University of South Australia

School of Natural and Built Environments

Institute for Urban Renewal

Coastal Settlements Adaptation Study-Parham

Framework Report

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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. ARIs, also known as return periods, are an estimate of the average interval of time between events of a certain magnitude. 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 ARI storm surge would be higher than a 1 in 50 year or 1 in 10 year ARI storm surge height. It is important to remember that this is just a statistical calculation and represents the long term theoretical average; there is nothing preventing a 1 in 100 year ARI 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 a aircraft that bounced millions of infra-red light beams to the ground and then created a digital topographical map. This digital map is combined with aerial photography and an operator can use a computer to check the height of land features.

EROSION

Erosion occurs when 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 rise in the water level along the coast due to the action of the wind alone or its combination with the reduction of atmospheric pressure accompanying it. The effects of a storm surge are more severe when it occurs in conjunction with high tide.

Introduction

1.1 Background

In May 2013 the District Council of Mallala (DC Mallala) commissioned the University of South Australia, School of Natural & Built Environments to undertake the Coastal Settlements Adaptation Study (CSAS). The aim of the study is to identify and evaluate potential sea level rise adaptation options for the coastal settlements of Parham, Webb Beach, Thompson Beach and Middle Beach.

1.2 Investigative framework

This study uses an adaptation of the Coastal Adaptation Pathways Decision Map developed by the Local Government Association of SA and University of South Australia for the Department of Climate Change and Energy Efficiency (Balston et al, 2012) to identify and analyse the threats posed by sea level rise. Each settlement is reviewed within the following framework:

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

1.3 The stages of the study

The study is conducted in three main stages:

Stage 1: State of Play Report:

The *State of Play Report* contains the findings from steps 1-6 from the investigative framework and was endorsed by the District Council of Mallala at its Ordinary Meeting on 25 November 2013.

Stage 2: Community Consultation:

Subsequent to completion of the draft *State of Play Report* the community was invited to contribute to the report at a public meeting at the Dublin Hotel on 10th September 2013 or in writing to DC Mallala. The findings from community consultation were integrated into the *State of Play Report* and the report was endorsed by the District Council of Mallala at its Ordinary Meeting on 28 October 2013

Stage 3: Propose adaptation options:

Taking into account the findings of the first two stages, this report represents Step 7 of the Investigative Framework - 'propose adaptation options'. These adaptation options are proposed within the following five categories of adaptation responses:

- **Protect:** use means such as construction of sea walls and levees, beach sand replenishment or installation of drainage swales to protect existing development;
- **Accommodate**[1]: use means such as raising buildings, protecting buildings from flooding, or employ warning and evacuation strategies;
- **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 options analysed but there are valid reasons to wait until to a later date to act;
- **Do nothing:** ignore the risks and do nothing.

1.4 Reporting and consultation

While the scope of the Coastal Settlements Adaptation Study (CSAS) covers the four settlements of Parham, Webb Beach, Thompson Beach and Middle Beach, adaptation responses options available to each settlement are reported separately. This report contains the adaptation options for:

Parham.

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

- DC Mallala Infrastructure Services Department, on 7th November, 2013.
- Coast Protection Branch, DEWNR, on 12th November, 2013.
- Geoff Fisher, Australian Water Environments (AWE), on 19th November, 2013. Geoff Fisher (AWE) also reviewed the adaptation proposals and offered technical advice.

1.5 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.

1.5.1 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 flood is a factor that enables the settlement to prepare for the flood more effectively. The general characteristics of a sea-flood in the Mallala region are shown in **Table 1**.

[1] Protection options in this study relate to the community as a whole and are generally measures that are taken to stop the flow of water into the community at its borders as a first line of defence. Measures that a resident might take to protect the water from entering their own dwelling are classed as accommodation options. The exception to this rule is when dwellings are situated on the shoreline itself.

Table 1: Sea flood characteristics for DC Mallala coastal region.

Flood characteristic	Mallala region
Velocity of water	Low, due to tidal action and ocean terrain
Direction of flow	From the west
Duration of flood	Short 1-2 hours
Warning	Predictable as flood normally relates to tide.

To contextualise the flood risk in the Mallala region, **Table 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 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 Mallala coastal region have been in conjunction with the highest astronomic tide (often referred to as a king tide), which in the majority of cases, would 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 1 in 100 ARI scenarios provided in the *State of Play Report* (**Table 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 3: Sea flood scenarios for DC Mallala coastal region.

Flood	2013	2050	2100
Storm surge (at king tide)	2.6m	2.6m	2.6m
Wave set up	0.1m	0.1m	0.1m
Wave run up	0.0m	0.0m	0.0m
Sea level rise	0.1m	0.3m	1.0m
Totals	2.8m AHD	3.0m AHD	3.7m AHD

1.5.2 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 adhere to Coast Protection Board policy and directions. 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 are also required to 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.

1.5.3 Adaptation responses that take into account time

The *State of Play Report* has analysed the possible impact of the three one in one hundred ARI flood scenarios (2013, 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 and 2100 threats)?
- 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**).

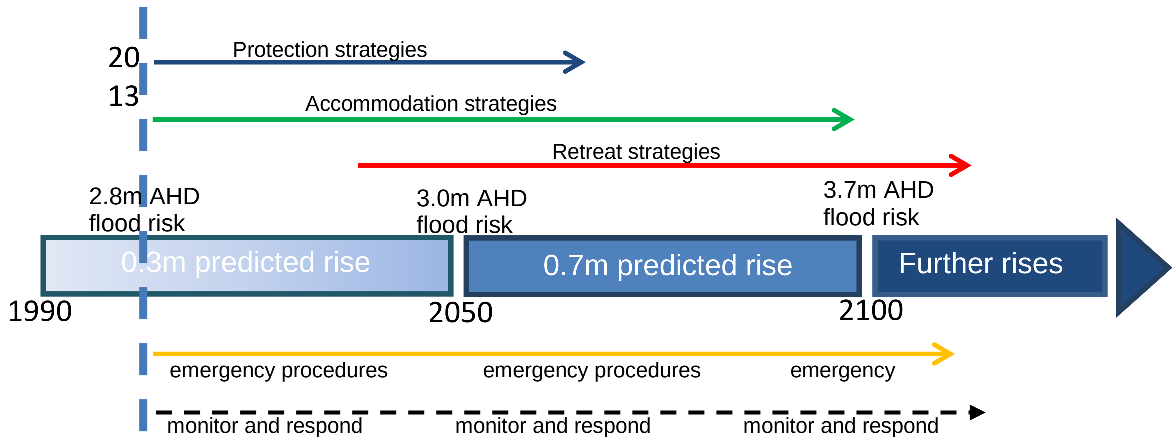


Figure 1: Adaptation responses are time related and sometimes contingent on each other but also contingent on the rate of sea level rise which is to be monitored over time (M. Western, 2013).

1.5.4 Adaptation responses that do not take into consideration:

- The effect of rising sea levels on ground water within Parham.
- The potential for a rain flood event either combined or not combined with a king tide.
- The possibility of a sea-flood event caused by unforeseen event such as a tsunami.

2. Parham Protection Options

2.1 Protection options to cater for sea-flood risk at 2100 (3.7m AHD)

Should the 1 in 100 ARI sea-flood event of 3.7m AHD shown in **Figure 2** occur then:

- The Esplanade road would be inundated to depth of 1.6-1.8 m.
- Port Parham Road would be inundated at depth of 0.4m.
- All ground within the settlement would be inundated, from 2.0m depth at the end of Prime and 0.8m at the Port Parham Sports Club.

Additionally, should sea levels rise by 1.0m as predicted, the dunes north and south of Parham, and the dune upon which Webb Beach Road is situated, would likely be eroded away for two reasons. First, the increase height of water would create new inlets that become wider over time, until the frontal dune system eroded completely away. This is occurring already south of Parham and south of Webb Beach (See State of Play Maps, p.8). The second is that the increase height of water may increase the wave 'set up' and 'run up' (see **Table 3**) thereby increasing the amount of erosion to the dunes (Geoff Fisher, AWE, 26.11.13).

