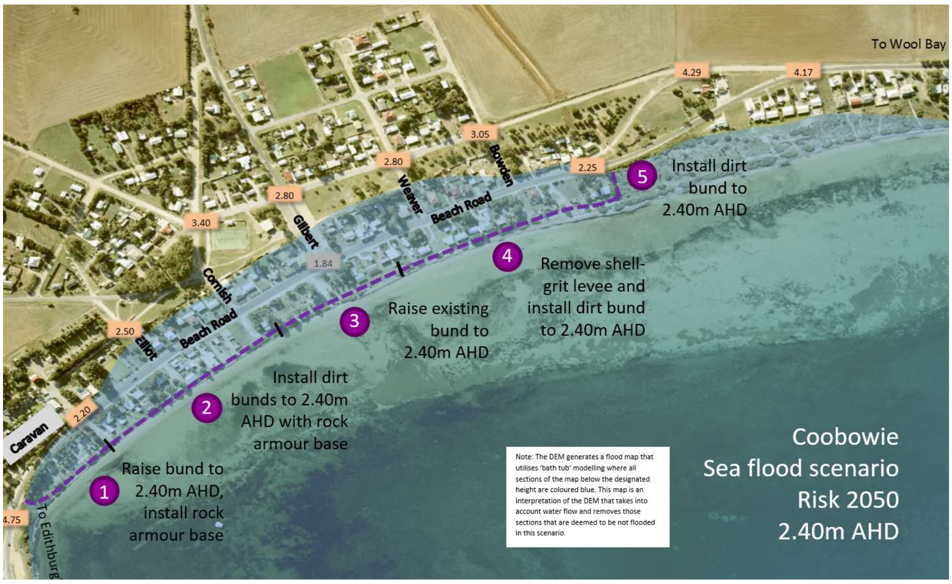
4. Preliminary cost calculation: Remove shell grit levee and install dirt bund (per property)							
Location	Existing elevation	Levee height increase	Levee length	Area of profile face	Volume (approx) m^3	*Cost per m^3	Cost (approx)
Foreshore	Unknown	1.2m	20m	5.3m^2	120m^3	$70	$ 8,400[13]
Foreshore				Remove shell grit levee			$1,250[14]

<u>Preliminary cost estimate:</u>

- Cost per property to remove the shell grit levee is estimated at $1250.
- Cost per property to install a dirt bund with top at 2.4m AHD is $8400.
- Cost to reinstate wooden crossovers at two beach access points $2,500 (each).
- The contribution expected from each private property owner is estimated at $4,800

[13] Yorke Peninsula Council can supply and deliver dirt at $20 per m^3, the upper supply and install rate has been used from the Port Clinton and Pine Point quotes.
[14] Geoff Wilde Earthmoving

5. Install traverse levee to eastern end of settlement

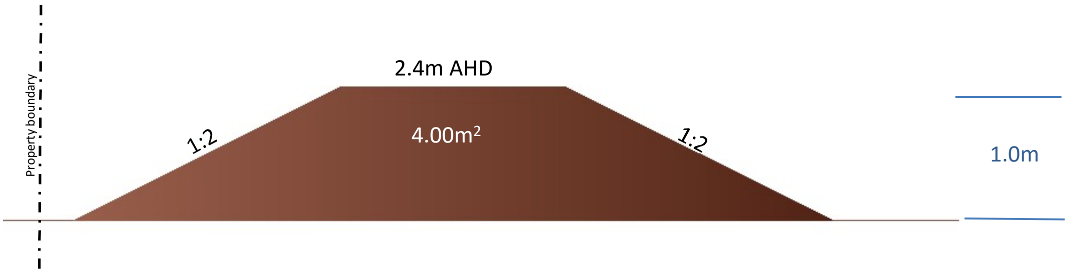


The dune system to the east is substantially lower in places than the current risk level of 2.2m AHD, and this factor will be exacerbated over time as sea levels continue to rise. The purpose of these works is to prevent any water that may encroach through the dunes east of the Coobowie settlement from flowing back into the Coobowie settlement.

Proposal

Install 70 LM of traverse bund with top at 2.40m AHD (Assumes natural ground level of 1.2m AHD based upon adjacent property).

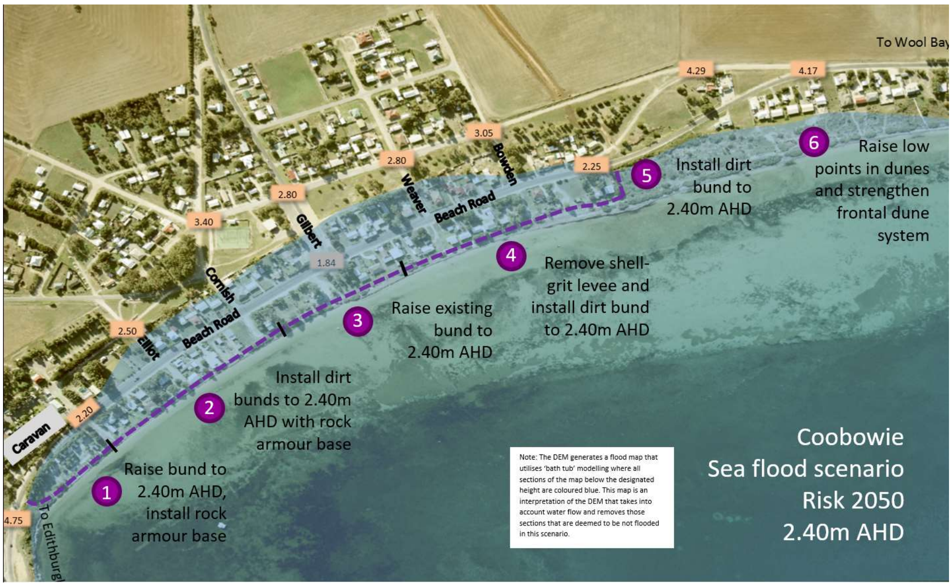
Figure 2:19 Suggested profile of dirt bund



5. Preliminary cost calculation: Install dirt bund to eastern end of Coobowie settlement							
Location	Existing elevation	Levee height increase	Levee length	Area of profile face	Volume (approx) m^3	*Cost per m^3	Cost (approx)
Foreshore	Unknown	1.2m	20m	$4.0m^2$	$80m^3$	$80	$ 6,400[15]

[15] Yorke Peninsula Council can supply and deliver dirt at $20 per m^3, the upper supply and install rate has been used from the Port Clinton and Pine Point quotes.

6. Raise low heights in dunes and strengthen frontal dune system



<u>Background</u>

Sand mining in the 1960s and 1970s has depleted the natural dune system to the east of the main Coobowie settlement.

Figure 2:20 Location of sand mining east of Coobowie (main settlement)

Photograph: Coast Protection Board (1974) Inset photograph (M. Western, 2015)

In the 1981 sea-flood event, the only place where water encroached into the settlement was through this dune system. Subsequent to the 1981 event, it is likely paddock rocks were placed in the area where the water flowed over the dune system (**Figure 2:20**).

The current dune system varies in height from 1.60m AHD to 3.20m AHD and if the current sea-flood of 2.2m AHD occurred, the dune system would be severely breached (Note: the implementation of Option 5 will prevent water from flowing back into the settlement, but should water flow into this area, it is likely that the vegetation would die and may not recover).

Additionally, further east, residents have formed informal access ways through the dune system and some of these access ways are at heights as low as 1.40m AHD (**Figure 2:21**).

Figure 2:21 Location of informal access ways and associated heights

Rendition from DTM (M. Western, 2015)

Proposal 6 (a)

Utilise the material from the removal of the shell-grit levee system (Option 4 above) and strengthen and widen the dune system. Note: the material for the shell-grit system that was installed in the 1960s was sourced from the Coobowie Beach.

Figure 2:22 Re-use shell grit material from Option 4 within existing dune system

Rendition from DTM (M. Western, 2015)

Preliminary cost estimate

Approximate costs assigned to Option 4 above.

Proposal 6 (b)

Reduce informal pedestrian access ways to three, raise the low points in the dunes, and formalise the access with wooden 'ladder' dune stabilisation mechanisms. Note: use sand bags to provide core strength and back fill with sand from the Coobowie Beach.

Figure 2:23 Raise informal access points and formalise with dune stabilisation mechanism

Preliminary cost estimate

Raise seven low points, formalise access to three of these, and encourage revegetation for the four closed points.