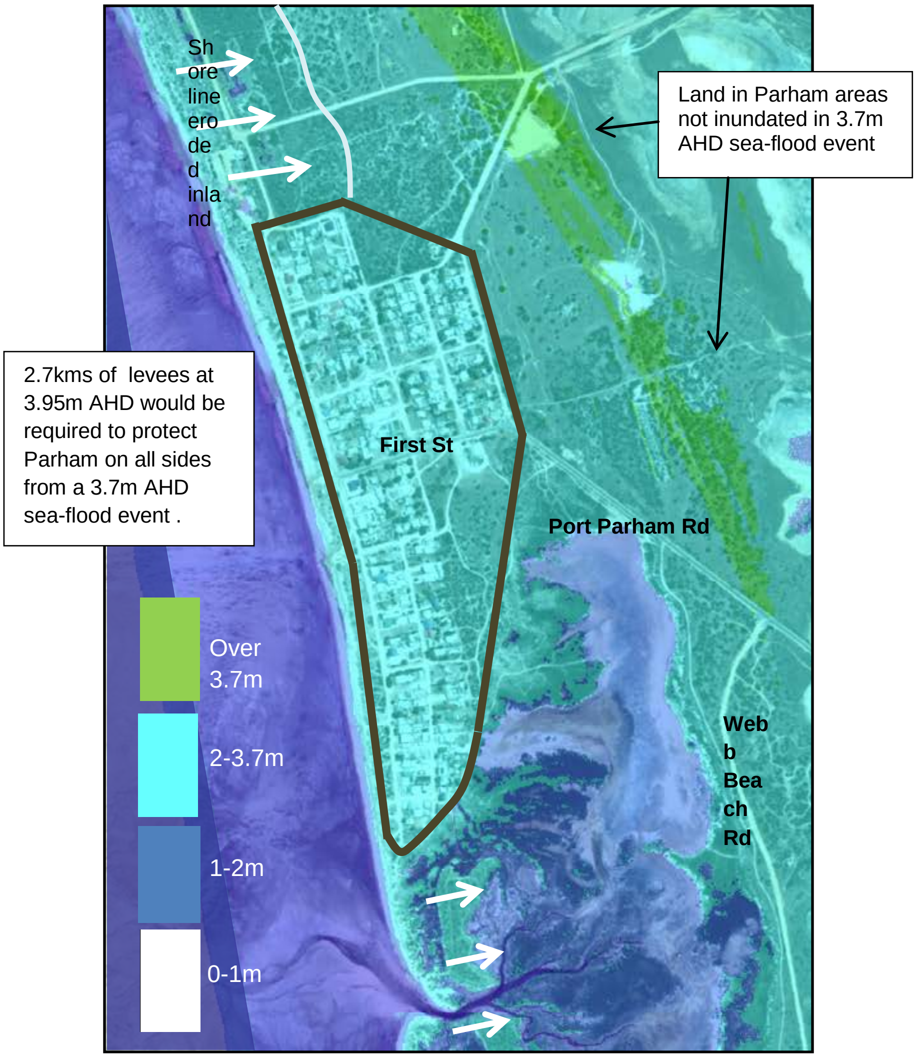


Figure 2: Parham map indicating sea-flood risk at 3.7m AHD and protection requirements at 3.95m

To provide a contemporary context, if the existing dwellings in Parham were subject to 3.7m AHD inundation,135 dwellings out of 141 total dwellings would have water over their floor levels (**Figure 3**).

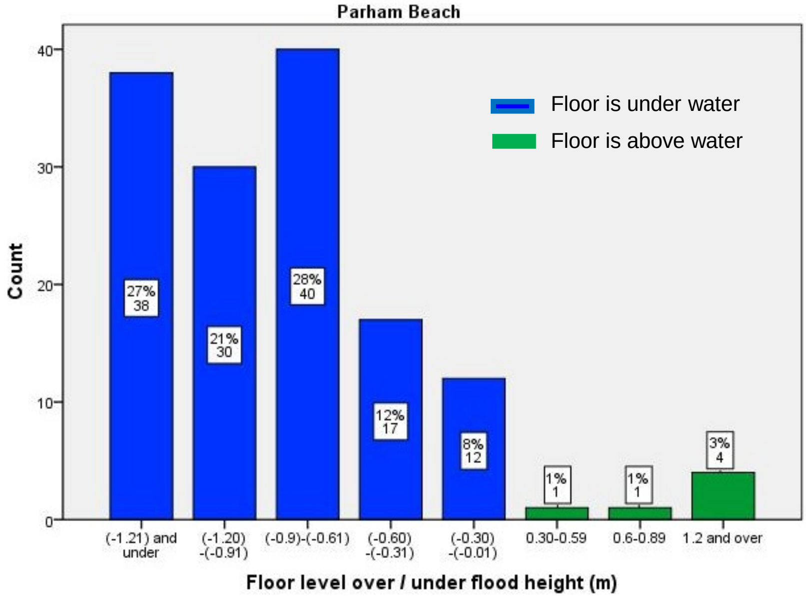


Figure 3: Flood height vs floor level: 1 in 100 ARI event 3.7m AHD (2100)

While to implement protection levees as illustrated in **Figure 2** is possible in pure engineering terms, the erosion factor makes the proposal untenable as the dunes north and south of the settlement are likely to be eroded away leaving the settlement as a promenade, and facing increased erosion of its defences as a result. Finally, if the sea level does increase as predicted, then there is nothing to suggest that the sea won't keep rising past 2100, thereby rendering the defences at 3.7m AHD ineffective.

<u>Conclusion:</u>

To protect Parham with levees to cater for the 1 in 100 ARI event of 3.7m AHD event is not viable and options that utilise protection measures at lower heights combined with accommodation options should be considered in long term adaptation options for Parham.

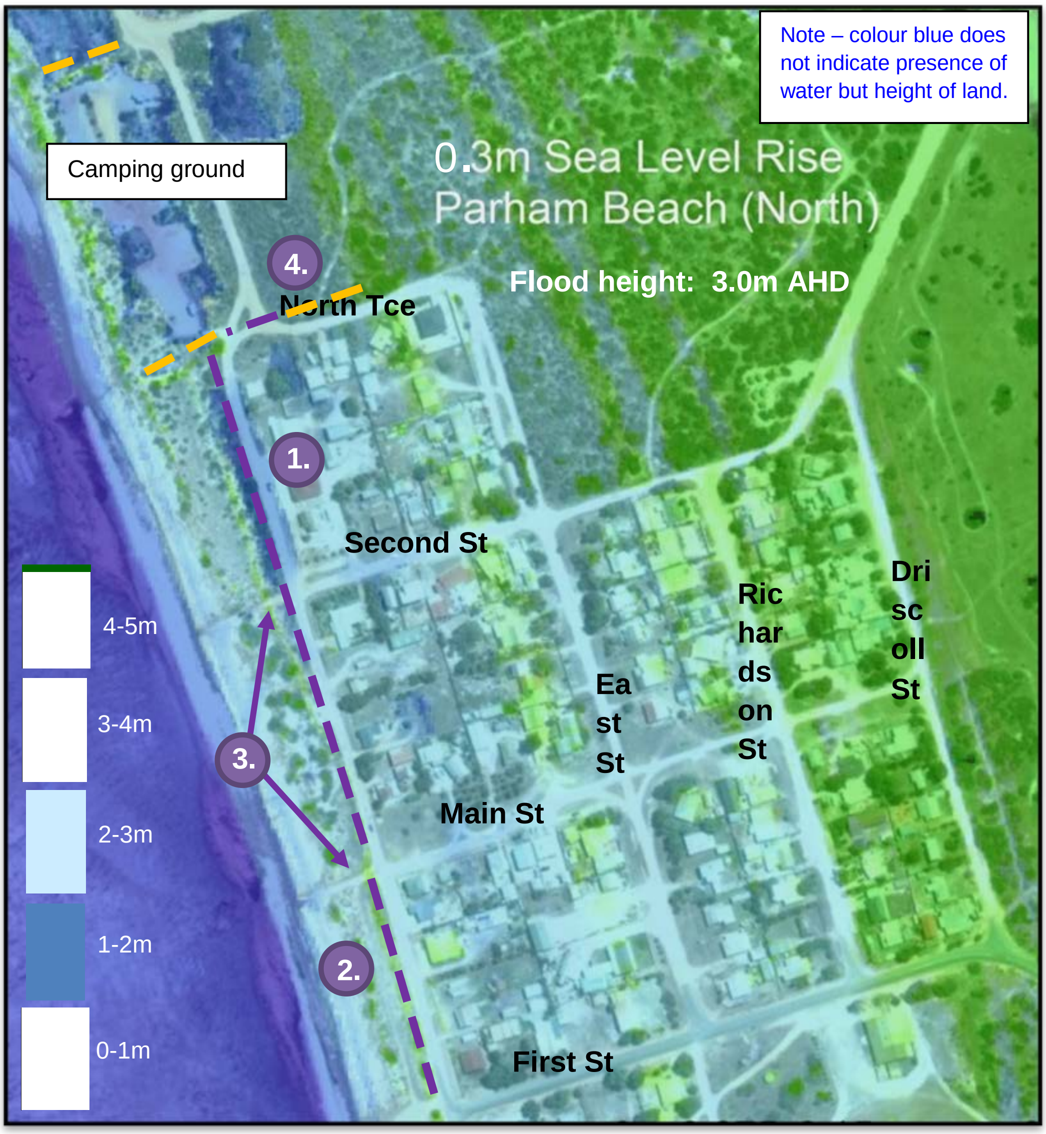
2.2 Protection options to cater sea-flood risk at 2050 (3.0m AHD)

In contrast to the 2100 flood scenario, protection options for Parham should be considered for the 2050 1 in 100 ARI flood risk (3.0m AHD but Coast Protection Board request 0.25m above this level) for the following reasons:

- Protection measures are feasible and likely to be effective (see **Figure 4**);
- Protection of development to cater for the 2050 flood scenario (3.0m AHD) is Coast Protection Board policy (Coast Protection Board, 2012);
- 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 predicted sea level rises past 2050.

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.

2.2.1. Protection options for Parham (North)



Existing protection measures

Figure 4: Parham (north) - map indicating sea-flood risk at 3.0m AHD (2050 scenario)

1. Install levee to height 3.25m AHD to the east side of the existing dune (**Figure 4**):

Install levee in accordance with methodology proposed for Thompson Beach (refer DC Mallala Infrastructure Services Department,). Briefly this entails, working from roadside edge, cutting into existing dune, installing a clay levee in accordance with **Figure 5**, and backfilling with material removed in the initial cut. Where no dunes are present to the sea-side of the proposed levee, use levee profile shown in **Figure 5a**.

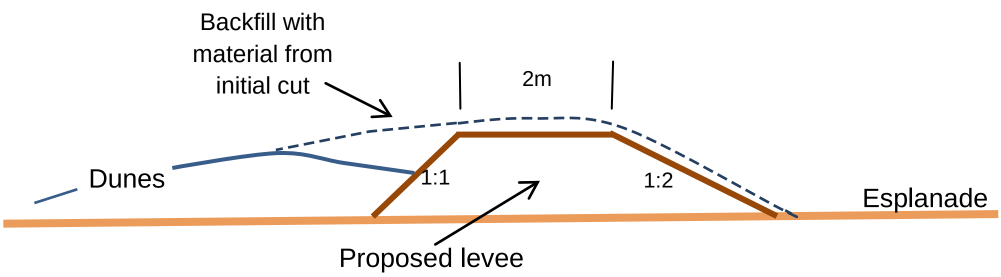


Figure 5: Parham- typical cross section of proposed levee where sand dunes exist to the sea-side of the proposed levee.

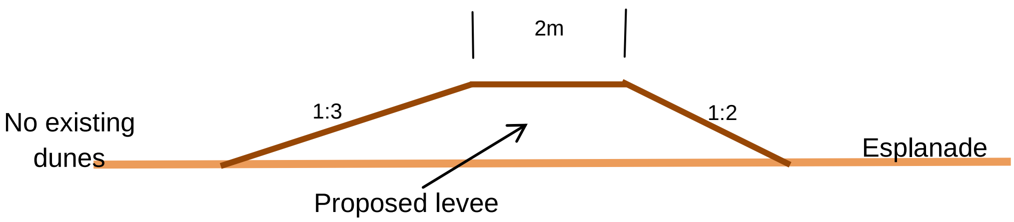


Figure 5a: Parham- typical cross section of proposed levee where no sand dunes exist to the sea-side of the proposed levee.

1. Preliminary cost calculation: Installation of foreshore levee (Figure 4)								
Location	**Existing road elevation**	**Ground elevation adjacent**	**Levee height increase**	**Levee length**	**Area of profile face**	**Volume (approx) m³**	***Cost per m³**	**Cost (approx)**
North Tce-Second St	1.8m to 2.0m AHD	1.90m AHD	1.4m	154m	5.74m²	880m³	$26	$22,900
Second St to Main St	2.1m to 2.3m AHD	2.1m – 2.3m AHD	1.0m	163m	3.50m²	570m³	$26	$14,800
Main St to First St	2.4m to 2.5m AHD	N.A.	0.8m	129m	2.56m²	330m³	$26	$ 8,600
						Total		**$46,300**

*Estimate: DC Mallala Infrastructure Services

2. Subsequent to installation of the levee, restrict access points to the beach, fence off and vegetate* (as has occurred on the southern end of the Esplanade).

2. Preliminary cost calculation: Install dune protection fencing (Figure 4) (subsequent to installation of (1))					
Location	**Length (north/south)**	**Length (east/west)**	**Total length (m)**	****Unit cost (per metre)**	**Estimated cost**
North Tce to Second Street	155m	25m	180m	$7	$1,260
Second Street to Main Street	165m	50m	220m	$7	$1,540
Main Street to First St	130m	50m	180m	$7	$1,260
		Total	580m	$7	**$4,100**

*Vegetation costs not included

**Estimate: DC Mallala Infrastructure Services

3. Check height of crossovers at Second Street, Main Street and First Street and raise to 3.25m AHD where required (**Figure 6**). Review whether access points at Second Street and Main Street are required with suggested option to change one or both of these to walking access only.

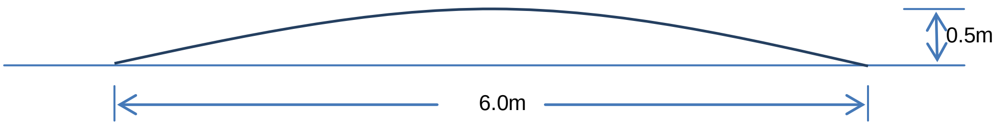


Figure 6: Example of section of crossover at corner of Second Street and Esplanade.

3. Preliminary cost calculation: raise vehicular beach crossovers (Figure 4)							
Location/ section	**Existing height AHD**	**Width of crossover**	**Height of increase**	**Length of curve**	**Volume of fill m^3**	***Unit cost**	**Estimated cost**
Crossover at cnr Second St	2.80m AHD	4m	0.5m	6m	$8m^3$	$30.00	$250
Crossover at cnr Main St	3.00m AHD	4m	0.3m	6m	$5m^3$	$30.00	$200
Crossover at cnr. First St	2.70m AHD	6m	0.6m	6m	$15m^3$	$30.00	$450
					Total		**$900**

*Estimate: Mark Western

4. Raise road height of North Terrace to 3.0m AHD (a secondary defence) on western end between the end of the clay levee parallel to North Terrace, and the dune that runs east-west from the end of North Terrace. Check height and stability of the clay levee and the man-made dune levee (**Figure 4**).