Approximate cost: $2,500

7. Devise and implement means of dealing with storm water (or sea-water that may be dammed behind the defences subsequent to a sea-flood event).

The scope of this study does not include dealing with storm water issues but irrespective of this, stormwater issues were reviewed in the State of Play report (SOP, p. 22). Adaptation going forward, should also take into account how storm water might be more effectively dealt with rather than accumulating in the Beach Road area.

In relation to dealing with sea-water flooding, if the protection items outlined in 1-6 are implemented, then it isn't likely that a sea-flood would over top these. However, it is always possible that an unforeseen sea-flood could eventuate, and it is probable that if the sea continues to rise, at some time in the future, the proposed defences will become inadequate and flooding will resume. Therefore, adaptation options should take into consideration how to effectively drain away the flood waters should flooding occur.

For example, at the time that bunds are upgraded, water drainage points could be designed and implemented (see also p. 28 below).

This adaptation option is not costed.

3. Coobowie Accommodation Options

Accommodation options are necessary when sites and buildings are not able to be protected by reasonably practical means to cater for the 1 in 100 ARI event for the 2100 sea-flood scenario. Infrastructure and buildings implemented in the present time will have life spans in excess of eighty years and thus are likely to be in existence around 2100. This study has found that protection options are only viable to cater for the 2050 sea-flood scenario and therefore, other accommodation options should be implemented.

3.1 Accommodation option - prepare the community to be 'flood ready'.

As noted above (see p. 5), a community that is prepared to deal with a flood is likely to suffer much less in financial terms, and also less likely to suffer human tragedy. Further, a prudent community prepares for emergency events that may fall outside of its historical context as 'mother nature' does not necessarily adhere to ARI tables. The following are ways in which the community could prepare itself to be 'flood-ready':

3.1.1 Implement general warnings of general flood risk.

Yorke Peninsula Council to implement general warnings to residents about the general risk of flood. These warnings may include:

- Flood mapping and floor levels of dwellings made available to residents to allow them to more fully evaluate the flood risk to their property. It is noted here that two community work shops have been held, and the State of Play reports containing flood mapping have been posted on the Council website. All land owners were notified of the meetings and where to find the State of Play report.
- New residents made aware of the risk of flooding in the Form 1 required as part of a real estate contract at time of purchase within the settlement.

3.1.2 Implement warning systems for possible flood events.

Coobowie Progress Association (or other appropriate community organisation) to implement flood warning systems such as:

- Community run warning systems to inform residents of upcoming king tides. Examples of warning systems include: sending tide charts to all residents, and/or utilising SMS or email to send messages to community members with king tide information.
- Implement systems to warn residents of predicted storms. For example, SMS and email storm warnings are available from the Bureau of Meteorology and could be forwarded to residents. The SES or CFS may also have other ways in which to warn residents.
- Install flood depth markers to where required[16].

[16] Unit cost $150, approximate labour cost $250, installation $400 per flood depth marker.

3.1.3 Implement flood emergency procedures.

Coobowie Progress Association (or similar community body) in partnership with the Council to establish flood emergency procedures such as:

- Establish an emergency assembly point (s) within the Coobowie settlement. A logical point of assembly would be the Coobowie Community Hall.
- Establish emergency evacuation routes that residents can use on foot that lead away from the source of the flood and to the emergency assembly point. The grid pattern of the road network in Coobowie means that most residents are able to move directly away from the source of the flood to higher ground.
- The grid pattern of the road network of Coobowie suggests that emergency service vehicles should be able to access most parts of Coobowie into close enough proximity to carry out any emergency work.

Figure 3:1 Routes that residents can utilise to move to the emergency assembly point (Example Only)

Flood mapping from DTM: M. Western (2015)

3.1.4 Prepare written Flood Emergency Action Plans.

Coobowie Progress Association in partnership with Council to prepare a guide to assist residents to prepare Flood Emergency Action Plans and to educate new and existing residents of its contents. The Guide should include evacuation policies based on the level of warning, what each member of the household should do if flood waters enter the dwelling, and describe how each member will access the emergency assembly point.

3.2 Accommodation Option- amend Development Plan policy.

Planning policy should ensure that:

- All new buildings (apart from minor structures such as sheds) to be capable of being raised to 3.35m AHD (and not that they are capable of being raised to 1.25m above the standard sea-flood level);

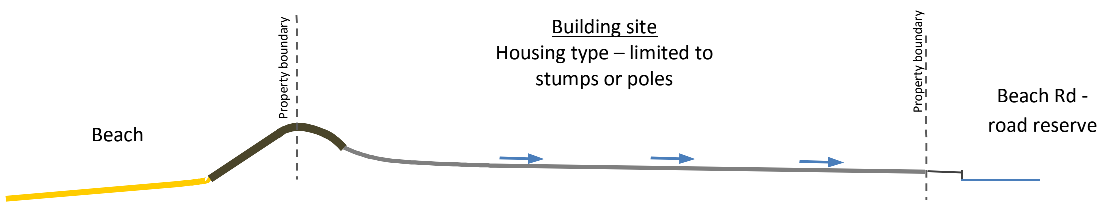
- Site levels are no longer required to be 'protected' from standard sea-flood risk level. Sites should no longer be required to be 0.3m above the standard sea-flood risk. Substitute clauses should have the sense of 'managing' the site in relation to sea-flood risk;

- The requirement that practical measures are available to 'protect' new development against additional sea level rise of 0.7 metres is removed and replaced with a clauses that have the sense of 'accommodating' additional sea level rise;

- The profile of the building site of proposed dwellings to the southern side of Beach Road are designed so that water flows away from the defence system and is collected within the Beach Road drainage system. Furthermore, that site profiles be coordinated laterally so that water might run laterally across property boundaries (if required).

  An efficient means of draining water from Beach Road would need to be identified.

  Figure 3:2 Site profiles to be designed so that water flows efficiently to collection points and also to work laterally with each other



- Review the specifications of septic systems to be installed with new dwellings at Coobowie to ensure that these are adequate to cater for potential sea flood scenarios later in the century.

3.3 Accommodation Option - adapt existing buildings

3.3.1. Raise the floor level of dwellings.

The predominant housing construction in Coobowie in the 'at risk' area is brick (62%) and concrete is overwhelmingly the preferred type of foundation (85%). Those dwellings on stumps could be raised if required, but these tend to be newer dwellings and are likely to have been installed at appropriate heights. If a decision is made to 'do nothing' about the protection options outlined above (p.11-25) or a decision is made to defer for any length of time, then residents may choose to raise their dwellings if the frequency and heights of inundation increase. However, this option will be limited in Coobowie because of historical preferences in building with brick and/or concrete foundations.

3.3.2 Water proof dwellings

Other flood accommodation options that residents could employ should the threat of inundation increase are to:

- Internally water proof buildings and raise electrical outlets above the predicted flood levels.
- Provide temporary flood barriers to the outside of dwellings when tides are predicted to be high[17].

Figure 3:3 Flood diversion/ protection method for dwellings

[17] These are examples from Blobel Flood Protections Systems (Blobel Environmental Engineering, 2013) and may not be directly applicable to dwellings in Coobowie.

4. Coobowie Retreat Options

The data from tide gauges at Port Stanvac and Thevernard have shown that sea has been rising in the region at an average of 4.3mm per year over the past 20 years. For the sea to rise 0.7m in the second half of this century as predicted would require an average rate of rise at 14mm per year. In reality this rate would be much lower than 14mm at 2050, and a much higher rate at 2100. Therefore, between now and 2050-2060 it should be possible to monitor the rate of increase and adjust predictions accordingly. There are two possible scenarios that will emerge from the monitoring in this time frame:

- If the rate of change of sea level rise does not increase and the predictions for 2100 are proven to be inaccurate, then at the very least as a result of implementing the adaptation strategies above, Coobowie would have become a far more resilient community and prepared for any unforeseen flood event.

- If the rate of change of sea level rise does accelerate and the predictions are likely to be accurate, then Coobowie can expect to be inundated far more frequently as the century approaches its close. Even though planning changes foreshadowed above mean that the floor levels of dwellings are above the flood levels, roads are likely to be more frequently cut off and damaged, emergency vehicles may not be able to enter the settlement, and the safety of people may be increasingly at risk.

Therefore, if future monitoring of sea level rise indicates that the rate of change is accelerating, then planning policy should be devised and implemented to ensure that all new buildings are capable of being removed. Policy should be developed so that a predetermined event triggers the removal of buildings, for example, when a certain sea level height is reached, residents may have 5 years (for example) to remove dwellings. It is important to note that this study is not recommending that such a change be made now, but that sea level rise be monitored over the coming decades and the change made when:

- It is recognised that the rate of sea level rise is accelerating[18]
- Dwellings constructed now will be reaching the end of their life span and sea levels reach a point that may not be properly accommodated.