4. Preliminary cost calculation: raise section of road to 3.0m AHD						
Location	**Raised**	**Length**	**Width**	**Volume/ area**	***Unit cost**	**Estimated cost**
North Tce	0.6m	40m	6m	$145m^3$	$20	$2900
		40m	6m	$240m^2$	$4	$ 960
					Total	**$3900**

*Estimate: DC Mallala Infrastructure Services

2.2.2. Protection options for Parham (south)

Figure 7: Map Parham (south) sea flood scenario 3.0m AHD

6. Install levee to height 3.25m AHD to the east side of the existing dune in accordance with methodology proposed for Thompson Beach (refer DC Mallala Infrastructure Services Department,). Briefly this entails, working from roadside edge, cutting into existing dune, installing a clay levee in accordance with **Figure 5**, and backfilling with material removed in the initial cut.

6. Preliminary cost calculation: install levee to west side of the Esplanade (Figure 7).							
Location/ section	**Existing road elevation**	**Length**	**Height of levee**	**Area of levee profile**	**Volume of fill m^3**	***Unit cost**	**Estimated cost**
Cnr First St to South Tce	2.20m to 2.40m AHD	143m	1.0m	3.50m^2	500m^3	$26.00	$13,000

*Estimate: DC Mallala Infrastructure Services

7. Review height of dune between South Terrace and Good Street. If dune and natural vegetation is deemed to not provide adequate protection for 3.0m AHD event, remove the fence, and install levee in accordance with **Figure 5**.

7. Preliminary cost calculation: install levee to west side of the Esplanade (Figure 7).							
Location/ section	**Ground elevation (adjacent existing levee)**	**Length**	**Height of levee**	**Area of levee profile**	**Volume of fill m^3**	***Unit cost**	**Estimated cost**
Cnr South Tce. To Cnr Good St.	2.20m to 2.40m AHD	210m	1.0m	$3.50m^2$	$740m^3$	$26.00	$19,200

*Estimate: DC Mallala Infrastructure Services

8. The digital elevation model indicates that the section of dune between Good Street and Wilson Street is at generally at height 3.0m AHD or above. Review the height of this section and if the dune and natural vegetation is deemed to not provide adequate protection for 3.0m AHD event either:

- remove the fence, and install levee in accordance with **Figure 5**.

or

- where low points are less than 10m in length north-south, use geotextile sand bags to fill the void, fill over with sand and revegetate.

Note: (8) has not been costed.

9. Subsequent to installation of the levee, restrict access points to the beach, fence off and vegetate (as has occurred on the southern end of the Esplanade).

9. Preliminary cost calculation: Install dune protection fencing (Figure 7) (subsequent to installation of (6))					
Location	**Length (north/south)**	**Length (east/west)**	**Total length (m)**	***Unit cost (per metre)**	**Estimated cost**
First St to South Tce.	140m	50m	190m	$7	$ 1300

*Estimate: DC Mallala Infrastructure Services

10. Check height of beach crossovers at South Tce and the beach crossover south of Good Street and raise to 3.25m AHD where necessary (refer **Figure 6** for cross section details).

10. Preliminary cost calculation: raise vehicular beach crossovers (Figure 7)							
Location/ section	**Existing height AHD**	**Width of crossover**	**Height of increase**	**Length of curve**	**Volume of fill m^3**	***Unit cost**	**Estimated cost**
Crossover at cnr South Tce	2.80m AHD	5m	0.5m	6m	$10m^3$	$30.00	$300
Crossover 90m South of cnr Good St	Unknown	unknown			$10m^3$	$30.00	$300
					Total		**$600**

*Estimate: Mark Western

2.2.3 Protection options for north and south of Parham.

Maintaining a healthy dune system to the north and south of Parham is vital for the long term viability of the settlement. Small inlets that eventuate as a result of a storm surge are likely to become large inlets over time, and increase the erosion rate of the dune system.

Check the dune system north and south of the settlement to identify any new incursions through the dunes. Close any recent inlets in the dune system by:

- Obtaining permission from Coast Protection Board, which permission can be given verbally (Comment, Murray Townsend, CPB, 14th November, 2013);
- Use local materials and fill with sand and brush;
- Revegetate;
- Additional option: Use geotextile sand bags to provide initial stability of base (Comment: Geoff Fisher, AWE,20th November, 2013) .

Figure 8: Tidal incursion through sand dunes 50m south of Parham (M Western, 2013)

11. Preliminary cost calculation: close incursion in dunes				
Location	**m^3**	**Estimated number of days work**	**Unit cost**	***Estimated cost**
50m south of Parham		2	$1500	$3000

Estimate: Mark Western

2.2.4. Parham- other protection options

Council to establish a monitoring regime in which levees and dunes are monitored:
- After each inundation event greater than 2.50m AHD
- Annual sight inspections to assess possible weaknesses.
- Higher level engineering inspections once every 5 years.
- Obtain photographic imagery every 5-10 years and compare.

3. Parham Accommodation Options

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

As noted above (see p. 4), 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 methods are ways in which the community could prepare itself to be 'flood-ready'.

3.1.1 Implement general warnings of general flood risk.

DC Mallala to implement general warnings to residents about the general risk of flood. These warnings may include:

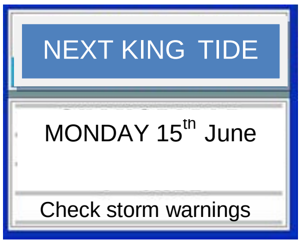
- Flood mapping and floor levels of dwellings made available to residents to allow them to more fully evaluate the flood risk to their property.

- 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.

Council and the Parham Resident's Association (or other relevant community organisation) to implement flood warning systems such as:

- Community run warning systems to inform residents of upcoming king tides, either by installing a 'king tide warning' sign, 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. It is also possible to receive a SMS warning from a tide gauge in the Port River once it exceeds a predetermined high level[2] which may give half hour warning of a larger than expected storm surge.

[2] This gauge is owned by Port Adelaide Enfield Council and there may be a charge associated with this service.

3.1.3 Implement flood emergency procedures.

Council and Parham Resident's Association (or other appropriate community body) to establish flood emergency procedures such as:

- Establish an emergency assembly point at the Parham Sports Club and mark the spot with a sign.

- 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.

  In Parham North residents can generally move directly away from the flood towards the east and use either Driscoll Terrace or Richardson Street to arrive at the Parham Sports Club (emergency assembly point).

Figure 8: Emergency egress from Parham (north)

  In Parham (south) roads are generally lower but the natural ridgeline to the east provides a means by which to move to the Parham Sports Club on foot. Good Street provides an access point in the middle of the ridgeline and the newly constructed levee provides a means for residents to walk away from the flood. However at present the ridgeline is criss-crossed with various tracks and covered with vegetation which could be difficult to navigate if an emergency occurred at night in stormy conditions (**Figure 9**).

- Establish emergency evacuation routes that emergency vehicles can utilise to enter the settlement.

  In Parham (north) when the Esplanade area is flooded, emergency vehicles can utilise the existing streets to bring emergency personnel to within 150m of most dwellings (**Figure 8**).

In Parham (south), when the Esplanade area is flooded, emergency vehicles could utilise the ridgeline to the east. Good Street provides an access point in the middle of the ridgeline and the newly constructed levee is wide enough for a vehicle which would bring emergency service vehicles within 150m of most dwellings. However at present the ridgeline is criss-crossed with various tracks and covered with vegetation which could be difficult to navigate if an emergency occurred at night in stormy conditions (**Figure 9**).

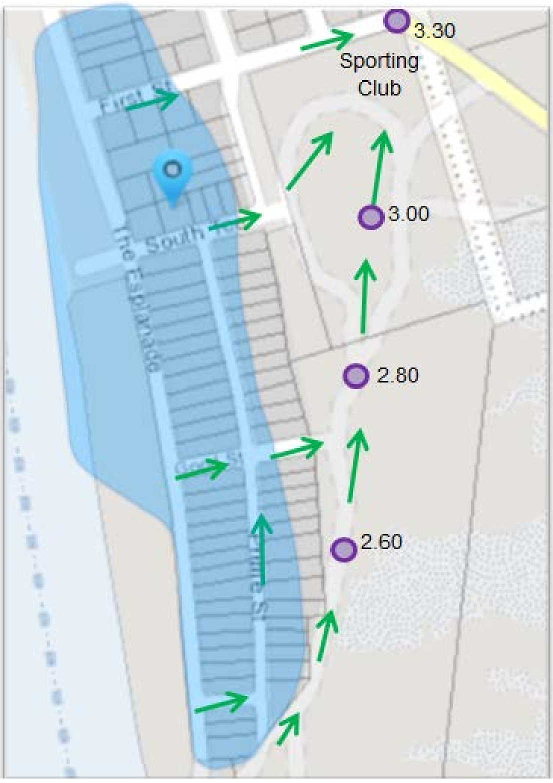


Figure 9: Emergency track from Parham Sports Club to east of Parham (south).