In summary, such a policy would allow residents the liberty to continue to develop their properties, but with the knowledge that the development may have a limited life span and plan accordingly. Additionally, within this strategy is the assumption that should sea level rise as predicted and coastal properties become increasingly threatened by inundation or erosion, people's attitudes will change to living in certain coastal areas. It is also likely that this changing attitude will be reflected as reduced values of some coastal properties.

[18] Caution: the rate of sea level rise is not constant and thus longer term trends should be employed to ascertain whether the rate of change is accelerating.

In regard to Council owned infrastructure it is anticipated that:

- Any new buildings or infrastructure would be implemented taking into account the flood mapping provided by this study,
- Council will increasingly make decision not to upgrade infrastructure if it has become obvious that in the longer term a settlement cannot be protected,
- Should a retreat strategy be implemented, Council would need to implement its own retreat strategy for its own assets.

In conclusion, using the strategy outlined above, the Council will not be in the position of needing to implement a retreat strategy until it is obvious that such a strategy is required, and that fair warning had been given to all residents with the establishment of a pre-determined trigger a few decades prior.

5. Coobowie Adaptation Costs (preliminary)

The cost estimates provided below have been prepared based on very limited data and without engineering design calculations. They are therefore indicative only and have been prepared to assist council with the priority setting processes. They should not be relied on for budgeting or construction cost management purposes. **Table 5:1** is a summary of the adaptation options for Coobowie grouped according to the categories of *protect, accommodate, or retreat*.

Table 5:1 Summary of adaptation options for Coobowie

	Adaptation options	Approximate cost (Council)	Approx cost (Residents)	Reference pp.
Protect	Raise caravan park levee and install rock armour base.	$23,500		12-13
	Install earthen bund with top at 2.4m AHD ($12,700 per property/ beach access point).	$112,950	$82,550	14-17
	Raise existing levee to 2.40m AHD.	$20,240	-	18-19
	Remove shell-grit levee and replace with earthen bund (9,600 per property/access way)	$96,200	$72,000	20-21
	Install traverse levee to eastern end of Coobowie (main settlement)	$6,400		22
	Strengthen frontal dune system (cost assigned to Option 6)	-	-	23-25
	Raise low points in dunes and formalise pedestrian access ways (3)	$2,500	-	23-25
Accommodate	Implement emergency procedures – establish warning systems; establish emergency assembly point; establish evacuation policies; establish community emergency action plans.	Council & Progress Association		26-28
	Install flood depth markers to Beach Road (if required)	$2,000		26-28
	Devise and implement planning policy that ensures: new dwellings are capable of being raised to 3.35m AHD; and site levels are not required to be raised.	Not costed		28
	Adapt existing dwellings (if required) – residents to raise floor levels; utilise internal waterproofing; or temporary protection mechanisms.	By owners		30
Retreat	Subject to monitoring that demonstrates that the rate of sea level rise is accelerating, devise and implement planning policy that ensures that new dwellings are capable of being removed (once a predetermined trigger point has been reached, for example a particular AHD height).	Not costed.		31-32