4. Council to establish an emergency access way on the ridgeline east of Parham (south):

- One north-south track to be cut that takes as a direct line as possible from the northern end of the newly installed levee to the Parham Sports Club;
- One east-west track to be provided to allow access from Good Street to intersect as a T-junction to the track running north-south;
- That the other tracks be closed and revegetated;
- That the emergency track be designated as ‘emergency access only’.

Preliminary cost calculation: install emergency access track to east of Parham (South)					
Location	**Length**	**Width**	**Area**	**Unit cost**	***Estimated cost**
From end of new Parham levee to Parham Sports Club	500m	4m	2000m^2	$4 /m^2	$8000
From end of Good Street to above track.	40m	4m	160m^2	$4 /m^2	$ 700
Signage at various locations (4)				$200	$ 800

*Estimate: Mark Western

Figure 9.a Emergency access track to access the Parham Sports Club

Important note: these emergency procedures are only designed to cater for sea-flood risk to 3.0m AHD or 2050 levels.

3.1.4 Prepare written Flood Emergency Action Plans.

Parham Residents Association (or other appropriate community body) 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.Parham Residents Association (or other appropriate community body) to encourage households to prepare emergency action plans and provide assistance if required.

3.2 Parham accommodation option- amend Development Plan policy.

Planning policy should ensure that:

- All new buildings (apart from minor structures such as sheds) are capable of being raised to 3.95m AHD (and not that they are capable of being raised to 1.25m above the standard sea-flood level).

- Site levels to be no longer required to be ‘protected’ from standard sea-flood risk level and 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 for practical measures to be available to ‘protect’ new development against additional sea level rise of 0.7 metres is removed and replaced with a clause that has the sense of ‘accommodating’ additional sea level rise.

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

3.3 Parham accommodation option - adapt existing buildings

3.3.1. Raise the floor level of dwellings.

The predominant housing construction in Parham is either light weight or transportable[3] and constructed on stumps or poles (**Figure 10**). Many of these dwellings would be capable of being raised if they are subject to inundation.

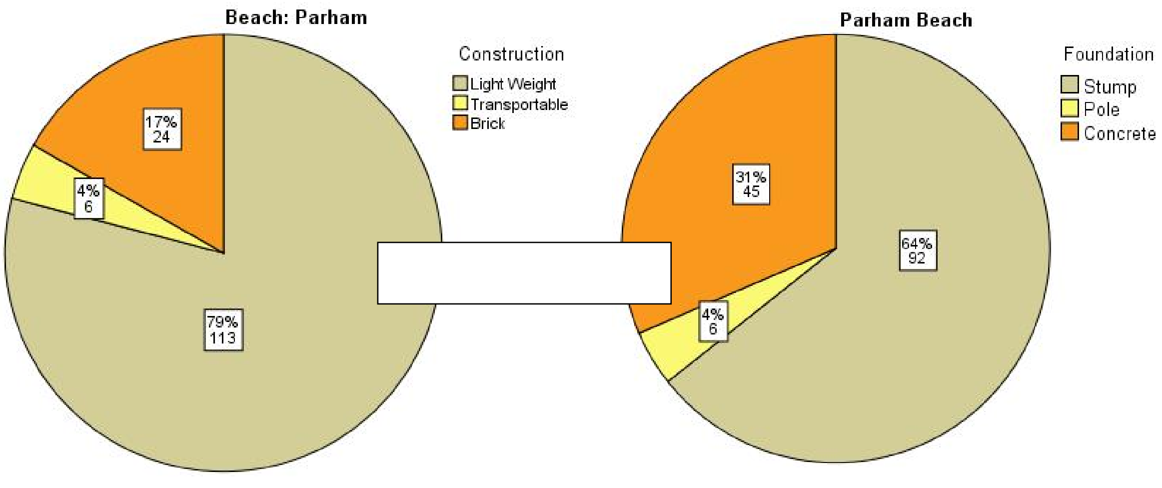


Figure 10: Construction types in Parham

[3] It is likely that in collection of data that ‘lightweight’ has been over applied rather than the ‘transportable’ category but this is of little consequence to the accommodation strategy proposed here.

The number of existing dwellings subject to inundation at the current predicted 1 in 100 ARI event of 2.8m AHD is 68 (**Figure 11**) with a likely damage bill for to private property in current dollars at $887,500 (*State of Play Report*, p. 44). If a decision is made to do nothing about the protection options outlined above (p. 7-11), or a decision is made to defer for any length of time, then residents may choose to raise their dwellings.

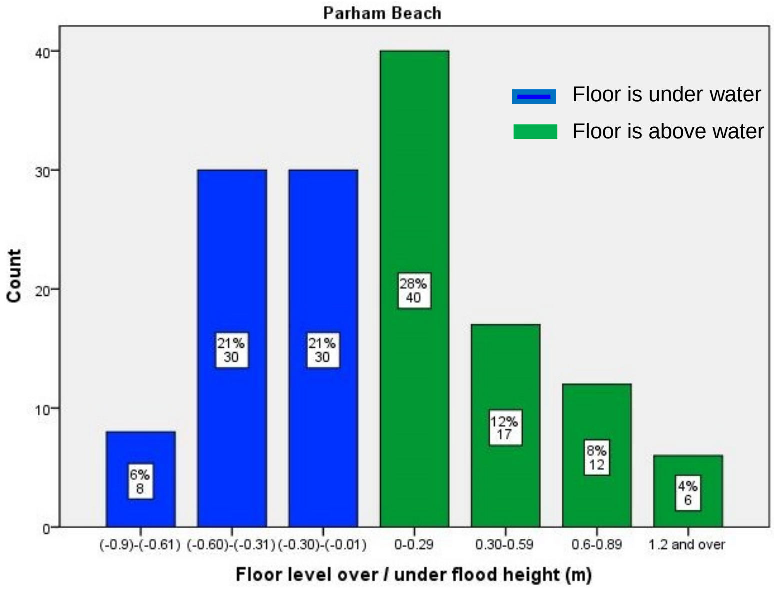


Figure 11: Parham - Flood height versus floor level in 1 in 100 ARI event 2.8m AHD (2013)

It is anticipated over the next 30-40 years that many of the existing dwellings in Parham will be replaced. If the proposed protection options outlined above (p. 7-11) are implemented then it is conceivable that a number will still remain with floor levels lower than the sea-flood risk subsequent to 2050. Residents could raise their dwellings to deal with the sea-flood threat subsequent to 2050 when the proposed protection options may not always protect the settlement from the sea-flood risk.

3.3.2 Water proof houses.

Other flood accommodation options that residents could employ are:

- To internally water proof buildings and raise electrical outlets above the predicted flood levels.
- To provide temporary flood barriers to the outside of dwellings when tides are predicted to be high. Examples from Blobel Flood Protections Systems are shown in **Figure 12** and **Figure 13** (Blobel Environmental Engineering, 2013)

Figure 12: Flood protection wall to divert water away from the house

Figure 13: Flood protection barrier to stop water entering the house

4. Parham 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 last 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, in decades of 2020s, 2030s, and 2040s 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 suspected to be inaccurate, then at the very least as a result of implementing the adaptation strategies above, Parham 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 Parham 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 frequently cut off and damaged, emergency vehicles frequently would not be able to enter the settlement, evacuation procedures may become part of life in Parham, and the safety of people may be at risk.

If such a situation eventuated, and to provide some context from a planning perspective, the District Council of Mallala Development Plan (consolidated 13/01/2013) states:

- 'Development should not occur where essential services cannot be economically provided and maintained having regard to flood risk and sea level rise, or where emergency vehicle access would be prevented by a 1-in-100 year average return interval flood event, adjusted for 100 years of sea level rise'. Control 26 (p.33)

Therefore, if monitoring of sea level rise in the 2020s, 2030s and 2040s indicates that the rate of change is accelerating, then planning policy should 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, and then 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[4]
- In time so that dwellings constructed now will be reaching the end of their life span when sea levels reach levels that may not be properly accommodated.

In conclusion, such a policy would allow residents the liberty to continue to develop their properties, but with the knowledge that the development may have limited life span and plan accordingly.

[4] 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.

5. Parham Risk Analysis

Using the National Emergency Risk Assessment Guidelines (NERAG) (Australian Government, 2010) four risk statements have been generated for the Parham settlement. The risk assessment is completed taking into account existing protection and emergency procedures and for a sea-flood height that exceeds 2.5m AHD but less than 2.8m AHD, the latter being the current 1 in 100 ARI sea-flood event (See **Appendix 1** for full analysis).

5.1 Risks to people

Risk statement one

There is the potential that a storm surge exceeding 2.5m AHD but less than 2.8m AHD resulting from a south easterly to north-westerly wind combined with a king tide will cause floods to Parham, which in turn will cause impact on the residents.

The analysis in **Appendix 1** resulted in a risk category assigned as ALARP 4 (see **Figure 14).** The risk to human life is 'tolerable', trending toward being 'broadly acceptable' mainly because the potential flood events are generally predictable, and the nature of the flood is of low velocity and of short lived duration. These risks should be managed with the implementation of warning systems and emergency procedures. Should protection be installed to the foreshore of Parham the rating would be ALARP 5, risks are negligible or small.

5.2 Risks to infrastructure

Risk statement 2

There is the potential that a storm surge exceeding 2.5m AHD but less than 2.8m AHD resulting from a south-easterly to north-westerly wind and combined with a king tide will cause floods to Parham, which in turn will cause damage to private infrastructure.

The analysis in **Appendix 1** resulted in a risk category assigned as ALARP 3 which is in the 'tolerable region' but should be driven further towards the 'broadly acceptable region'. However, there is no way to reduce the risk without implementing protection either to the foreshore or by undertaking accommodation measures on dwellings such as temporary protection measures, or raising floor levels.

Risk statement 3

There is the potential that a storm surge exceeding 2.5m AHD but less than 2.8m AHD resulting from a south-easterly to north-westerly wind combined with a king tide will cause floods to Parham, which in turn will cause damage to public infrastructure.

The analysis in **Appendix 1** resulted in a risk category assigned as ALARP 4 which is in the 'tolerable region' trending towards the 'broadly acceptable region'. The main public infrastructure in Parham would be mainly confined to 'roads'. As the duration of the flood is short lived and the velocity normally low, damage to roads is likely to be low. However, there may be disruption to normal traffic flow for a number of days while water was drained away. There is no way to reduce the risk without implementing protection to the foreshore or by raising roads (the latter not regarded as cost effective).

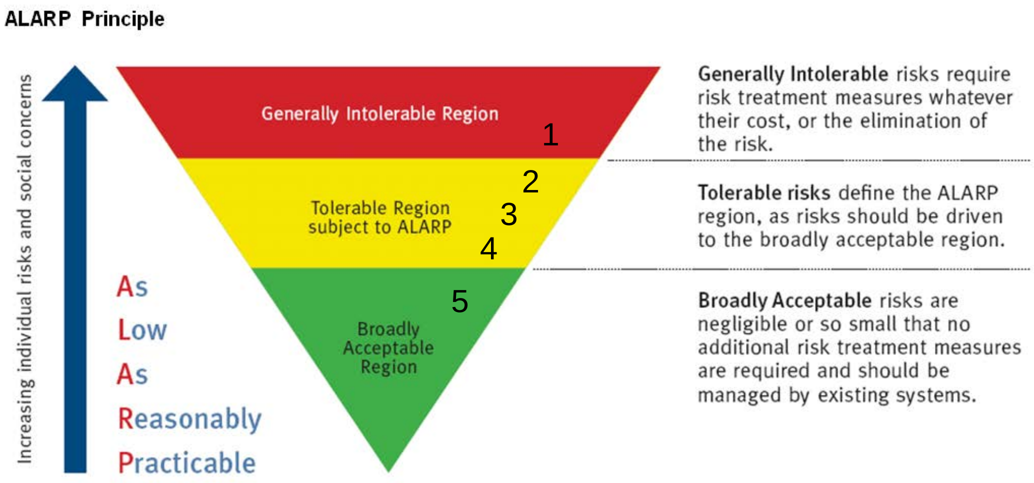


Figure 14: National Emergency Risk Assessment Guidelines – ALARP assessment.

6. Parham 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 4** is a summary of the adaptation options for Parham grouped according to the categories of *protect, accommodate, or retreat*.

Table 4: Summary of adaptation options for Parham

	Adaptation option		Approximate cost	Reference pp.
Protect	1.	Install approximately 590 m of levee at 3.25m AHD to west side of Esplanade from corner of North Terrace to corner of South Terrace	$59,300	10,12
		If required subsequent to checking dune height, install a further 210m of levee from corner South Terrace to corner Good St.	$19,200 (if required)	13
	2.	Restrict access to the dunes from corner North Terrace to corner South Terrace, fence off and vegetate (vegetation not costed)	$ 5,400 (excludes vegetation)	10,13
		If required, remove the fence from corner South Terrace to corner of Good Street, and replace when levee at (1) is installed (260m).	$ 1,800 (if required)	13
	3.	Check height of beach crossovers and raise to 3.25m AHD where required. Review whether both access points at Second and Main are required.	$ 1,500	11,13
	4.	Raise 40m of North Terrace to height 3.0m AHD (a secondary defence). Check height and stability of man-made dune to the west, and the levee east of the Esplanade.	$ 3,900	11
	5.	Check height of natural dune from Good St to the southern end of the Esplanade. If less than 3.0m, remove existing fence and install levee as per (1), or if only minor sections are low, use geotextile sand bags, cover over with sand and revegetate.	Not costed.	13
	6.	Implement monitoring regime to check dune system north and south of Parham. Fill incursion 50m south of Parham to prevent further erosion of the dune system.	$ 3,000	14
Accommodate	7.	Implement emergency procedures – establish warning systems; establish emergency assembly point; establish evacuation policies; establish community and households emergency action plans.	DC Mallala administration	16
		Establish emergency evacuation access tracks to the east of Parham (south) from end of levee to Parham Sports Club (approx. 500m x 4m wide). Close off and revegetate existing tracks. Install ‘emergency access only’ signs (4).	$9500	18

	8.	Devise and implement planning policy that ensures: new dwellings are capable of being raised to 3.95m AHD; and site levels are not required to be raised.	Not costed.	19
	9.	Adapt existing dwellings – residents to raise floor levels; utilise internal waterproofing; or temporary protection mechanisms.	Not costed.	19
Retreat	10.	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.	22

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.

7. Parham Adaptation - Timing and Prioritisation

7.1 Timing of adaptation options

Figure 15 illustrates how the different protection, accommodation, and retreat options interrelate over time. Sea level rise and erosion are monitored over time and response made accordingly. Emergency procedures are always in place and amended according to the conditions. When protection measures become inadequate, accommodation options help to mitigate the risk. Subject to ongoing monitoring, longer term decisions are made in relation to the viability of the settlement itself.

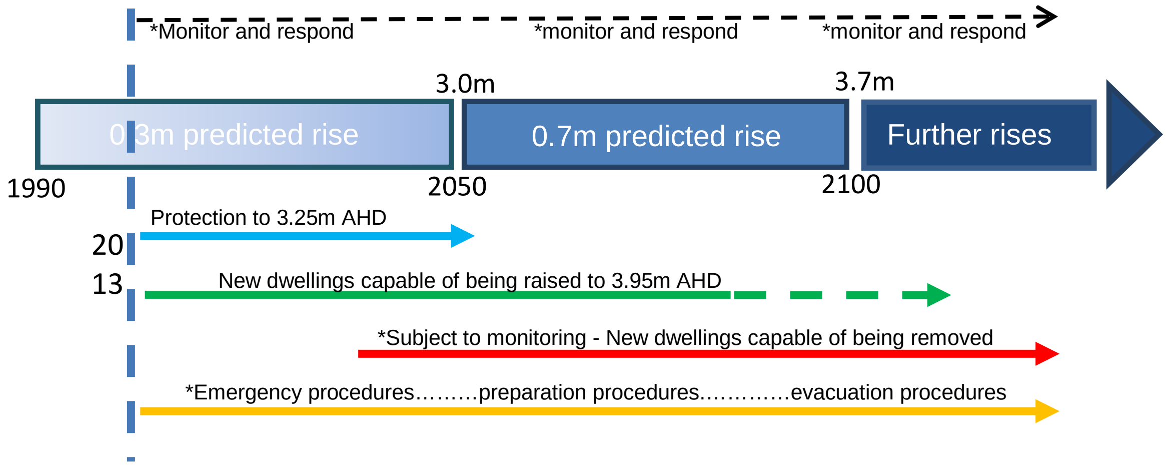


Figure 15: The relationship of decision making on options to time

7.2 Prioritisation of adaptation options

Prioritisation of adaptation options is based on the following criteria:

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

Based on the above criteria **Table 5** lists the recommended prioritisation for the adaptation options for Parham:

Table 5: Prioritisation and responsible entities for adaptations at Parham

	Adaptation response	Risk rating and other priority factors	Response time	Entity Responsible
1.	Implement warning systems and emergency procedures which should be maintained even if protection options are implemented.	Such procedures are a wise response to living adjacent to an unpredictable threat as well as a way to educate the community about existing and future threats.	Within 1 year	Council and Parham community
2.	Devise and implement planning policy that ensures that all new buildings are capable of being raised to 3.95m AHD and sites are not required to be raised (check adequacy of sewer system specifications).	Some dwellings constructed now may still be in use in 2080-90 when the 1 in 100 ARI flood risk is 3.7m AHD.	Within 1 year	Council
3.	Implement monitoring systems to assess the state of levees (within the settlement and dunes (both in and north and south of the settlement).	A duty of care for levees, and provides information about dune system so that breaches can be closed.	Within 1 year	Council
4.	Install approximately 590 m of levee at 3.25m AHD to west side of Esplanade from corner of North to South Tce.	Parham is vulnerable to significant flooding in 2.8m event. Risk assessment – ALARP 3.	Within 1 year	Council
5.	Raise the western end of North Terrace to height 3.0m AHD. Check height and stability of man-made dune to the west, and the levee east of the Esplanade.	Protects water from entering from the north, for which there are historical precedents. Risk assessment – ALARP 3	Within 1 year	Council
6.	Check the height of all beach ramps and create humps at 3.25 where there is shortfall.	Hard surfaces provide less resistance to water. Risk assessment – ALARP 3	Within 1 year	Council
7.	Restrict access to the dunes, vegetate, and fence off.	Vegetation strengthens the integrity of the dune system and assists in holding back water in a flood.	1-2 years	Council
8.	Check dunes north and south of Parham for recent incursions of tidal water. Fill gaps as required.	The health of the dune system north and south of Parham is vital to long term viability of the settlement	1-2 years	Council
9.	Check height of natural dune from Good Street to the southern end of the Esplanade. If less than 3.0m, remove existing fence and install levee as per (1), or if only minor sections are low, use geotextile sand bags and revegetate.	The dune may be sufficiently high enough for current flood-risk, but not likely to be for 3.0m flood-risk for 2050.	2-5 years	Council

10.	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 that all new dwellings are capable of being able to be removed once predetermined triggers have been realised.	Parham cannot be protected at 3.7m AHD levels. It sea level continues to rise then it will rise past 2100. The settlement may not be viable if it is continually inundated and repairs of roads and infrastructure become prohibitive.	15-25 years (depending on monitoring)	Council
11.	Dwellings are raised, or water proofed internally, or temporary protection strategies employed.	Community protection has become insufficient.	As required.	Residents

8. References

Balston, J.M., Western, M.D., Kellett, J., Wells, G., Li, S., Gray, A, 2012, *Climate change decision framework and software for coastal councils*, Local Government of Association of South Australia, Adelaide, SA.

Coast Protection Board (SA), 2014, *Coast Protection Board Policy Document: Revised 22 May 2012.*

District Council of Mallala Development Plan (consolidated 31/01/2013)

Blobel Environmental Engineering, 2013, *Flood protection – manual and automatic flood defence*, viewed at http://www.blobel.com/e_html/02-02e-flood-protection.html, on 12th December, 2013.

National Emergency Management Committee, 2010, *National Emergency Risk Assessment Guidelines*, Tasmanian State Emergency Service, Hobart.

Victorian Government, 2000, *Rapid Appraisal Method (RAM) for floodplain management*.

9. Appendices

Appendix 1: Risk analysis utilising NERAG

1. Risk statement:

There is the potential that a storm surge that exceeds 2.5m AHD resulting from a south easterly or north-westerly storm will cause floods to Parham, which in turn will cause impact on the residents.

Risk identification:

Source of threat	Storm surge
Impact category	People
Prevention controls	Levee installed to south-east side of Parham but no levee to frontal dune
Preparedness controls	No emergency procedures
Response	SES, ambulance, fire, police
Recovery	Pumping, draining water away. Repair of houses and roads.

Credible consequence level to people:

'Minor' - isolated cases of serious injury (not likely) but it is remotely possible for loss of life to occur.

Likelihood:

'Likely'- two one in 20 ARI events in previous decade which is at 2.5m AHD. The current 1 in 100 ARI event is 3.0m AHD .

Consequence Level:

Qualitative Risk Matrix

	Consequence Level				
Likelihood Level	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Low	Low	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium
Very Rare	Low	Low	Low	Low	Medium
Almost Incredible	Low	Low	Low	Low	Low

Degree of confidence in the above assessment:

High confidence – extensive study conducted, historical data known, hazard known, and comprehensive knowledge of the receiving environment.

Confidence Table

Confidence Criteria	Low Confidence	Moderate Confidence	High Confidence
Data/Information	Neither community nor hazard specific; anecdotal only	Community or hazard specific; validated historical or scientific	Community and hazard specific; validated historical and scientific
Team knowledge	Neither hazard nor process (risk assessment) specific	Hazard or process specific	Hazard and process specific
Agreement	Neither on interpretations nor on ratings	On interpretations or ratings	On interpretations and ratings

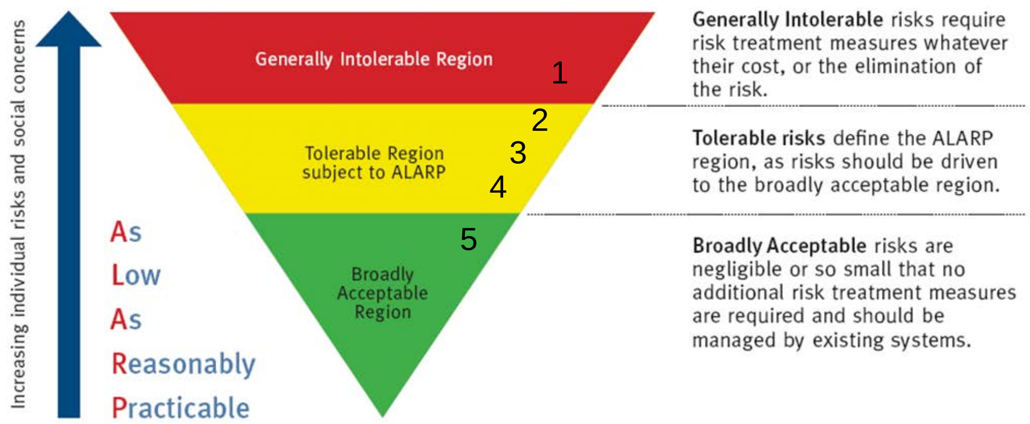
Classification of risk tolerability:

Risk Tolerability Tables

High Confidence Level

Likelihood Level	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	4	3	2	1	1
Likely	5	4	3	2	1
Possible	5	5	4	3	2
Unlikely	5	5	4	3	3
Rare	5	5	5	4	3
Very Rare	5	5	5	5	4
Almost Incredible	5	5	5	5	5

ALARP Principle



Conclusion:

Risk category is ALARP 4 which is tending toward ‘broadly acceptable’. With implementation of warning and emergency procedures, the risk will be more effectively managed. Should protection measures be installed at 3.0m the risk would be well within the ‘broadly acceptable’ category for risk to human life.

2. Risk statement:

There is the potential that a storm surge greater than 2.5m AHD resulting from a south-easterly or north-westerly storm will cause floods to Parham, which in turn will cause damage to private infrastructure.

Risk identification:

Source of threat	Storm surge
Impact category	Infrastructure
Prevention controls	Levee installed to south-east side of Parham but no levee to frontal dune
Preparedness controls	None relating to infrastructure
Response	SES, ambulance, fire, police
Recovery	Pumping, draining water away. Repair of houses and roads.

Credible consequence level:

Private Infrastructure – 'moderate'

Likelihood:

Likely (maybe possible) – two events in last decade have approached 2.5m AHD. One in one hundred is 2.8m AHD.

Consequence Level:

Qualitative Risk Matrix

	Consequence Level				
Likelihood Level	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost Certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Low	Low	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium
Very Rare	Low	Low	Low	Low	Medium
Almost Incredible	Low	Low	Low	Low	Low

Degree of confidence in the above assessment:

High confidence

Confidence Table

Confidence Criteria	Low Confidence	Moderate Confidence	High Confidence
Data/Information	Neither community nor hazard specific; anecdotal only	Community or hazard specific; validated historical or scientific	Community and hazard specific; validated historical and scientific
Team knowledge	Neither hazard nor process (risk assessment) specific	Hazard or process specific	Hazard and process specific
Agreement	Neither on interpretations nor on ratings	On interpretations or ratings	On interpretations and ratings

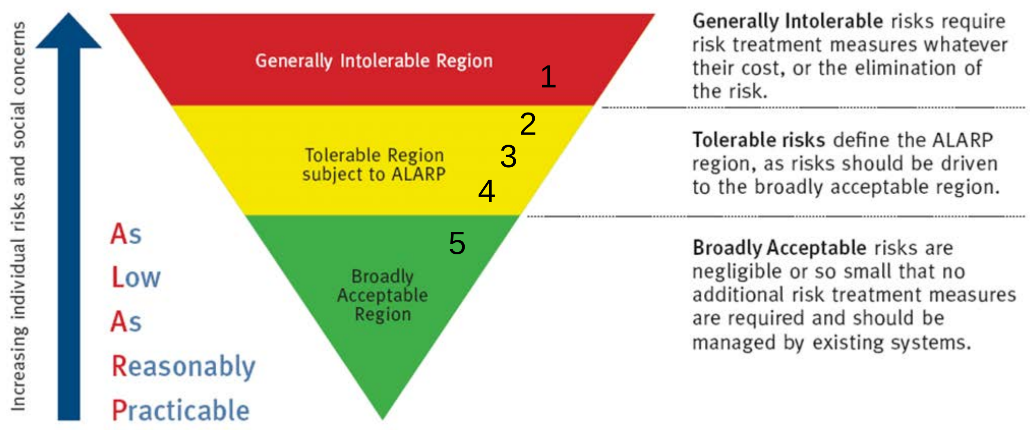
<u>Classification of risk tolerability:</u>

Risk Tolerability Tables

<u>High Confidence Level</u>

<u>Likelihood Level</u>	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	4	3	2	1	1
Likely	5	4	3	2	1
Possible	5	5	4	3	2
Unlikely	5	5	4	3	3
Rare	5	5	5	4	3
Very Rare	5	5	5	5	4
Almost Incredible	5	5	5	5	5

ALARP Principle



<u>Conclusion:</u>

Risk category is ALARP 3 which is in the 'tolerable region' and should be driven further to the 'broadly acceptable region'. There is no way to reduce the risk without implementing protection either to the foreshore or by undertaking accommodation measures on dwellings such as temporary protection measures or raising floor levels.

3. Risk statement

There is the potential that a storm surge exceeding 2.5m AHD resulting from a south-easterly or north-westerly storm will cause floods to Parham, which in turn will cause failure or damage to public infrastructure.

Risk identification:

Source of threat	Storm surge
Impact category	Infrastructure – primarily roads. Other infrastructure likely to remain unaffected. Power lines above ground.
Prevention controls	Levee installed to south-east side of Parham but no levee to frontal dune
Preparedness controls	None relating to infrastructure
Response	SES, ambulance, fire, police
Recovery	Pumping, draining water away. Repair of roads.

Credible consequence level:

Private Infrastructure – 'minor' to 'insignificant'

Likelihood:

Likely (maybe possible) – two events in last decade have approached 2.5m AHD. One in one hundred is 2.8m AHD.

Consequence Level:

Qualitative Risk Matrix

	Consequence Level				
Likelihood Level	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Low	Low	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium
Very Rare	Low	Low	Low	Low	Medium
Almost Incredible	Low	Low	Low	Low	Low

Degree of confidence in the above assessment:

High confidence

Confidence Table

Confidence Criteria	Low Confidence	Moderate Confidence	High Confidence
Data/Information	Neither community nor hazard specific; anecdotal only	Community or hazard specific; validated historical or scientific	Community and hazard specific; validated historical and scientific
Team knowledge	Neither hazard nor process (risk assessment) specific	Hazard or process specific	Hazard and process specific
Agreement	Neither on interpretations nor on ratings	On interpretations or ratings	On interpretations and ratings

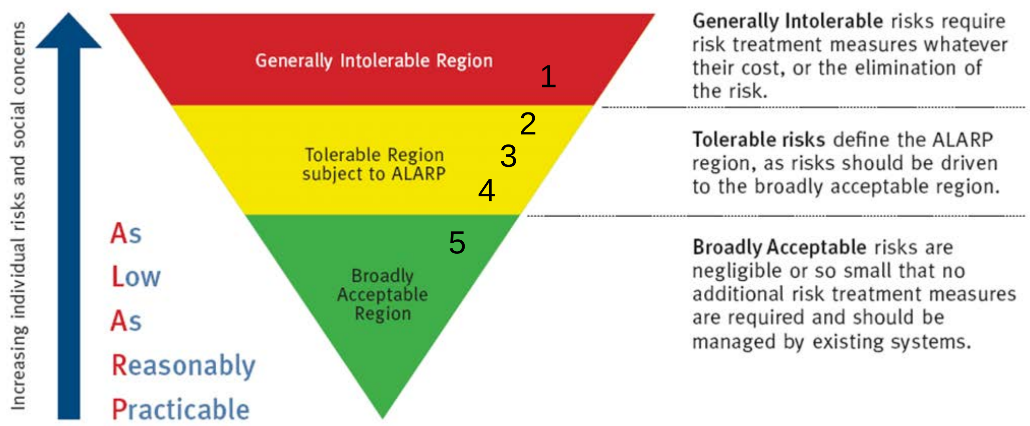
<u>Classification of risk tolerability:</u>

Risk Tolerability Tables

<u>High Confidence Level</u>

Likelihood Level	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	4	3	2	1	1
Likely	5	4	3	2	1
Possible	5	5	4	3	2
Unlikely	5	5	4	3	3
Rare	5	5	5	4	3
Very Rare	5	5	5	5	4
Almost Incredible	5	5	5	5	5

ALARP Principle



Conclusion:

Risk category is ALARP 4 which is in the 'tolerable region' and should be driven further to the 'broadly acceptable region'. There is no way to reduce the risk without implementing protection to the foreshore or by raising roads (not cost effective).