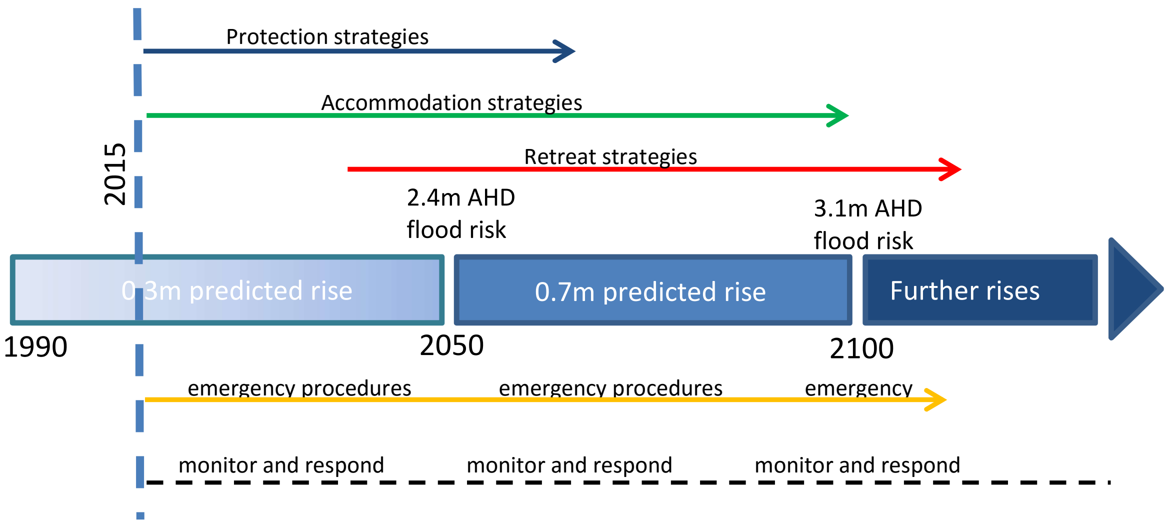
Within all of these adaptation options is the option to 'defer' or 'do nothing'. For example, cost may prohibit the implementation of a protection measure and therefore the project is deferred. In other cases, the risk might be deemed so minor that 'do nothing' is adopted.

6. Coobowie – Timing and prioritisation

6.1 Timing of adaptation options

In general, **Figure 6:1** illustrates how the different protection, accommodation, and retreat options interrelate over time. Sea level rise and erosion are monitored over time and responses made accordingly. Emergency procedures are always in place and amended according to the conditions. When protection measures become inadequate, accommodation options mitigate the risk. Subject to ongoing monitoring longer term decisions are made in relation to the viability of the settlement itself.

Figure 6:1 The interrelationship with adaptation strategies with time



6.2 Prioritisation of adaptation options

The prioritisation of adaptation options is based on the following criteria:

- First, warning and emergency procedures to ensure people are safe.
- Second, implement monitoring systems because these are not onerous, and the Council may be liable without them.
- Third, begin changes to planning policy as this process takes time, and the life span of infrastructure is long.
- Fourth, install protection works to protect Coobowie for the current sea-flood risk (if applicable).
- Fifth, protection works to protect Coobowie for the sea-flood risk for 2050.

Subject to Council and community input the following prioritisation in **Table 6:1** is recommended for Coobowie.

Table 6:1 Prioritisation and responsible entities for adaptations at Coobowie

	Adaptation response	Risk rating and other priority factors	Response time	Map reference
1.	Implement emergency procedures – establish warning systems; establish emergency assembly point; establish evacuation policies; establish community emergency action plans.	Such procedures are a wise response to living adjacent to an unpredictable threat.	Within 1 year	NA
2.	Implement monitoring systems (annual) to assess the state of protection bunds/walls	A duty of care exists for the condition of bunds/ levees	Within 1 year	NA
3.	Install flood depth markers to Beach Road.	Flood depth markers will increase awareness and safety of drivers.	Within 1 year	NA
4.	Devise and implement planning policy that ensures: new dwellings are capable of being raised to 3.35m; and site levels are not required to be raised.	Some dwellings constructed now may still be in use in 2080-90 when the 1 in 100 ARI flood risk is 3.1m AHD.	1-2 years	NA
5.	Remove shell grit levee and replace with earthen bund	The shell grit levee is narrow and in poor condition.	1-2 years	4
6.	Strengthen dunes (using material from (5)), raise informal entry ways and formalise (3).	Should an event any higher than 1.80m AHD occur, water is likely to flow through the dunes	1-2 years	6
7.	Install traverse levee to eastern end of Coobowie (main settlement section)	Should an event any higher than 1.80m AHD occur, water is likely to flow through the dunes and flow back into the Coobowie settlement.	1-2 years	5
8.	Install earthen bund (with 0.3m) top to property boundaries between caravan park and playground area.	Should the 2.20m AHD current risk sea-flood occur, water would flow over the existing defences and inundate the township (contextual note – the highest likely flood event to date is 1.80 – 1.90m AHD).	3-5 years	2

9.	Raise bund in front of playground	Should the 2.20m AHD current risk sea-flood occur, water would flow over the existing defences and inundate the township (contextual note – the highest likely flood event to date is 1.80 – 1.90m AHD).	3-5 years.	3
10.	Raise caravan park levee to 2.4m AHD and install rock armour to base.	The caravan park bund is at adequate height to cater for the current risk of 2.20m AHD but erosion is occurring at the base.	3-5 years	1
11.	Subject to monitoring from the present until the 2020s- 2030s, should sea level rise accelerate to indicate more rapid rise, devise and implement planning policy that ensures new dwellings are capable of being able to be removed once predetermined triggers have been realised.		30-40 years	NA
12.	Adapt existing dwellings (if required) – residents to raise floor levels; utilise internal waterproofing; or temporary protection mechanisms.	Residents responsibility	30-40 years	NA

7. Coobowie - Community consultation

7.1 Consultation methodology

All land owners were mailed an invitation to attend a community workshop on 20th August 2015 at 7.00pm. The invitation included the summary table from the State of Play Report (p. 69-70) and notification that the State of Play report had been uploaded to the Council website.

Mark Western gave a formal presentation in which a review was undertaken of the State of Play report and the adaptation options presented.

At the conclusion of the formal presentation, maps showing the location of the proposed adaptation options and a feedback sheet were provided for participants to record responses (See Appendix A). Participants were also asked to give responses as to how to be 'flood ready':

- Do you think it necessary to be flood ready?
- What type of warning systems could be implemented?
- What emergency procedures could be implemented?

The facilitators of the meeting were Mark Western (Integrated Coastal Management), Natasha Hall (Central Region Climate Change Officer), Stephen Goldsworthy (Yorke Peninsula Council).

Thirty two people attended the meeting.

7.2 Community feedback

Feedback on the proposal for the community to be 'flood ready':

Q1. Do you think it necessary to be flood ready?

Facilitators reported that there was general support for this notion.

Q2. What type of warning systems could be implemented?

No formal suggestions were given by participants.

Q3. What emergency procedures could be implemented?

No formal suggestions were given by participants.

Feedback on the proposed adaptation options:

Generally the feedback was positive about the adaptation proposals. Specific feedback is recorded below:

1. Raise caravan park bund to 2.40m and install rock armoured base.

Ensure that the rock armour can't be 'pulled out on to the beach by kids'.

2. Install sea walls with rock armour base or earthen levee

General feedback was that an earthen levee was preferable. Specific written comments included:

- *'prefer earthen levee at 2.40m AHD'*
- *'prefer earthen levee'*
- *'earth levee that can be vegetated'*

3. Raise existing levee to 2.40m AHD (in vicinity of playground).

General feedback was positive. Specific written comment included:

- *'agree'*

4. Remove shell grit levee and replace with earthen levee at 2.40m AHD.

General feedback was positive. Specific written comment included:

- *'agree'*

5. Raise (or strengthen) dunes at 2.40m AHD or install traverse levee to east of Coobowie (main settlement section).

'Raise dunes at 2.40m AHD' [19]

6. Raise pedestrian access ways and limit to 3 (increase eight of dunes or install traverse levee)[20].

General feedback was positive. Specific written comment included:

- *'agree'*

[19] Subsequent to the community consultation, it is deemed that to raise the dunes to height 2.40m AHD from places that are 1.70m AHD may not be possible.

[20] Subsequent to the community consultation it has been deemed that installing the traverse levee is the only way to adequately protect from water running through the dunes and back into Coobowie.

Appendix A: Community consultation feedback sheets

(Samples: Originals produced in A3)

Coobowie – community consultation feedback

	Adaptation option	Feedback
1	Raise the caravan park levee to 2.4m AHD and install rock armour base	
2	Install walls to 2.40m AHD with rock armour base (or install earthen levee at 2.40m AHD)	
3	Raise existing levee to 2.40m AHD	
4	Remove shell-grit levee and replace with earthen levee at 2.40m AHD	
5	Raise (or strengthen) dunes at 2.40m AHD or install traverse levee to eastern boundary of last dwelling on sea front). This strategy is to prevent water running back into Coobowie.	
6	Raise pedestrian access ways and limit to 3. (Increase height of dunes or install traverse levee). This strategy is to prevent water running back into Coobowie.	

How can our community be flood ready?

Do you think it is necessary to be flood ready?

What type of warning systems could be implemented?

What emergency procedures could be implemented?

WRITE YOUR COMMENTS HERE: