University of South Australia

School of Natural and Built Environments

Institute for Urban Renewal

Coastal Settlements Adaptation Study

Stage 1: State of Play

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CONTENTS

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 Annual 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 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 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 south-westerly gale. The combination of these factors is given a height AHD and used by planners to work out what height buildings and infrastructure should be placed along the shore.

Introduction

1.1 Background and aim

In May 2013 the District Council of Mallala (DC Mallala) commissioned the University of South Australia (UniSA), School of Natural & Built Environments (NBE) to undertake the Coastal Settlements Adaptation Study. The aim of the study is to identify and evaluate potential sea level rise adaptation strategies for the coastal settlements of Parham, Webb Beach, Thompson Beach and Middle Beach. The intent is to clearly define the benefits, risks and estimated costs associated with realistic and achievable adaptation options.

1.2 Focus

Previous study has been undertaken in relation to the natural ecology of the DC Mallala region (for example, Caton et al 2009; Clarke B., Simpson 2010) and some analysis has been completed of the policy framework in which DC Mallala operates to deal with coastal adaptation (Clare B., Simpson 2010; Balston JM et al (2012). However no investigation has been completed to date that relates specifically to the impact of rising sea levels on human settlements. Therefore the prime focus of this study is to evaluate how rising sea levels, will impact the human settlements of Parham, Webb Beach, Thompson Beach and Middle Beach, and then to suggest adaptation strategies to cope with anticipated changes in sea level. This focus does not negate the importance of how rising sea levels may impact the ecology of the region and thus the companion report, *Overview of the ecology and heritage of Parham, Webb Beach, Thompson Beach and Middle Beach (2013)* has been prepared as part of this study.

1.3 Investigative framework

This study uses an adaptation of the Coastal Adaptation Pathways Decision Map developed by the Local Government Association of SA and UniSA 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. Analyse possible adaptation actions.

1.4 Methodology and staging

The study is conducted in three main stages:

Stage 1: State of play – analysis of impacts from the sea upon the four settlements

(Steps 1-6)

In this stage analysis is to be completed by:

- consultation with staff at DC Mallala Council and Coast and River Murray Unit at Department of Environment, Water and Natural Resources, SA (DEWNR).
- review of existing reports and correspondence at DC Mallala and Coast and River Murray Unit (DEWNR),
- review of minutes of Coastal Management Advisory Committee / Environmental Management Advisory Committee,
- inspections of the settlements and surrounds,
- analysis of flood mapping and evaluation of settlement topography,
- collection of housing and infrastructure data,
- physical survey to validate data.

Stage 2: Consultation phase

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 or in writing to DC Mallala. Long standing Council staff, members who serve or have served on advisory committees, and residents who have lived in the coastal settlements are a valuable source of information about the history of the interaction between the ocean and the settlements. Contributions from residents in public consultation process are typed in the colour green.

Stage 3: Adaptive solutions proposed (Step 7)

The findings of the consultation phase will be used to inform the 'State of Play' report as well as the formulation of adaptive solutions. There are 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, 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.

Keeping this framework in mind may assist the reader in understanding why certain data is collected and analysed in this first stage of the project.

2. Investigative Framework

The purpose of this section is to explain the rationale and methodology for the investigation. A more detailed explanation is found within the PowerPoint© presentation, *Dealing with the impacts of sea level rise on coastal assets* (Western, Kellett 2013).

2.1 Settlement history

2.1.1 Rationale

The first step is to understand and gain knowledge about the history of the four settlements and how the settlements are currently protected from actions of the sea. A history of the founding of each settlement provides an important cultural context to the study and may also improve understanding of any initial assessments that were undertaken in relation to potential impacts of the sea.

2.1.2 Assessment questions

- When was the settlement established?
- What account was taken in relation to potential impacts from the sea?

2.1.2 Methodology

- Document review of DC Mallala and Coast and River Murray Unit (DEWNR) records relating to the establishment of the settlements.
- Review policies relating to climate change, in particular, rising sea levels.

2.2 Analysis of existing sea-flood protection

2.2.1 Rationale

Protection can be afforded a settlement in two ways: natural land forms and man-made protection works, such as a levee. There are two reasons for paying particular attention to man-made protection works:

<u>Reason 1:</u>

The original development application and conditions of approval for the settlement and/or the implementation of protection works will provide information on the science that was utilised, the options considered, and the engineering specifications used in the construction of the works. Additionally, any conditions of approval relating to the ongoing maintenance of the protection works will be more easily identified. A review of subsequent Council records and correspondence will inform whether the protection works have been breached or repaired, or whether the council has fulfilled its maintenance obligations over time.

Reason 2:

A review of policies and cases around the world (Balston et al, 2012) found that there was the potential for increased liability for Councils where protection works have been implemented. Therefore, to review the circumstances of the implementation and historical performance of the existing protection works, and whether any maintenance obligations have been fulfilled will help inform the question of current and future responsibilities for council and landowners. .

2.2.2 Assessment questions

- What existing protection exists in the settlement?
- Have the protection works ever been breached?

2.2.2 Methodology

- Document review of DC Mallala and Coast and River Murray Unit (DEWNR) records relating to implementation of protection works.
- Site inspection to review protection to the west and east of the settlements, and dune protection approximately 1km north and south of the settlements.
- Evaluation of topography using a digital elevation map (DEM) to ascertain heights of existing natural land forms and manmade protection works.

2.3 Analysis of impact of the sea.

2.3.1 The problem with climate change predictions

Much has been written at an international, national, and state level about the predicted effects of climate change upon human settlements. These predictions range more broadly from decreased rainfall, increased incidents and intensity of storm events, and increased incidents and intensity of heatwaves. In coastal regions, there are predictions of increased sea level, increased coastal flooding, beach and dune erosion, changes to ground water, and possibly altered wave patterns (Caton et al 2009: p. 119). All of these factors will impact the ecology of the coastal environment and long term viability of coastal settlements. For example, decreased rainfall may deplete vegetation growing within a dune system, with the result that the dune becomes more vulnerable to erosion from the sea. While all of these predictions are based upon current science the 'level of uncertainty of climate change projections makes it difficult for Local Governments to prioritise their commitment to adaptation' (Department of Climate Change, 2009a; p.1). Therefore, in this study the main criterion to evaluate each settlement is predicted sea level rise. Erosion is reviewed as a secondary factor by identifying places where erosion is already taking place.

This does not infer that other matters are less important but confining the study to one main criterion provides the ability to apply a more simple and certain filter that may then inform where further evaluation of other factors is required. For example, the Environmental Impact Assessment for the Thompson Beach approval process identified the possibility of flooding from the Light River in a major rain event. While there hasn't been any event where rain has been a significant factor in 25 years, this does not mean this factor should be completely discounted in a future study.

2.3.2 Relative sea level rise

Coastal land is not always static and land subsidence or uplift may occur. In cases where the land is subsiding, the sea level relative to the land would appear to rise. Conversely where the land is uplifting the sea level relative to the land would appear to fall. When factoring in actual sea level rise, where land subsidence is occurring, the rate of sea level rise would appear to be faster, but where land uplift was occurring, the rate of sea level rise would appear to be slower. In relation to the Mallala region John Cann, Adjunct Professor of Geology at University of South Australia, offered the following opinion:

> 'With reference to relative sea-level change along the eastern shore of northern Gulf St Vincent, there has been measurable uplift since culmination of the postglacial marine transgression, about 7000 years ago. This has been attributed to isostatic loading of the continental slope and shelf due to a rise in sea-level of 120-130 metres, commencing ca. 18,000 years ago. The slope and shelf sag under the increased weight of water and this creates a see-saw effect with compensatory uplift of areas inland of the immediate coast. This phenomenon has been termed hydroisostasy. Such uplift is of the order of just a few metres and in most cases might not be detected. However, the continental shelf seaward of the SA gulfs is broad and thus particularly susceptible to the impact of this extra weight of water; and the gulfs provide access to sea water well inland of the general trend of the coast – uplift of the land…' (Email to Jon Kellett, UniSA, 11th October, 2013).

In relation to the Mallala region, the uplift has been approximately 3m over 7000 years (Cann, J, N.D.) or stated in annual terms, 0.43 of a millimetre per year (0.00043m).

Longer term trends of erosion or accretion can also cause the coast to migrate seawards or landwards. John Cann adds:

> 'Another relevant factor is the rapid rate of sedimentation in the northern areas of both gulfs. Marine carbonate sediment comprising mollusc shells, entire and comminuted skeletal algal remains, foraminifera and sundry other grains of organic origin are accumulating at an amazingly rapid rate, trapped and bound by plants ranging from cyanobacterial mats to mangroves. Thus, in addition to the hydroisostatic uplift, coastal sedimentary facies are actively aggrading and prograding seawards' (Email to Jon Kellett, UniSA, 11th October, 2013).

While hydroisostatic uplift is unlikely to be having any mitigating effect upon sea level rise, the active aggrading (increase in land level) and prograding (moving of the shoreline seawards) may have some mitigating effects in the region. At this stage of the research there is no quantitative data to apply regarding the rate of change to the coastline.

2.3.3 How threats from actions of the sea are assessed for planning purposes

Historically planners have evaluated potential threats from inundation from the sea by considering the compounding effect of the highest possible tide, the largest storm surge height, and the configuration and action of the waves. This compounding effect is unique to each coastal location due to differing sea floor level formations and wind intensity and direction (See Figure 1):

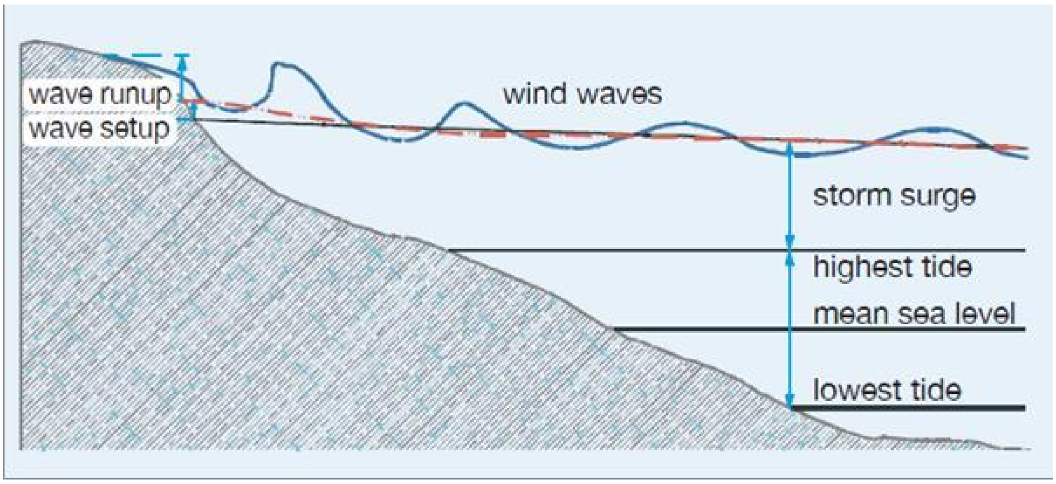

Figure 1: Highest potential water level is calculated with a combination of factors

Water levels are expressed in terms of Australian Height Datum (AHD) which is 1.45m lower than predicted tide charts (Chart Datum). The following diagram further explains the established methodology that planners utilise to ascertain appropriate planning heights for development in coastal regions (Figure 2):

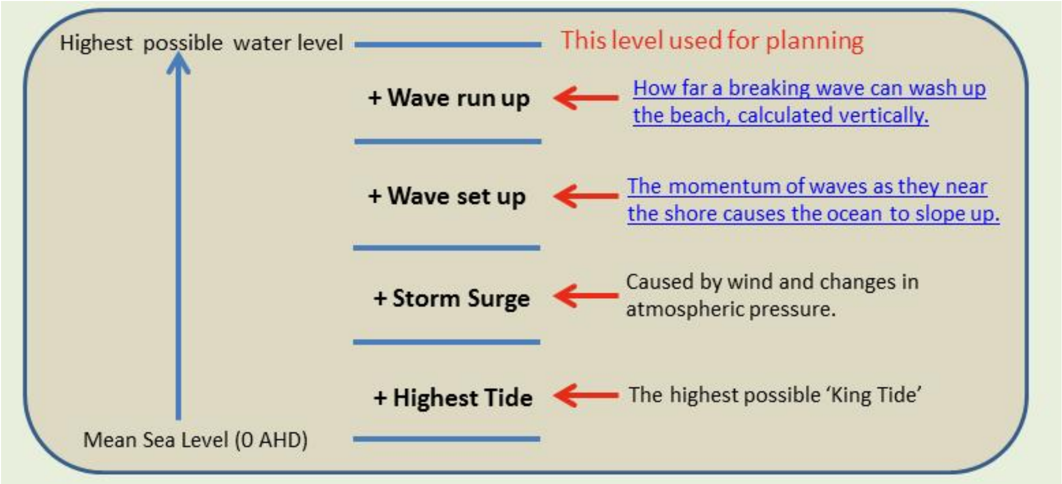

Figure 2: The accumulated height of each component gives the highest probable water level.

Specifically in relation to DC Mallala coastal regions SA Coast Protection Board utilises the following calculations (See Table 1) for the 1 in 100 Annual Return Event[1]. Acting under the

[1] ARI is an acronym for Annual 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 likely 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

Development Act 1993, the Council is required to refer any development to Coast Protection Board and can rely on the advice received.

Table 1: 1 in 100 ARI storm event – DC Mallala Coastal region

Storm surge (at king tide)	2.6m AHD
Wave set up	0.1m AHD
Wave run up	0.0 m AHD
Total	**2.7m AHD**

Wave set up and wave run up is low in the DC Mallala coastal region due to the very slow incline of the sea floor.

2.3.4 Predicted sea level rise

While there are varied predictions of the rate of sea level rise around the world, local councils in South Australia can rely on the benchmarks set by South Australian Coast Protection Board in 1990 as follows:

Year 2050 – 0.3 m sea level rise (from 1990 levels)
Year 2100 – 1.0 m sea level rise (from 1990 levels)

Therefore taking into account the likely action of the sea in the coastal region of DC Mallala the planning benchmarks are incorporated into Table 2.

Table 2: 1 in 100 annual return event, with sea level rise predictions provide the planning benchmarks for DC Mallala.

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

2.3.5 Actual sea level rise

Since 1990, two sophisticated gauges at Port Stanvac south of Adelaide, and at Thevernard west of Ceduna have been collecting data. These gauges remove the 'noise' from the movement of the sea and the land and calculate changes to mean sea level over time. The data from both of these gauges provide clear evidence that sea level rise from 1990 to 2010 has been 4.3mm per year (Figure 3). By comparison, longer term monitoring from the gauge at Pt. Adelaide which has over a hundred years of data, indicates that the rate of increase over the last century was 1.5mm per year.

height. It is important to remember that the ARI calculation is a probably event based on historical observations and there is nothing preventing two or even three 1 in 100 ARI events within days or weeks of each other.

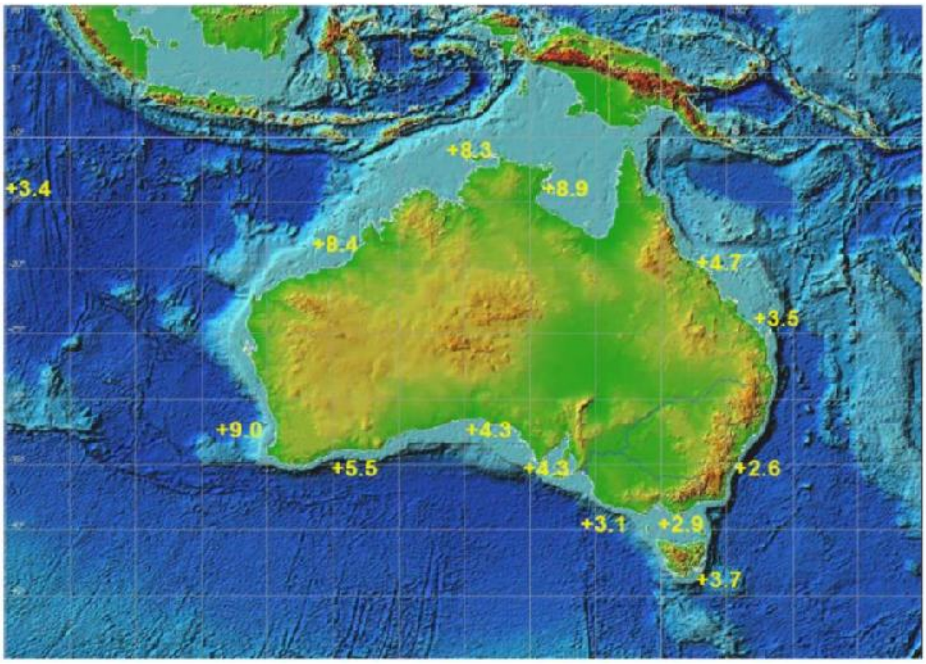

Figure 3 – Sophisticated gauges at Thevernard and Pt Stanvac have recorded an average of 4.3mm per year since 1990 (Bureau of Meteorology, 2013)

Assuming that the rate of sea level rise remains reasonably constant until 2050, a simple multiplication of 4.3mm x 60 years suggests an increase in mean sea level of 258mm which is comparable with the SA Coast Protection Board's prediction of 300 mm (0.3m). In the longer term, the prediction of 1.0 m sea level rise by 2100 assumes that the sea level will rise more rapidly in the second half of this century.

2.3.6 Which sea level rise scenario?

It is proposed in this study to primarily utilise the storm surge and sea level rise event calculated for year 2050 for the following reasons:

- There is more certainty around sea level rise to this date with recorded data from the last 20 years providing a good degree of confidence in the predictions of the SA Coast Protection Board.
- It provides a 37 year time frame which will allow data to be tracked and verified and more accurate predictions developed for the second half of the century. This data will could also include more quantitative data relating to the prograding and aggrading of the coastline should this trend continue (see p. 6)
- It provides a sufficiently long time frame for adaptations to be employed to cater for the second half of the century.
- The community is more likely to be engaged within this time frame rather than using the year 2100 which is more remote.
- Logically, it makes sense that if a settlement is under threat at 2050 then it will be under greater threat at 2100. Conversely, by using the 2050 yard stick it may be ascertained that a settlement is manageable until 2050 but there may be problems thereafter, so, planning mechanisms could be employed to cater for those threats.

In summary, using 2050 as the main focus of this study will provide a pivotal point upon which to assess settlements against both the shorter term and longer term. There are three possible outlooks for a settlement using predicted sea level rises at 2050:

(1) Settlements that are not threatened at 2050 and have minimal threat at 2100.
(2) Settlements that have minimal threat at 2050 but face increased threats by 2100.
(3) Settlements that are threatened at 2050 and therefore face severe threat by 2100.

In the case of outlooks (1) and (2) time is a 'friend' because planning mechanisms can be instituted to cater for new dwellings and replacement dwellings. Settlements with outlook number (3) may require more immediate attention.

Finally, the one in hundred sea-flood event to be utilised in 2013 may be calculated by incorporating the amount the sea has risen since 1990.[2]

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

The recent storm event on 4th July, 2007 provides some context to the assessment which was estimated at an approximate height of 2.5 AHD[3]. Anecdotal evidence would indicate that the flood event of 25th April 2009 was similar in height. On the annual return interval (ARI) scale, this event represents a 1 in 20 ARI event[4].

2.3.7 The characteristics of inundation in the region

Other than depth of water, additional factors that influence the impact of a flood on a settlement are the velocity of the water (speed) and the duration of the flood (how long it lasts). How much warning is possible for a flood is a factor that enables the settlement to deal with the flood more effectively, and the topography of the settlement will influence how well people are able to enter or leave the settlement. While these factors are dealt with more fully in a hydraulic study, the general characteristics of a sea-flood in the Mallala region are shown in Table 4.

[2] Sea level rise since 1990 level is calculated by 4.3 average rise per year x 22 years = 95mm (0.1m)
[3] A resident in Middle Beach has a flood marker that was surveyed at 2.48m AHD. This marker relates to a 1971 flood level but water level almost reached this level on 4/07/07. Video of 25/04/09 shows water over the road on the southern end by about 200mm. A check on the digital elevation map reveals an approximate flood height of 2.4m AHD. Tide height at Port Adelaide was 3.68 CD less 1.45 = 2.23m AHD event, but expected to be higher further up the gulf (M. Townsend, CPB, 13.08.13). Alvin Jenkin and Barbara Reid in Parham used the water mark left on ground and survey equipment to establish that flood height was 2.54m AHD.
[4] Rob Tucker, Coast Protection Board, interview 13.08.13

Table 4: Sea flood scenarios for DC Mallala coastal region.

Flood characteristic	Mallala region
Depth of water	Generally under 1m (to 2050 scenario)
Velocity of water	Low, due to tidal action and ocean terrain
Direction of water	From the west
Duration of flood	Short 1-2 hours
Warning	Predictable as flood will relate to tide.

2.3.8 Assessment questions

- What is the likely impact on the settlement for a 2.8 m AHD event (2013)?
- What is the likely impact on the settlement for a 3.0 m AHD event (2050)?
- What is the likely impact on the settlement of a 3.7m AHD event (2100)?

2.3.9 Methodology

- Use bath tub flood mapping and analysis taking into account the natural and man-made protection systems within and around the settlements.

2.4 Analysis of emergency access and egress.

2.4.1 Rationale

The purpose of this investigation is to provide a filter through which a preliminary assessment can be made of each of the four settlements in relation to two basic criteria:

- In the event of 3.0 m AHD flood event can emergency services access the settlement?
- In the event of a 3.0 m AHD flood event, can residents move directly away from the place where flooding is occurring (egress)?

It is pertinent to note that due to the slow incline of the sea floor in the region that Coast and River Murray Unit (DEWNR) does not expect any flood to contain a significant velocity of water or large wave height, but that the movement of water would be more tidal. Video in the flood event of 25th April, 2009 at Middle Beach (John Kneuitt, 2009), provides an example of how flood water may act in a storm event. Furthermore, the fact that any significant inundation will be related to tidal action means that potential flooding events are very predictable. In terms of managing emergency access and exit this is a positive aspect because ample warning can be given and evacuation procedures employed if necessary.

Figure 4: Screen print from Video by J. Kneuitt, Middle Beach at 29:53, 4th July 2007.

However, the anticipated low velocity and height of water in a flood does not imply that these events are without risk. The vulnerable of the community, the aged, disabled, or young, may be in danger, especially if an event was to occur at night. Furthermore, more damage is done to houses, roads and infrastructure as the tide recedes since the water naturally finds the easiest way back to the ocean. This factor means that the velocity may increase in unpredictable places, and also that roads near the foreshore may be eroded making them dangerous to traverse by foot or vehicle. Also an unrelated emergency such as a heart attack or a fire may prove more serious if emergency service vehicles are unable to access the settlements.

2.4.2 Emergency service driver protocols

The following protocols apply to emergency service drivers accessing water across roads. The State Emergency Service (SES) is the lead agency for dealing with floods. The drivers of SES vehicles do not operate under any set protocols but are required do a rapid risk assessment of each situation before entering flood waters. This would normally be an assessment on foot to establish the velocity of the water, depth of water, and characteristics of the surface underneath. All SES vehicles have 4 x 4 wheel drive capabilities. Depending on driver capability standard 4 x 4 vehicles can operate at depth wheel height (60-70 cms), or where the driver is more capable at the height of the bonnet (90-100cms). When required the SES has access to 4 x 4 wheel trucks that have much higher clearance (Bob Stevenson, State Emergency Management Planning Officer, phone call 29th October, 2013).

South Australian Ambulance Service (SAAS) drivers are to take their lead from the SES before accessing flood waters. In the absence of any SES workers, ambulance drivers conduct an assessment of the flood waters on foot and would not enter where the water showed any significant velocity, the surface underneath was unstable, or where the water is higher than the door seals of the ambulance or approximately15cms (Andrew Hillier, Acting Driver Manager and Trainer, phone call 30th October, 2013).

In relation to fire services, the DC Mallala is overseen by Region 2, Country Fire Service that operates from Williston (awaiting response). Consultation with Michael Shepherd, Metropolitan Fire Service, suggested that due to the size of fire vehicles that access would likely to be achievable in the flood scenarios described in this study.

2.4.3 Assessment questions

- In a 3.0m AHD sea-flood event could residents move away from the source of the flood and firstly, move to a safe place, and secondly, exit the settlement?
- In a 3.0m flood event could emergency vehicles access the settlements?

2.4.4 Methodology

- Review each of the four settlements to ascertain if the topography and street network allows residents to move away from the source of the flood to ground that is at least 3.0m AHD.
- Review each of the four settlements to ascertain if main access roads into the settlements are at 3.0m AHD or above.
- Review the internal road network and the access roads to each of the four settlements to ascertain which roads are at 3.0m AHD or higher.

Due to the fact that anticipated flood events will be related to tidal movements and therefore of a predictable duration, such events may not reach inland at 3.0m AHD and therefore some leeway to the heights of access roads may be acceptable. On the other hand, the immense volume of water in the sea would mean that a prolonged event would probably inundate most areas indicated on the flood maps.

2.5 Establish profile of assets at risk

2.5.1 Rationale

It is common practice to divide flood damages into the following types: tangible damages (direct and indirect) and intangible damages as illustrated in Figure 5.

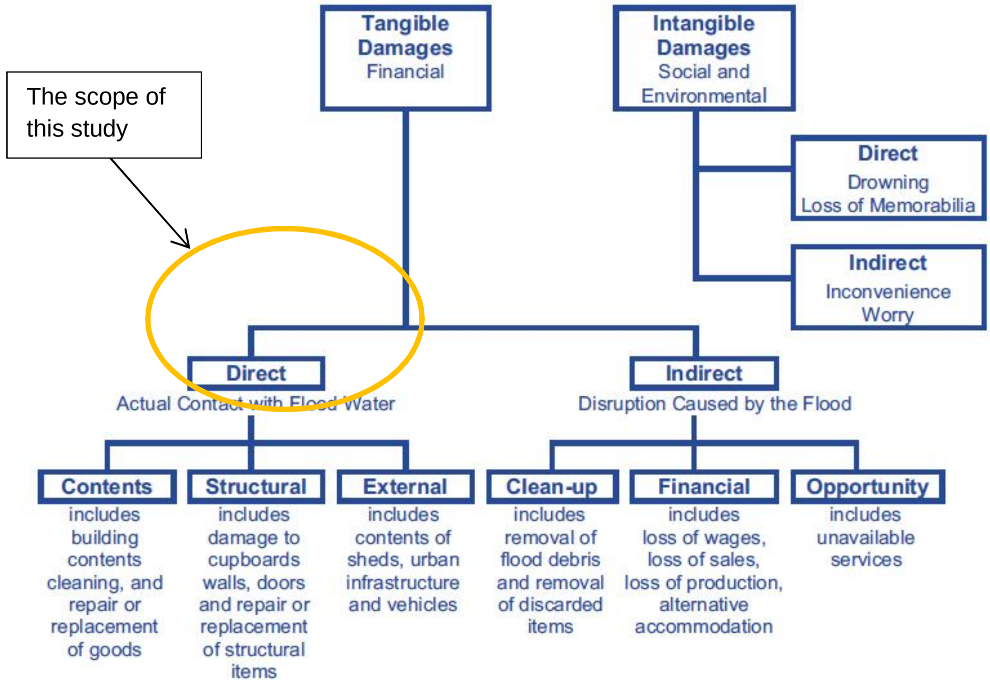

Figure 5: Types of flood damage (NSW Government, 2005)

The scope of this study is to deal only with *tangible* damages and those that relate *directly* to the flood. These assets are categorised as:

- Privately owned – houses, land.
- Council owned – roads, shelters, public toilets, playgrounds and equipment.
- Owned by others – Telstra, SA Power Networks, SA Water.

Depth of water over floor levels for buildings is ascertained for two reasons. The first is to evaluate the extent to which houses may be under threat from inundation. The second reason is that flood depth over floor level is the established way the insurance industry estimates potential flood damage. Figure 6 is the flood depth/damage curve is utilised in this study[5]. Due to the large proportion of holiday type houses in the Mallala coastal settlements, the 'small house' scenario has been chosen from the curve.

[5] This flood/damage curve was used in a flood study in a small Victorian town of Barmah. The flood/damage curve in that study was adapted from ANUFLOOD and factored up to 2008. This study adjusted the 2008 amounts using CPI adjustment from ABS to factor the damage rates to 2012.

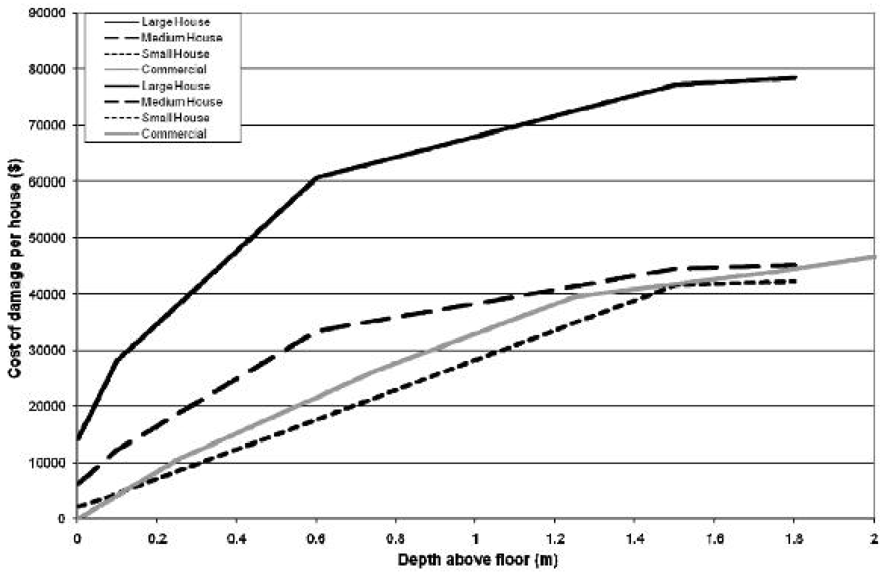

Figure 6: Flood / damage curve (Sinclair Knight Merz, adapted from ANUFLOOD,2008).

In flood calculation it is common to reduce the estimated amount of damage taking into account a number of factors: the velocity of the water, the likely duration of the event, how much warning can be given of the flood, and how experienced the community to deal with a potential flood. Some of this factoring is illustrated in Table 5:

Table 5: 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

While a reduction of actual damages may be warranted, in this study no factoring has been applied at this stage of the study.

2.5.2 Methodology

In relation to privately owned assets the methodology was to:

- Use a cadastral map and record whether the site is vacant or occupied.
- Use a digital elevation map (DEM) to pinpoint the land in front of the building to ascertain its height above mean sea level (AHD).
- Conduct a site survey of all dwellings and record into a spread sheet
    - Estimated height of finished floor above ground level in front of house.
    - Single or double storey
    - Type of construction – brick, lightweight construction, transportable.
    - Type of foundation – concrete, stumps, poles.

- Assess finished floor levels against 3.0m AHD flood height to ascertain potential flood depth over finished floor levels.
- Use data from the DEM to provide elevation data of the road in front of all allotments within settlements.
- Validate the abovementioned data using surveyed measurements carried out by qualified professional surveyors on a sample of sites.
- Apply the damage cost to dwellings as related to depth of flood over floor level.

In relation to Council assets:

- The Council provided a list of assets.

In relation to other owned assets:

- Infrastructure maps were obtained from relevant authorities.

2.6 Exploration of liability issues.

It is important to recognise that this section is designated an 'exploration' rather than as definitive legal advice. Where there is any doubt about particular circumstances, these should be referred to the Council's legal advisors[6] (See also Appendix 1).

2.5.1 Rationale

The following questions are relevant:

- **In what way can councils become liable for loss or damage?**

Liability to Councils comes under two broad categories. The first is legal liability. A Council that accepts legal liability for an asset may face claims for future damage to that asset from its owners. If liability has not been clearly established such claims may result in legal action where both the Council and the land owner may have to spend time and money on court actions, with the risk of damages and costs to the losing party.

The second category is political liability. Governments can come under significant pressure to install protection works and other measures, regardless of whether they are legally obligated to protect assets which belong to others or not. Also, when Governments take action to mitigate the effects of rising sea levels, for example by limiting the types of development that can occur within settlements, political back lash may result.

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[6] The prime source for this exploration is, Australian Local Government Association (2011) *Local Council Risk of Liability in the Face of Climate Change Resolving Uncertainties*, A report commissioned by Australian Local Government Association, Sydney. Appendix 3, p. 10-17 in Balston JM et al (2012) provides an abridged synopsis of the Baker and MacKenzie (2011) report and pp. 41-59 in the same appendix provides an in depth case study of the only court action to date within Australia that relates directly to an action of the sea, Vaughan v Byron Shire Council (No 2) [2009] NSWLEC 110.

- **In what ways can Council be legally liable?**

There are two main ways a Council can incur cost relating to legal liability - through administrative appeals and tort based claims.

<u>Administrative Appeals</u>

Administrative appeals occur when someone appeals against a decision the Council has made. Examples include, when developers are refused a development application on the basis that sea level rise issues are not adequately addressed, or when Councils make amendments to the Development Plan that may restrict the types of development within the settlement. The liability to the Council is one of cost in defending the appeal at Court. The vast majority of climate change related cases to date are administrative appeals (Australian Local Government Association, 2011).

<u>Tort based claims</u>

There are two types of tort based claims where Council can be liable to pay damages: 'nuisance' and 'negligence'. There have been no climate change related court actions relating to 'nuisance' claims at the date of writing and only one case relating to 'negligence'. The only case to date is Byron Shire Council v Vaughan in NSW (See also Appendix 1).

<u>Legal defences</u>

In common law, the defence of 'voluntary assumption of risk' provides that there will be no liability of the defendant if it can be established that the plaintiff was fully aware of the risk, comprehended the risk, and accepted the whole risk. The concept of 'risk' has been strengthened by statute in Australia to include that the defendant is not liable for the occurrence of an obvious risk, i.e. one that is obvious to a reasonable person in the plaintiff's position.

A further statutory defence is that a defendant's liability for the 'materialisation of an inherent risk' (one that cannot be avoided by the exercise of reasonable care and skill) is limited only to a failure to warn of the risk. A contract between the plaintiff and the defendant may exempt the defendant from liability in negligence where there is a clear statement that liability for negligence is excluded. Where there is no contract, a disclaimer may give the plaintiff sufficient knowledge of the risk to satisfy the defence of voluntary assumption of risk or to constitute reasonable warning.

Additionally, a Council's financial resources are limited and the allocation of its resources cannot be challenged in Court. Therefore, while there might be protection works that may be implemented in theory, the Council may not have the resources in its budget, and its decision to allocate funds to other budgetary matters cannot be challenged.

The following may be a defence against a tort based claim:

- It is unlikely that an action might be successful against a council where it has failed to install protection works because the average person is aware of the risk from the sea, and in recent times is aware of the issue of rising sea levels.

- Councils have limited resources and have to make decisions based on this factor. The allocation or the lack of allocation of resources of a council is not challengeable at law.
- Councils that warn their constituents of their risk are likely to reduce their liability against possible claims, for example, where flood mapping is made available to residents.
- A council that incorporates the available science into its decision making reduces the possibility of liability. The Council is not required to get the science right per se and courts will judge the matter on the science that was available at the time of the decision.
- Councils that have demonstrated they have followed procedures in decision making and undertaken reviews such as this one, will improve the defence that they have upheld a duty of care.
- Finally Councils that have emergency action plans for their residents accomplish two objectives: one they demonstrate a duty of care, and two, emergency action plans are an effective way to inform residents of the risk they face in living close to the sea.

At what points is the council weak in relation to tort based claims?

- Where the council has approved settlements against the science or advice of the time.
- Where protection works have been installed incorrectly. For example where the council installs a protection work and fails to meet the requirements set down in engineering reports.
- Where the council had an obligation to maintain works or strategies and it has not done so, or even in the absence of written obligations, where the works fail because they have not been maintained or repaired.
- Where they have not advised their residents of the risk or do not have emergency action plans to deal with possible risk.

Summary

In summary, it makes logical sense to first ascertain what legal liability exists before ascertaining whether there is any political liability. This finding will at least enable the Council to act from a position of certainty if it can be determined that legal liability is unlikely in the given scenario. And finally, having no legal liability does not mean that the Council does not necessarily take any action to implement protection works and strategies. However, these actions need to be implemented carefully with public awareness strategies that do not impede the Council with new sets of liabilities.

2.6.2 Assessment Questions

- What obligations did Council have at the time the settlements were established to assess impacts from the sea?

- What protection works have been implemented and were they implemented in accordance with approved plans?
- Have protection works implemented by Council been breached?
- In the case of new development within the settlements, have appropriate planning and Coast Protection Board policies been followed?
- Has the Council made available sea level rise data to residents?
- Are there any emergency warnings and/or evacuation procedures in place?

2.6.2 Methodology

- Review site history and documents relating to the establishment of settlements (where available).
- Review documents relating to the implementation of any protection works.
- Analyse whether legal liability exists (get external advice)
- Analyse the potential for political liability.
- Analyse the nature and extent of warnings which Council has given to residents in relation to any potential threats from actions of the sea.

3. Existing policy context

The broader environmental policy context is described in Robyn Rawlings (2013), *Coastal Settlements Adaptation Study– Overview of ecology and heritage of Parham, Webb Beach, Thompson Beach and Middle Beach* (p. 8,9). Clarke and Simpson (2010, p.186-197) have reviewed the policy and decision making context of District Council of Mallala and produced a summary table. The table notes that two committees support the decision making of the Council: Coastal Advisory Committee and Mallala Greening Committee (now Environmental Advisory Committee).

Table 18.1 List of Interrogated Documents from the District Council of Mallala

	Type of Document
Policy 3.1 Vegetation Management 2007	Policy (B)
DC of Mallala Development Plan	Policy (SLR)
Draft Samphire Coast Conservation Strategy	Strategy
Uncategorised Documents	
Coastal Advisory Committee Terms of Reference 18 Feb 2008	ToR
Greening Committee Terms of Reference	
Coastal Advisory Committee Agenda 19 January 2010	Agenda
Greening Committee Minutes 12 October 2009	Minutes

Annotation for the list of interrogated documents from Mallala Council:
(B- Biodiversity, SLR- Sea Level Rise, ToR – Terms of Reference).

The main overarching policy document that deals with environmental issues as well as development issues is the DC of Mallala Development Plan (consolidated 31st January 2013). The existing policy context is detailed in Table 4:

Table 4: Policy context for coastal development within DC Mallala Development Plan (31.1.13)

Objective or Principle of Development Control (PDC)	**Reference**
General Section - Coastal Areas	
Development only undertaken on land which is not subject to or that can be protected from coastal hazards including inundation by storm tides or combined storm tides and stormwater, coastal erosion or sand drift, and probable sea level rise.	Objective 5 (p.29)
Development that can accommodate anticipated changes in sea level due to natural subsidence and probable climate change during first 100 years of development.	Objective 6 (p. 29)
Development which will not require, now or in the future, public expenditure on protection of the development of the environment.	Objective 7 (p. 30)

Development not located in environmentally sensitive coastal features such as sand dunes, cliff tops, wetlands, or substantially intact strata of native vegetation.	Control 3 (p.31)
Development should not be undertaken where it will create or aggravate coastal erosion, or where it will require coast protection works which cause or aggravate coastal erosion.	Control 4 (p.31)
Development should be designed and sited so that it does not prevent natural landform and ecological adjustment to changing climatic conditions and sea levels and should allow for the following: (a) unrestricted landward migration of coastal wetlands; (b) new areas to be colonised by mangroves, samphire and wetland species; (c) sand dune drift; long shore sand movement; (d) where appropriate, the removal of embankments that interfere with the abovementioned processes.	Control 8 (p. 31)
Development and its site should be protected against the standard sea-flood risk level which is defined as the 1 in 100 year average return interval flood extreme sea level (tide, stormwater, and associated wave effects combined) plus an allowance for land subsidence until the year 2100.	Control 19 (p.32)
Development including associated roads and paving areas….should be protected from sea level rise by ensuring all of the following apply: (a) site levels are at least 0.3 metres above the standard sea-flood risk level (b) building floor levels are at least 0.55 metres above the standard sea-flood risk level, (c) there are practical measures available to protect the development against an additional sea level rise of 0.7 metres, plus an allowance to accommodate land subsidence until the year 2100 at the site.	Control 20 (p. 32)
Buildings to be sited over tidal water or which are not capable of being raised or protected by flood protection measures in the future, should have a floor level of at least 1.25 metres above the standard sea-flood risk level.	Control 21 (p.32)
Development that requires protection measures against coastal erosion, sea or stormwater flooding, sand drift or the management of other coastal processes at the time of development, or in the future, should only be undertaken if all of the following apply: (a) the measures themselves will not have an adverse effect on coastal ecology, processes, conservation, public access and amenity; (b) the measures do not nor will require community resources, including land to be committed; (c) the risk of failure of measures such as sand management, levee banks, flood gates, valves or stormwater pumping; is acceptable relative to the potential hazard resulting from their failure; (d) binding agreements are in place to cover future construction, operation, maintenance and management of protection measures.	Control 22 (p.32,33)
Development should not compromise the structural integrity of any sea wall or levee bank adjacent to the foreshore, or compromise its capacity to protect against coastal flooding and erosion.	Control 23 (p. 33)

Development should be set back a sufficient distance from the coast to provide an erosion buffer (in addition to a public reserve) which will allow for at least 100 years of coastal retreat for single buildings or small scale developments, or 200 years of coastal retreat for large scale developments (ie new townships) unless either of the following applies: (a) the development incorporates appropriate private coastal protection measures to protect the development and public reserve from anticipated erosion; (b) the council is committed to protecting the public reserve and development from the anticipated coastal erosion.	Control 24 (p. 33)
Where a coastal reserve exists or is to be provided it should be increased in width by the amount of any required erosion buffer. The width of the erosion buffer should be based on the following: (a) the susceptibility of the coast to erosion; (b) local coastal processes; (c) the effect of severe storm events; (d) the effect of 0.3 metres sea level rise over the next 50 years on coastal processes and storms; (e) the availability of practical measures to protect the development from erosion caused by a further sea level rise of 0.7m per 50 years thereafter.	Control 25 (p. 33)
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)
Hazards section - flooding	**Reference**
Development should not occur on land where the risk of flooding is likely to be harmful to safety or damage property.	Control 4 (p. 43)
Development should not be undertaken in areas liable to inundation by tidal, drainage or flood waters unless the development can achieve all of the following: (b) buildings are designed and constructed to prevent the entry of floodwaters in a 1-in-100 year average return interval flood event.	Control 5 (b) (p. 43,44)
Development, including earthworks associated with the development, should not do any of the following: (a) impeded the flow of floodwaters through the land or surrounding land, (b) increase the potential hazard risk to public safety of person during a flood event, (c) aggravate the potential for erosion or siltation or lead to the destruction of vegetation during a flood, (d) cause any adverse effect on the floodway/function, (e) increase the risk of flooding of other land…	Control 7 (a-e) (p. 44)
Zone section – Coastal Settlement Zone (Parham, Webb Beach, and Thompson Beach)	**Reference**
The continued development of Parham, Webb Beach and Thompson Beach as minor townships with low-density residential and recreation uses.	Objective 4 (p. 131)

Dwellings should be upgraded to assist environmental improvements, including…reduction of the level or hazard risk.	Control 3 (p. 131)
Coastal Conservation Zone (Middle Beach)	**Reference**
Except where replacing an existing dwelling, residential development should not occur at any of the following locations: (b) Middle Beach	Control 2 (b) (p. 127)
Development should not be located within 100 metres of areas subject to erosion from coastal processes, including storm erosion, and flooding from a 1-in-100 year average return interval flood event including allowance for sea level rise.	Control 11 (p. 128)

The Council operates under the Development Act 1993 and Development Regulations 2008 that requires the Council to refer new development in coastal zones to Coast Protection Board for ‘regard’ or ‘direction’. Usually matters referred to for ‘regard’ are to do with the height that a housing site or floor level is to be set. Matters for ‘direction’ include the implementation of coastal protection works. Coast Protection Board policy since 1991 has been to advise Councils to set floor levels 0.25m above the one in hundred ARI event and an additional 0.3m to allow for sea level rise by 2050. New development should also be able to demonstrate how it will cater for an additional 0.7m sea level rise by 2100.

Prior to January 1994, the Council operated under the Planning Act 1982 and associated regulations. The system of referral was different than the current system with matters referred to external bodies being limited to ‘consideration’ only.

Prior to 1982, the statutory planning environment was provided by the Planning and Development Act 1966. However, DC Mallala was not part of the Metropolitan Planning Area nor part of the Metropolitan Development Plan and therefore the Act had no direct jurisdiction unless DC Mallala had its own development plan, a factor that has not been determined in this study.

4. Investigation of Settlements

In this section each of the settlements are analysed using the investigative framework explained above. This section is to be read in conjunction with Coastal Settlements Adaptation Study – Maps (DC Mallala) 2013. Contributions from the public consultation process are highlighted in green as a way to reference this information appropriately.

4.1 Parham

4.1.1 Settlement history

- **When was Parham established?**

Parham was proclaimed a township on 27 July 1876 by the Governor, Sir Anthony Musgrave. The main reason it was founded was to act as a port. It was named after Mr John Parham who transported the first load of wool by ship from Port Parham to Port Adelaide (Pat Thompson, Dublin History Group, 2013).

- **What obligation did the Council have to take into account impacts from the sea?**

Parham was founded prior to 1967 at which point in time the Mallala area was not part of the Metropolitan Planning Area and also prior to establishment of Coast Protection Act 1972. There was not any overarching statutory requirement for those who established Parham to take into account actions of the sea.

4.1.2 Analysis of existing protection - natural and manmade

The following assessment of natural and man-made land forms that provide Parham with protection from the sea is to be read while viewing the companion set of maps that append this report. Heights are expressed in metres AHD but often the acronym AHD is assumed in the context of the report.

Parham North (North of First Street)

What existing sea-flood protection exists in Parham?

To the west:

Map 1.a Parham North- shows that this part of the settlement has the following natural landforms:

- The Esplanade Road is at a height in this location of approximately 2.20m AHD to 2.5m AHD.
- Protection from the west is provided by a dune having a maximum height of 2.4m to 2.7m between Main Street and North Terrace, and a little higher between Main and First Street at 2.8m to 3.0m. Points are noted on the map where the dune may be lower. The levee is sparsely vegetated (See Figure 7)

- A rubble levee was constructed along the front in the 1960s and Peter Zeider used a front end loader to build up the levee on the southern end of Parham and between First Street and Main Street subsequent to the flood event of 4th July 2007.

Figure 7: Foreshore Parham (North) (Google Maps, 11.08.13)

- The settlement rises uniformly to the east to Driscoll Terrace that is approximately at height 2.80m to 3.30m. The green band on the *Map 1.a* indicates land levels are above 3.0m AHD in these locations.

<u>To the east:</u>

- To the east of the settlement is a significant band of scrubland on a ridge of sandy soil which is well vegetated with trees and shrubs (Figure 8).

Figure 8: Terrain to the east of Driscoll Terrace in Parham (Photo: M Western, 2013)

To the north (*See Map 1.c*):

- *Map 1.c* shows that a dune of approximately 20-40m wide exists along the foreshore. The green band of colour indicates that some of the ridgeline is at 3.0m or above but some locations may be as low as 2.5m height.
- A gully which is likely to have been mined for shell grit in the past lies between the dune and the Esplanade.
- The Esplanade road is at height 2.80m AHD in the north and 2.40m AHD adjacent the camping ground.
- Small acre rural allotments are situated to the east generally at 3.0m AHD and above.
- There is no evidence that sea water traverses from the north to the south behind the settlement and these mudflats are likely to contain rainwater only (*See Map 1.c*).

What flooding or erosion incidents have occurred?

The following incidents have been reported to Council Depot. Incidents that came to light in public consultation of 10th September, 2013 are reported in green.

- In 1968 flood waters entered from the southern end of the settlement at Prime Street and travelled the full length of Parham to North Terrace behind the houses on the Esplanade. Water also traversed the ramp at First Street(See map in Appendix 6).
- In 1980s water flooded around the back (ie. in the same manner as 1968).
- The flood level of 4th July 2007 event was calculated at 2.54m AHD from water stain on ground and using surveying equipment by Alvin Jenkin. Sea water eroded the northern levee and entered from the north between the dune and the Esplanade road and travelled south to towards the camping ground which was inundated by 2 to 3 feet of water. The water lay in the area for a number of weeks and vegetation was damaged, and has not recovered as yet (Source: Keith Earl, Mallala Council). (*See Map 1.c* and Figure 9). Water overtopped the levee/dune between First Street and Main and a 'small amount' of water came over the ramp at South Terrace.

Figure 9: Sea water decimated vegetation in April, 2009 (Photo: M.Western, 2013)

On 25th April 2009, the king tide eroded about 3m of vegetation from the coastline and this has not returned to date (Source: Keith Earl) (See Figure 10).

Figure 10: Vegetation line receded 3m on 25/09/09 and did not return (M Western, 2013)

- On 26th September, 2013 resident Alvin Jenkin estimated the tide height at 2.2m AHD and took photographs of water incursion into car park at the end of First Street, and water encroaching up the boat ramp at end of South Terrace (see also Appendix 7).

Figure 10a: Shelter car park at end of First Street (A. Jenkin, Parham, 26th September, 2013)

Figure 10b: Water encroaching up boat ramp at end of South Terrace (A. Jenkin, Parham, 26th September, 2013)

- While not specifically a marine flood, rain water tends to collect in the road reserves and may exacerbate flooding when the two elements combine. Residents indicated that there have been no incidents where rain water exacerbated sea flooding.

What man-made protection works have been installed in Parham (North)?

Three man-made protection works exist in Parham (North):

- A shell grit levee to approximately 1m high (and at 2.80m AHD approx) was installed between the dune and the Esplanade to halt any future sea water moving south. There have been no further incidents since 2009 (Figure 11). Work was installed in an emergency mode but no retrospective development approval was obtained. Input from residents suggest that this may have been a replacement of a levee rather than a new installation.

Figure 11: Shell grit levee on northern end of Esplanade (Photo: M. Western, 2013)

- The second man-made protection work is a levee that joins the dune and the Esplanade on the northern boundary of the camping ground. This levee has been in place longer than 27 years and presumably installed to stop sea water moving from the north into the camping ground (Figure 12).

Figure 12: Levee on northern boundary of camp ground (M. Western, 2013)

- The dune to the west of the Esplanade is likely to be a combination of natural and man-made protection that has accumulated over the generations and is the third man-made protection in Parham (North). Residents suggested that the levee was installed in 1950s or 1960s on the northern end of Parham (See Parham Map, Appendix 6) and parts of the levee raised in 2007 between First and Main Streets.

<u>Parham South (South of First Street)</u>

What existing sea-flood protection exists in Parham (South)?

<u>To the west:</u>

Map 1b - Parham South shows that this part of the settlement has the following landforms:

- The Esplanade Road is at a height of approximately 2.50m AHD at the corner of First Street and descends to 1.80 m AHD at the roundabout at the southern end (Fig. 13).

Figure 13: Southern end of Parham culminates in a roundabout (Google Maps, 2013)

- Protection from the west is provided by a dune having a maximum height of 2.7m to 3.0m. The green band of colour indicates where the dune is likely to be at height 3.0m or over but some sections of the dune are likely to be no higher than 2.4m (*see Map 1.b*). The dune is densely vegetated on the southern end and access is controlled by fencing. The height of the sand dune was also raised on the southern end of Parham, presumably in 2007 (See Parham Map, Appendix 6 and Figure 14).

Figure 14: Well-vegetated dune on southern end of Esplanade (M. Western, 2013)

- The settlement behind the Esplanade to the east is generally low with Prime Street, which runs parallel to the Esplanade being at height 2.10m AHD in the north grading down to 1.80m AHD in the south.

<u>To the east of Parham (South):</u>

- Behind the settlement to the east is a sandy ridge which is well vegetated and generally at height of 2.80m (Figure 15).

Figure 15: Well-vegetated ridge to the east behind Parham (M Western, 2013)

<u>To the south of Parham (See *Map 1.d Greater South*):</u>

- *Map 1.d* shows that between Parham and Webb Beach is a narrow foreshore dune at heights between 2.0m and 3.0m AHD and intersected by two tidal creeks.
- Behind the foreshore dunes are two more substantial dunes in excess of 3m AHD.
- Behind these dunes are mudflats which are fed by the tidal creeks.
- The mudflats are enclosed by Parham settlement, Parham Point Road, and the ridge upon which Webb Beach road runs. The only point where water can exit the area is in the south-east corner through a culvert under the road (*Map 1.d* and Figure 16).

Figure 16: Culvert under Webb Beach Road (M. Western, 2013)

What flooding incidents have occurred?

The following incidents have been reported to Council Depot. (There may be more incidents that public consultation will bring to light to be included in the final report).

- On 25th April, 2009, sea water broke through the shell grit levee on the roundabout at the southern end of Parham and travelled north along the Esplanade (Figure 17).

Figure 17: Location of break where water entered southern roundabout (M. Western, 2013)

- On 25th April, 2009, the tide broke through the dune system about 50m to the south of the roundabout (Figure 18) and water travelled north-east alongside the shell grit levee. Water entered rabbit boroughs in the levee at the end of Prime Street and the levee collapsed allowing water to flow down Prime at low levels and no damage recorded (Figure 19). Water entered to the rear of two or three houses at the end of Prime Street (Source: K. Earl). On 25th April, 2009, with a south westerly storm, water broke through sand dunes to the south of Parham creating 'a new creek', eroded the levee and entered Prime Street. Water lay on the eastern side of Prime Street. Water also overtopped the levee/dune between First Street and Main Street and a 'small amount of water' came over the ramp at South Terrace (Figures 19a to 19d).

Figure 18: The tide broke through dune 50m south of Parham (M Western, 2013)

Figure 19: Water broke through levee weakened by rabbit boroughs (M. Western, 2013)

The following photographs were obtained by DC Mallala in response to the public consultation process:

Figure 19a: Photo 25th April (Source: DC Mallala community consultation)

The levee in Figure 19a has since been upgraded (see Figure 21).

Figure 19b: Photo 25th April looking south of Prime Street (Source: DC Mallala community consultation)

Figure 19c: Water in Prime Street (Photo 25th April, 2009, DC Mallala Community Consultation)

Figure 19d: Facing to the west along Wilson Street (Photo 25th April, 2009, DC Mallala Community Consultation)

Note the height of the frontal dune system in relation to the level of water in Wilson Street. The 2009 event was approximately 2.4m AHD which did not breech the front levee. However, a higher event would be likely to breech the front levee.

What man-made protection works exist in Parham?

Three man-made protection works exist in Parham (South):

- A shell grit levee has been installed around the southern roundabout. However, this is only 1-3 metres thick and unlikely to withstand flood events. There is a significant height difference from the road (1.80m) within the roundabout to the top of the levee (3.0m approx.). The levee has no record of development approval. The shell grit levee at approx. 3.0m high continues from the roundabout around the rear of Parham (South) (Figure 20).

Figure 20:Shellgrit levee protects the roundabout and continues to east (M Western, 2013)

- The second man-made protection work is a clay levee installed to the rear of Parham (South) in April 2013 at heights 3.25 to 3.15 AHD (Figure 21). Development approval was obtained.

Figure 21: New clay levee installed to rear of Parham April 2013 (Mark Western, 2013)

The new clay levee joins the natural ridgeline to the east of Parham (South) which provides a significant degree of protection to the south and east (Figure 22).

Figure 22: Natural ridgeline to east of Parham joins newly installed levee (M. Western, 2013).

- The dune to the west of the Esplanade is likely to be a combination of natural and man-made protection that has accumulated over the generations and is the third man-made protection in Parham (North). Residents confirmed that the dune was raised on the southern end using sand (presumably in 2007).

4.1.3 Analyse the impact of sea-flood scenarios

What is the likely impact on the settlement of a 2.8m AHD sea-flood event (2013)?

The following issues are likely in Parham if such an event were to occur for a significant length of time (Figure 23):

- The dune/levee system to the west of the Esplanade (north of First Street) would be overtopped and inundate the Esplanade and properties to the east.
- The dune/levee system to the west of the Esplanade (South of First Street) may withstand a 2.8m event as this area is well vegetated and generally at heights 2.8m to 3.0m (*Map 1.b*).
- The shell grit levee on the southern roundabout is likely to be high enough but may not be thick enough to withstand the pressure of water.
- The newly constructed clay levee from the south of Parham that joins with the natural ridge to the east of Parham would withstand this event.
- The shell grit levee at the northern end of the Esplanade may be vulnerable due to its loose constituency (*Map 1.c*).

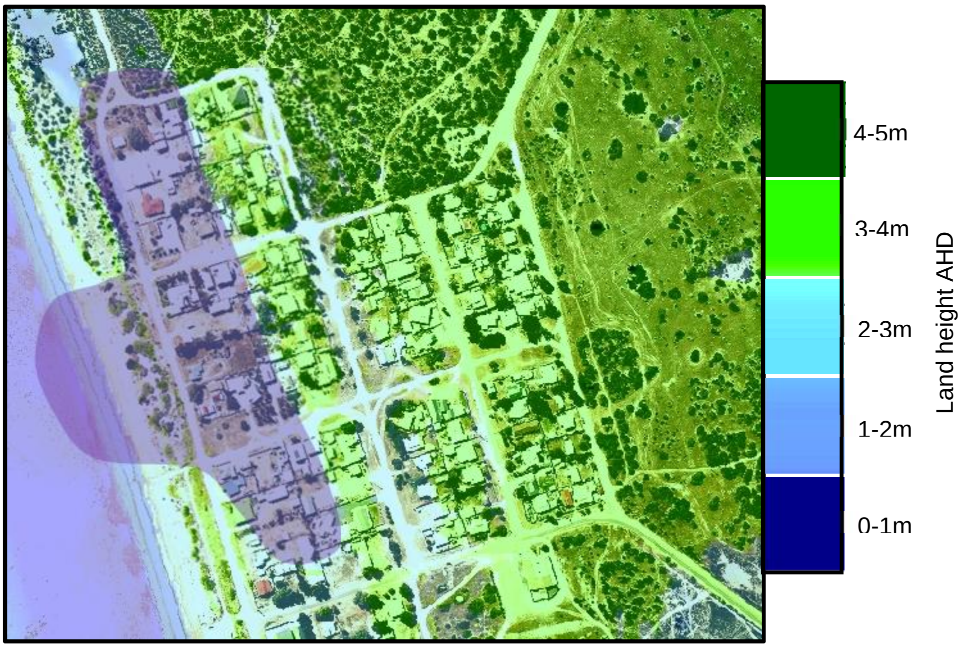

Figure 23: Possible flooding pattern of Parham North in 2.8m event of significant duration

What is the likely impact on the settlement of a 3.0m AHD sea-flood event (2050)?

The flood maps (See *Maps 1.a to 1.d*) illustrate the impact of a 3.0m flood event. The methodology utilised is known as 'bathtub' modelling and takes no account of land forms, man-made or otherwise. Bathtub modelling also does not take into account that the water is tidal and moves in from the west and then recedes within a time frame of about 2 hours. Therefore, while some roads and properties may be lower than the 3.0m event, the water may not encroach this far into the settlement, especially if the time of inundation is short. Irrespective of these factors, the following assessment can be made about Parham's vulnerability in a 3m event (See concept at Figure 24):

<u>Within the Parham settlement:</u>

- The shell grit levee on the northern end of the Esplanade is likely to be overtopped and water travel towards the camping ground (*Map 1.c*).
- The dune/levee system to the west of the Esplanade would be severely overtopped and inundate the Esplanade and residential properties.

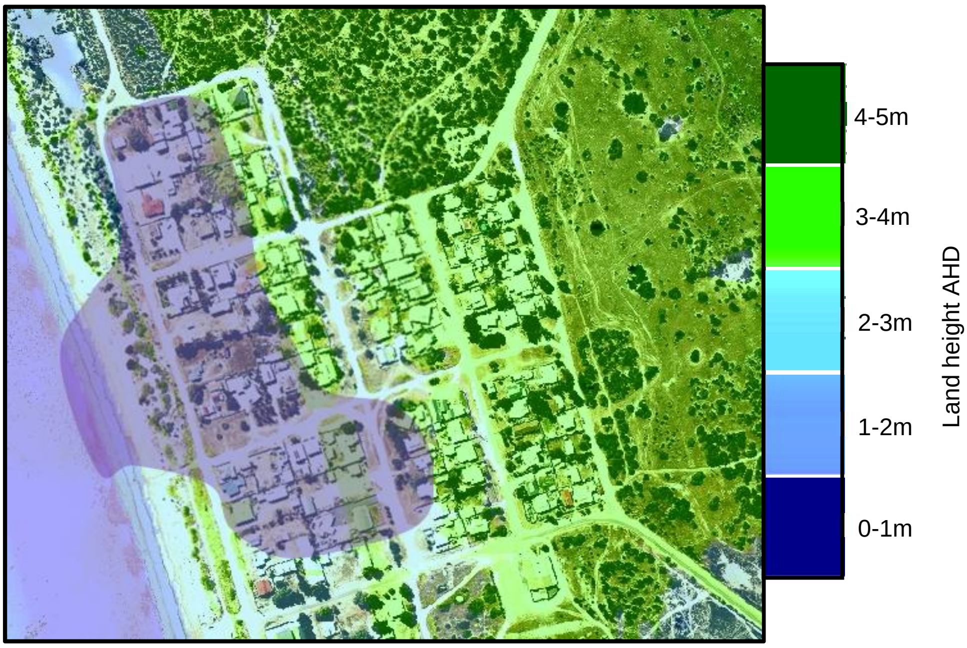

Figure 24: Possible flooding pattern of Parham North in 3.0m event of significant duration.

- The dune/levee system to the west of the Esplanade is higher and well vegetated would fare better, but due to the low points in the dune, water would be likely to enter the settlement. If the event was for a significant duration the following flooding pattern is possible (Figure 25):

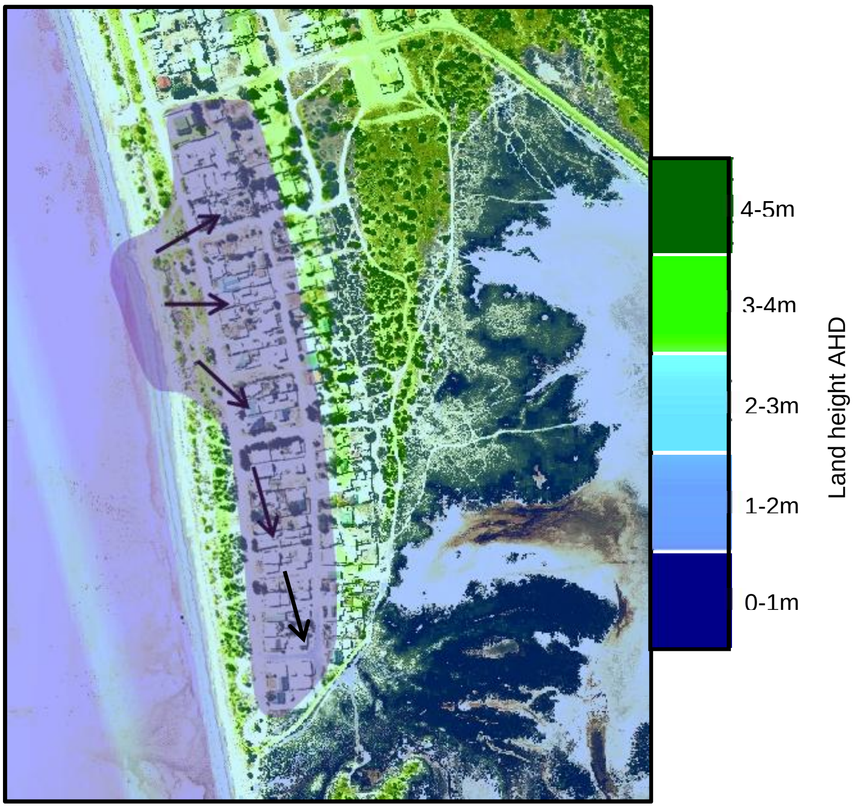

Figure 25: Possible flooding pattern of Parham South if storm event was of significant duration (assumes dune system holds on southern end).

- The southern point of the settlement is protected with a shell grit levee but the levee is quite narrow (less than 2 metres in places) and vulnerable to giving way.
- The eastern side of the settlement is very well protected with a shell grit levee/ clay levee that adjoin a natural ridge line with significant height and vegetation, all of which are at 3.15AHD or higher.

Greater North and Greater South of the Settlement:

It appears unlikely that a 3m sea-flood event would threaten the settlement further to the north or from behind the settlement to the east anywhere north of Point Parham Road (see *Map 1.c*).

In the south it is likely that increased sea level will also increase incursion into the sand dunes between Parham and Webb Beach. This has already been observed (See *Map 1.d*) and it is predicted that without any remediation work, the recent incursions through the dunes 50m south of the roundabout may become a new permanent inlet. If this was to occur other inlets would also eventuate and in time much of the existing dune system to the west may erode away. This would change the nature of the ecology between Parham and Webb Beach from a Samphire mudflat region to a tidal flat. Further research is required to ascertain what long term effects might occur to the human settlement if sea water was to enter this area more regularly and for longer periods of time.

What is the likely impact on the settlement of a 3.7m AHD sea-flood event (2100)?

It is not possible to predict whether the dune systems to the north and south of the Parham settlement would survive to 2100. However, if a 3.7m event were to occur with the existing defences and dune system, Parham would be significantly affected as there are no defences around the town higher than 3.0 m AHD.

4.1.4 Analyse emergency egress and access

In a 3.0m AHD sea-flood could residents move directly away from the source of the flood to a safe place?

Parham (north of First Street)

The grid pattern of streets would provide easy movement away from the sea front. Driscoll Crescent on the east side of the settlement is at 3.00m AHD and this street runs south to the community centre, also the place where Port Parham Road enters the settlement. Thus emergency egress appears feasible in this area (Figure 26).

Figure 26: Potential emergency egress away from place of flood in Parham North

Parham (South of First Street)

The southern side of Parham is more problematic as Prime Street, which is the only street parallel to the Esplanade to the east, has an AHD height of 1.80m AHD to 2.00m AHD. However, Good Street provides an access point to the ridgeline to the east of Parham. Residents could also walk along the newly constructed levee to reach the ridge behind the Parham settlement. However, if an event were to occur at night, navigating through the bushland towards the community centre would be difficult (Figure 27).

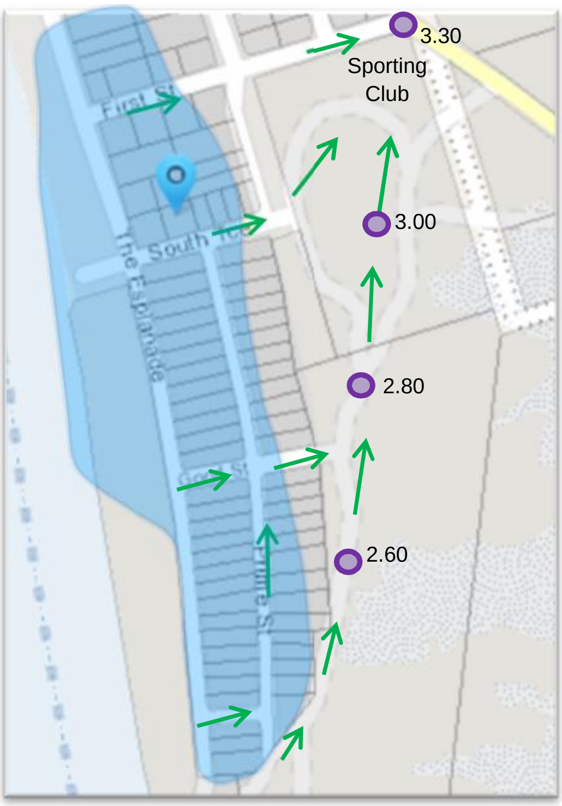

Figure 27: Potential emergency egress away from flood source in Parham South.

In a 3.0m AHD sea-flood event could emergency vehicles access Parham?

Parham (north of First Street)

Access along Driscoll at 3.00m AHD, or even Richardson at 2.80m AHD is predicted to be free of obstacles in this event which would put vehicles in close proximity to all of the houses and therefore emergency access is feasible to Parham (north of First Street). Table 5 delineates the likely access capabilities of the various emergency services.

Table 5: Access capabilities of emergency service vehicles in 3.0m AHD sea-flood.

	Access to the settlement	Maximum likely depth	Access within the settlement	Maximum depth of water within settlement
SES vehicles	Yes	0	Yes	0.6 to 0.8m on Esplanade
SA Ambulance vehicles	Yes	0	Access limited to within 100-150m of Esplanade	0.6 to 0.8m on Esplanade
CFS vehicles	Yes	0	Yes	0.6 to 0.8m on Esplanade

Parham (south of First Street)

The southern side of Parham is more problematic as all roads suffer some inundation in a 3.0m AHD sea-flood event. Table 6 delineates the likely access capabilities of the various emergency services.

Table 6: Access capabilities of emergency service vehicles in 3.0m AHD sea-flood.

	Access to the settlement	**Maximum likely depth**	**Access within the settlement**	**Maximum depth of water within settlement**
SES vehicles	Yes	0	Limitations with standard 4 wheel drive (depending on driver capability). Access ok with 4 wheel drive truck.	1.0m to 1.2m at Wilson Street. Generally 1m throughout
SA Ambulance vehicles	Yes	0	No access to Parham (south of First Street)	1.0m to 1.2m at Wilson Street. Generally 1m throughout
CFS vehicles	Yes	0	Yes	1.0m to 1.2m at Wilson Street. Generally 1m throughout

Residents confirmed that there have been no incidents to date of writing where emergency vehicles were unable to access Parham. Residents indicated that 'there are large problems with access here when flooding (Pt Parham Road and other unsealed roads connecting to Pt Parham Road)'. As Pt Parham Road is higher than 3.0m AHD qualification is required as to whether water overtops Pt Parham Road or this refers to water laying alongside.

4.1.5 Establish profile of assets at risk

This section profiles the range of assets at risk in three main categories: privately owned assets, council owned assets, other owned assets. An accurate profile of assets will assist in decision making when considering adaptation solutions in the second part of this project.

Privately owned assets:

1. Parham – total number of allotments and profile of improvements.

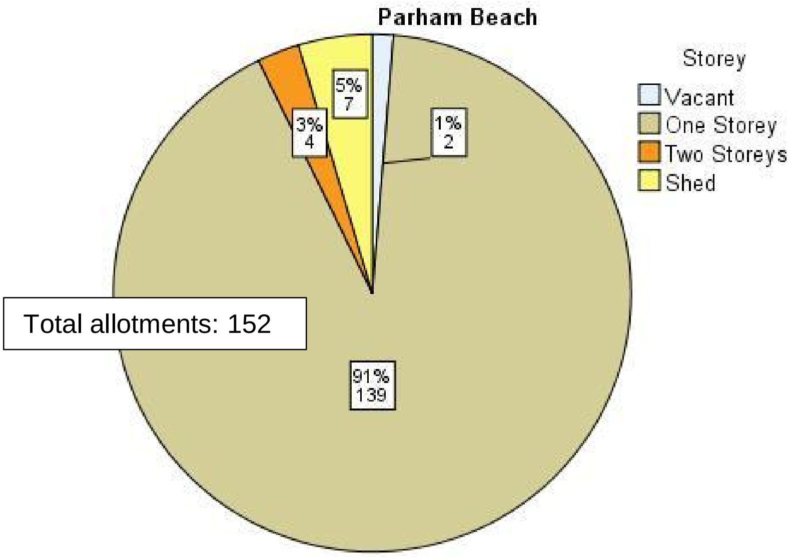

Figure 28: Parham – residential allotments and profile of improvements.

DC Mallala valuation records for 2013 show that the land and buildings are valued at:

Parham – value of residential assets	
Land	To be advised
Improvements	To be advised
Total capital value	$36,722,500

2. Parham – residential foundation types (stump, pole, or concrete).

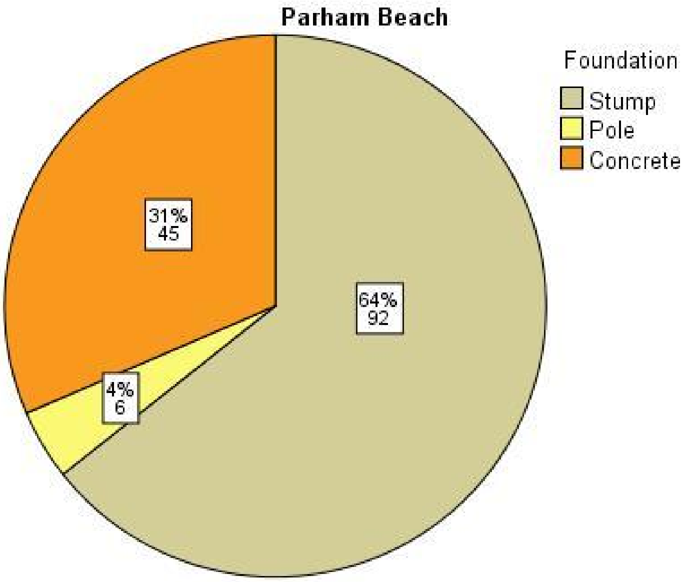

Figure 29: Parham – residential allotments and profile of improvements.

3. Parham – residential construction types*.

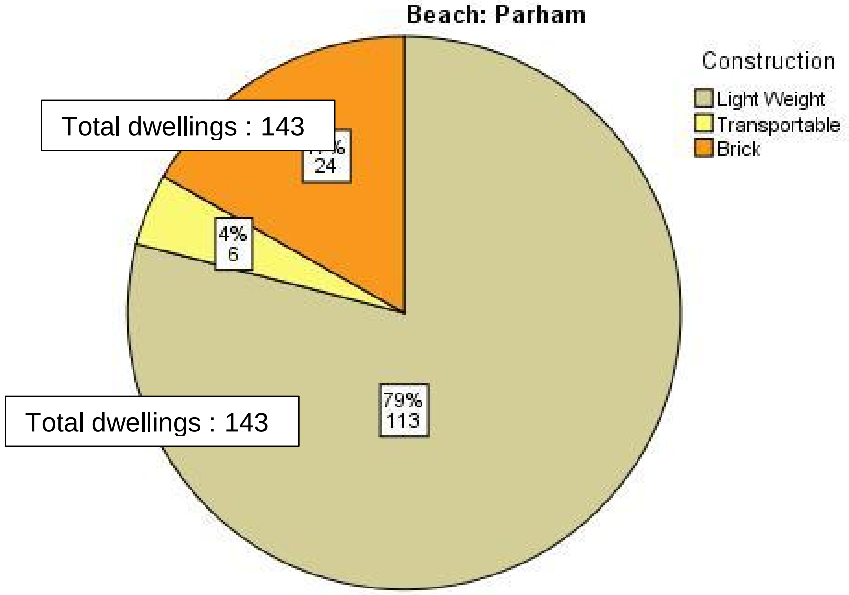

Figure 30: Parham – residential construction types.

*Note: Transportable homes may have been over categorised as light weight construction. However, the main point here is that generally light weight construction and transportable houses are on stumps or poles.

4. Impact on dwellings in selected sea-flood events:

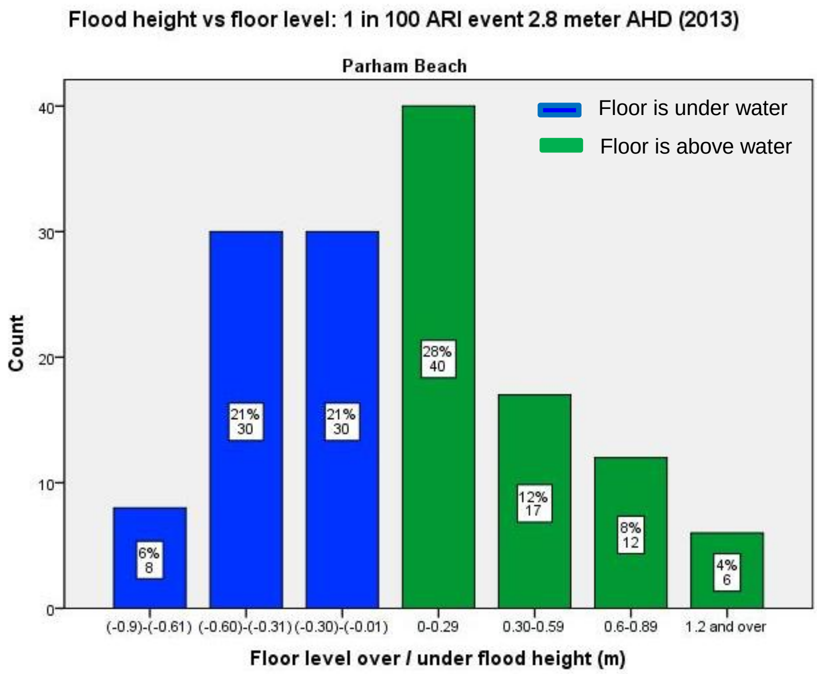

Figure 31: Parham – impact of 2.8m AHD sea-flood event on dwellings.

If the predicted one in one hundred year flood event occurred in 2013, and it lasted for a significant duration of time (and not just a brief overtopping of the dunes), 68 dwellings are likely to be inundated with a potential damage cost of $887,540 (Table 7).

Table 7: Parham 2.8m AHD event – potential residential damage cost.

Parham: Potential damage in 2.8m AHD flood.		
Water over Floor	Dwellings	$ damage
<0.10m	8	$35,680
<0.20m	13	$101,463
<0.30m	9	$100,350
<0.40m	17	$227,460
<0.50m	7	$117,075
<0.60m	6	$120,420
<0.70m	6	$133,800
<0.80m	2	$51,290
	68	$887,540

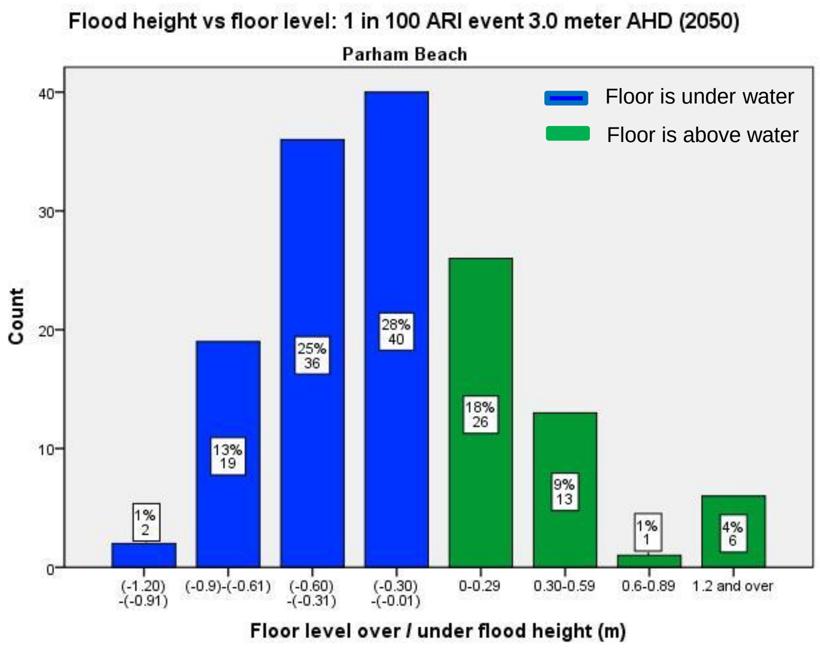

Figure 32: Parham – impact of 3.0m AHD sea-flood event on dwellings.

If the predicted one in one hundred year flood event occurred in 2050, and it lasted for a significant duration of time (and not just a brief overtopping of the dunes), 97 dwellings are likely to be inundated, with a potential damage cost of $1,485,000 (Table 8).

Table 8: Parham 3.0m AHD event – potential residential damage cost.

Parham: Potential damage in 3.0m AHD event		
Water over Floor	dwellings	$ damage
<0.10m	12	$53,520
<0.20m	17	$132,685
<0.30m	11	$122,650
<0.40m	11	$147,180
<0.50m	8	$133,800
<0.60m	16	$321,120
<0.70m	7	$156,100
<0.80m	7	$179,515
<0.90m	6	$173,940
<1.00m	2	$64,670
	97	$1,485,180

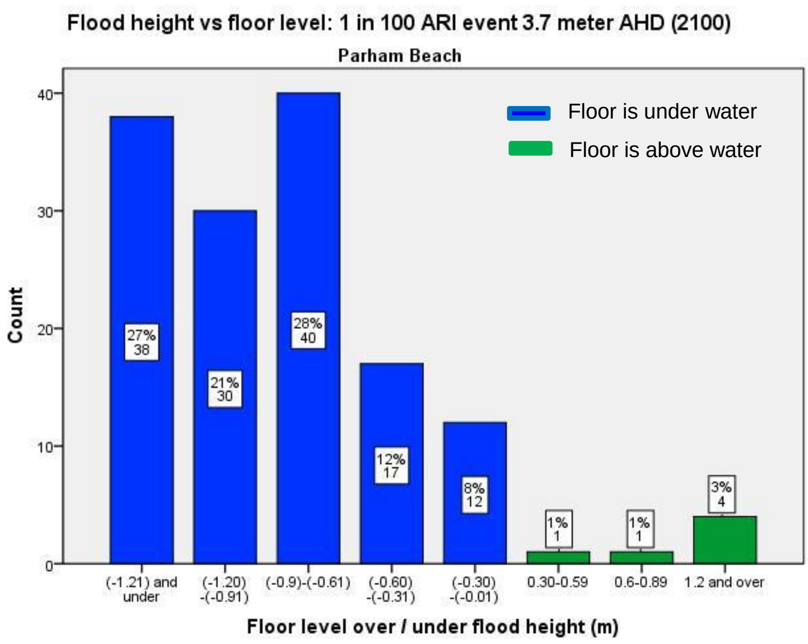

Figure 33: Parham – impact of 3.7m AHD sea-flood event on dwellings.

If the predicted one in one hundred year flood event occurred for 2100, and it lasted for a significant duration of time (in other words not just a brief overtopping of the dunes), only 6 dwellings would remain unaffected.

Council owned assets:

1. Profile of Council owned assets:

DC Mallala's assets in Parham are roads and other assets such as public toilets, shelters, picnic facilities, water tanks, fencing, and playground equipment (See Appendix 2 for an itemised list of Council assets). The Port Parham Sports Club and shedding valued at $1,466,000 are listed on the asset register but noted as 'not owned' by Council, and presumably owned by a 'not for profit' association. DC Mallala's valuation records for 2013 show that Council owned assets are:

Parham: Council owned assets	
Roads	$1,881,939
Facilities and infrastructure	$ 356,000
Parham Sports Club	$1,466,000
Total assets	**$3,703,939**

The value of the flood protection in Parham are not on the asset register. The clay levee installed on the south end of Parham in April 2013 had a construction cost of $20,000. Other levees in Parham are shell grit in construction and no records exist of their valuation.

2. Impact on assets in sea-flood event 3.0m AHD (2050).

Figure 23 and Figure 24 show possible flooding patterns which include the flooding of roads and other Council infrastructure. Infrastructure in the Port Parham Sports Club reserve would not be affected. Most of the Council owned infrastructure would probably exhibit minimal damage in a sea-flood event of 3.0m AHD. Ways to calculate possible cost of damage to roads is to ascertain the length of road affected by flood waters and then multiply the asset value of the road by 5% (Balston et al, 2012) or apply $8350.00 per km of length affected (Victorian Government 2000) but both of these methods appear arbitrary.

Assets owned by others:

Telstra, SA Water, and SA Power Networks have infrastructure in Parham and access to location maps of these are included in Appendix 3. No valuation is available for these assets.

Summary

This section provided an overall picture of the assets in Parham that are likely to be under threat if a 3.0m AHD inundation event occurred. Such an event may not just occur once, but could occur multiple times and therefore damage bills would also be multiple and become more prohibitive. In this sea-flood scenario, the greatest damage cost is likely to be for residential housing, with Council owned infrastructure damage minimal. However, if a 3.7m AHD event were to occur as predicted in the latter part of this century the damage would be significant for both residential, community owned, and Council owned infrastructure. Very few assets would remain untouched by this sea-flood event.

4.1.6 Explore liability issues.

- **What obligations did Council have at the time the settlements were founded in relation to assessing impacts from the sea?**

Parham was established in the late 1800s so there are no obligations or liability to the Council relating to the founding of this settlement.

- **What protection works have been implemented and were they implemented in accordance with approved plans?**

Levee	Install date	Responsibility and liability
Foreshore levee (combined with natural dune)	Unknown	No record of installation. Unlikely to have any maintenance responsibility or liability as levee works are largely indistinguishable from the natural dunes.
North border of camping ground	Unknown	No record of installation. Possible maintenance responsibility due to its obvious proximity to the camping ground.
Shell grit levee at north end of Esplanade	2009	Works were implemented in emergency mode but no retrospective approval was sought. Likely maintenance responsibility.
Shell grit levee at southern end of roundabout	Unknown	No records at Council. Possible maintenance responsibility as it protects the roundabout.
From roundabout to ridgeline behind Parham	2013	Development Application approved but with no conditions in relation to maintenance obligations. Maintenance obligation is likely.

- **Have protection works implemented by Council been breached?**

Yes, see incidents recorded above. There may be potential liability where protection works prove not to have been installed in accordance with approvals, or if there is no inspection and maintenance procedures. It is unlikely that a Council will be held responsible per se´ if a sea-flood exceeds the levee height.

- **In the case of new development within the settlements, have appropriate planning and Coast Protection Board policies been followed?**

Council advises that it has been policy to apply the heights of sites and buildings in accordance with Coast Protection Board advice.

- **Has the Council made available sea level rise data to residents?**

No, but upcoming community consultation will begin this process.

- **Are there any emergency warnings and/or evacuation procedures in place?**

No, and recommendations will be made in the second half of this study.

<u>Summary</u>

In relation to the tort based claims of nuisance and negligence where the payment of damages can eventuate, the following points are relevant to the discussion:

- Parham was subdivided and settled in the late 1880’s so the Council has no liability stemming from the founding of the settlement.

- While there is a general statute that Councils are to act to keep their resident's safe (see Local Government Act) it is unlikely that the Council is legally responsible to implement protection works per se´ and the limit of its direct financial liability is likely be to that of its own assets.
- It is common knowledge that threats can emanate from the sea and those that choose to live near the sea personally accept that risk (similar to those who choose to live in bushfire regions or in earthquake zones).
- In relation to liability with protection works, the Council is likely to have a responsibility to ensure that protection works are adequately maintained in integrity and height, especially for the more recent works.
- While there is no legal responsibility to implement protection works, Councils are likely to have a responsibility to warn their constituents of any danger. Therefore, the Council should make the findings and mapping from studies available to the public.
- Warning systems and evacuation procedures can be implemented and overseen by local resident's associations and also fulfil the Council's responsibility to ensure that residents are as safe as possible.

Administrative appeals may arise out of the solutions proposed to mitigate the threat of increased sea levels and storm surge heights. For example, if the Council were to restrict the types of development that could be approved, appeals to these decisions may be likely. However, recent trend in Court decisions indicates that the Court will give due recognition to climate change related facets of a case.

4.1.7 Summary Table – Parham

Stage	Question	Summary comment
1. Site history	When was the settlement established?	1876
	Were climate change and sea level rise issues relevant?	No, there was no requirement to take into account sea level rise.
2. Existing protection	What existing natural protection exists?	Dunes to the foreshore, ridgelines to the rear of the settlement.
	What breaches have occurred?	Four breaches occurred in 2009. Others have been reported.
	What manmade protection works have been installed into the settlement?	Rubble installed to front dune in 1960s. A shell grit levee on the far north of the Esplanade (2009). A shell grit levee to the north boundary of the camping ground (earlier than 1985). A shell grit levee to the southern roundabout- n.d. (No DA sought for above levees) A clay levee to the rear of Parham connects to the natural ridge (DA approved 2013).
3. Impact of storm events	What is the likely impact for a 2.8m AHD event?	Front dune overtopped on northern end of Parham and more minor in south. Ramps overtopped. Some flooding expected of roads and 68 residential properties.
	What is the likely impact for a 3.0m AHD event?	Front dune overtopped, especially on northern end, but some likely in the south as well. Flooding expected of roads and 97 residential properties.
	What is the likely impact of a 3.7m AHD event?	Front dune, northern levee, severely overtopped. Extensive flooding of roads and 137 properties.
4. Emergency access and egress	Egress issues in a 3.00m AHD event.	Egress is clear in Parham (North), more impeded in the south.
	Emergency vehicle access in a 3.0m AHD event.	Access is ok for most vehicles in Parham (North) but restricted in the south.
5. Profile of assets at risk	What is the likely impact in 3.0m AHD event?	In 2050 flood scenario 97 dwellings may be affected with damage estimated at $1,220,000. Damage to Council assets expected to be minimal.
6. Liability issues	Does liability exist if Council fails to implement protection?	Direct financial liability likely to be limited to the value of its own assets. Check liability relating to protection works, especially those installed in recent years without any development approval.
	Have residents been warned?	Public consultation about to begin.
	Have emergency procedures been implemented?	Not yet.
	Are there conditions relating to the maintenance of protection works	None in writing, but regular maintenance/ checking required.
	Is there a maintenance regime of protection works?	Unknown.

4.1.8 Parham - Other issues raised in public consultation

Public consultation contribution (10th September, 2013):

Mr. A Jenkin (Parham resident and familiar with the area since 1953) stated his opinion that the sea levels appeared to be falling. He admitted that he had no hard evidence but based on observations of the coastline over a long period of time.

Note: Taking into account the opinion of John Cann (p. 6) it should not be discounted that rapid increase in sediment in the area is causing aggradation and prograding of the coastline seaward.

Public consultation question (10th September, 2013):

Where do you see that Parham is vulnerable to flooding from the sea?

- Levee weakness between Main Street and Second Street
- Levee weakness south of Wilson Street (penetrated by the 2007 and 2009 flood)- water broke through here and water stayed in area behind properties

Public consultation question: Any other issues?

- Importance of seaweed and coastal vegetation as buffer (it was noted that in flood events, seaweed accumulated at the front of the flood and prevented water from moving inland).
- Need for larger pipes under road surface on Webb Beach Causeway (prone to clogging by vegetation and become blocked) (See Appendix 6, Map).
- Poor access on Pt Parham Road and other unsealed roads could be addressed by placing larger pipes under the road to direct the flow of water. Currently the small pipes block easily during wet periods and the water stays behind the properties at the south of Parham Beach or floods over the road.

4.2 Webb Beach

4.2.1 Settlement history

- **When was the settlement established?**

Webb Beach was sub divided in the late 1950's or early1960's and the first houses were built in the mid 1960's (Source: Pat Thompson, Dublin History Group, 2013).

- **What obligation did the Council have to take into account impacts from the sea?**

Webb Beach was founded prior to 1967 at which point in time the Mallala area was not part of the Metropolitan Planning Area and also prior to establishment of Coast Protection Act 1972. There was not any overarching statutory requirement for those who established Webb Beach to take into account actions of the sea.

4.2.2 Analysis of existing protection - natural and man-made

The following assessment of natural and man-made land forms that provide Webb Beach with protection from the sea is to be read while viewing the companion maps that append this report. Heights are expressed in metres AHD and often the acronym AHD is assumed in the context of the report.

What existing natural or man-made protection exists in Webb?

<u>To the west:</u>

Map 2a Webb Beach (Settlement) shows the following natural landforms:

- Collins Road at the front of Webb Beach is at a height of approximately 2.00m AHD to 2.45m AHD.
- Protection from the west is provided by a dune having a height of 3.0m to 3.8m and the dune is heavily vegetated (Figure 34). Residents perceived this dune to have been man-made (presumably, partly). The height of the ramp to the beach is 2.90m AHD.
- The settlement rises uniformly to the east to Jury Street that is predominantly at height 2.70m to 3.00m. Green bands on the plan indicate areas 3.00m and above.

Figure 34: Vegetated Dune (Source: Google Maps Street view 11.08.13)

<u>To the east:</u>

- The east of Webb Beach has a significant portion of land at 3.00m AHD that protects it from inundation from behind the settlement.

<u>To the north:</u>

- To the north of George Street is a band of scrubland of varying heights along which the tide flows from the inlet. Areas adjacent George Street are generally low but two ridgelines are likely to exist within the scrub (See *Map 2.a*) (Figure 35).

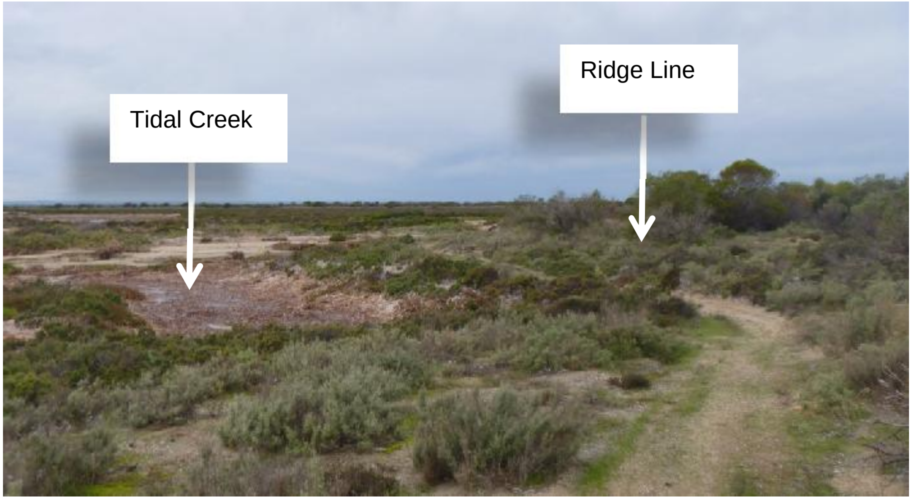

Figure 35: Dune north of Webb Beach Settlement (M.Western, 2013)

<u>To the south:</u>

- Jarmyn Street runs along the southern border of Webb Beach at a height of 2.45 m at the front to 2.53m at the rear (with a hump in the middle at 2.80m). Extensive vegetation exists to the south of Jarmyn Street. However a gully runs from the south-east corner of the settlement and may be susceptible to inundation in the future. A small levee may be situated at the bottom end of this gully (to be confirmed). Residents reported that this is a natural feature and not man-made.

What flooding incidents have occurred?

The following incidents have been reported to Council Depot. (Further incidents uncovered in public consultation are included in green).

- Residents indicated that prior to 2000's there were flooding incidents at Wasley Street (presumably through frontal dunes).
- Residents indicated that there have been two major events – 2007 (ie 4th July, 2007) and 2009 (ie 25th April, 2009) with the event of 2007 'isolating the community' meaning that the causeway was overtopped.
- On 4th July 2007, sea water entered Webb Beach settlement from behind the public toilets and travelled up George Street towards Jury Street (*Map 2.a*).
- On this same day, the shell grit levee that wraps around the north-west corner eroded back a distance of 2-3m (Figure 36).
- On the same day, sea water entered through the inlet directly to the north, as well as through a new inlet south of Webb Beach and crossed the causeway. Residents reported that water traversed the causeway from the east (presume south-east) which indicates that a large volume of water entered through the dunes further south of Webb Beach (see Map 2.b). Residents indicate the causeway has been overtopped twice in ten years, and perhaps six times in twenty years.
- Residents report that the 'boat ramp 'floods quite a bit – maybe 3 or 4 times a year' (presumably this means on the sea side without overtopping).

While not specifically a marine flood, rain water tends to collect in the road reserves after downpours and may exacerbate flooding when rain is combined with a sea-flood event.

What man-made protection works have been installed in Webb Beach?

Two man-made protection works exist in Webb Beach:

- A shell grit levee has been installed to the north-west corner of the settlement and protects the public toilets and tanks as well as the settlement itself from inundation (Figure 36). The shell grit levee has a life of about 4-5 years before needing remedial work (Opinion: Keith Earl, DC Mallala).

Figure 36: Shell grit levee protects north-west corner of Webb Beach (M. Western, 2013)

- Subsequent to the event of 25th April 2009, (Residents suggest 4th July 2007) a shell grit levee at height 3.00m to 2.80m was joined to the aforementioned levee to protect Webb Beach from further inundation (See Figure 37). This levee was installed in 'emergency mode' and development approval was not obtained for these works.

Figure 37: Levee installed in 2009 subsequent to flood event (Photo: M. Western, 2013)

4.2.3 Analyse the impact of sea-flood scenarios

<u>What is the likely impact on the settlement for a 2.8m AHD event (2013)?</u>

By way of comparison, the flood event of 4th July, 2007 was at height of approximately 2.50m AHD. The following issues would be likely in Webb Beach if such an event were to occur:

- The dune/levee system to the west would likely defend the settlement. However, the ramp at 2.90m AHD would be susceptible to overtopping due to its hard surface offering less resistance to water flow (*See Map 2.a)*.
- The east of Webb Beach is elevated at 3.00m or above and no inundation is likely here. However, the access road into Webb Beach would be overtopped by 0.5 to 0.6m cutting off egress and access to the settlement (See *Map 1.d*).
- The northern side of Webb Beach is susceptible to flooding with some portions of natural defences at 2.4m AHD or even lower. The shell grit levee would likely impede some water flow but may not be of sufficient compaction to withstand a large event.
- The southern side of Webb Beach is well vegetated but a 2.8m AHD event may enter the gully on the south-east corner of the settlement which is protected by a small natural levee (see *Map 2.b*).

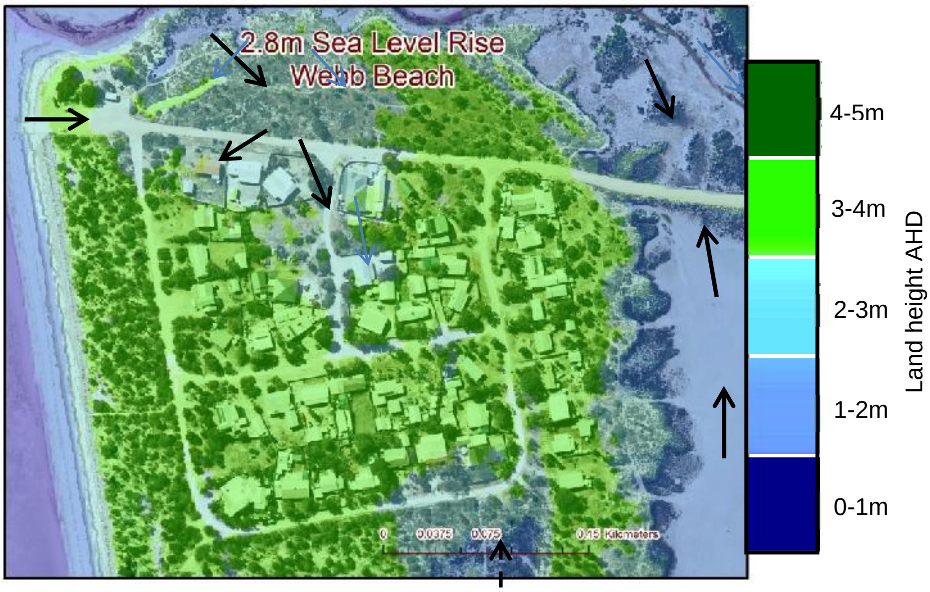

Figure 38: Possible impact of 2.8m AHD event if of significant duration

What is the likely impact on the settlement for a 3.0m AHD event (2050)?

The flood maps (See *Maps 2.a and 2.b*) illustrate the impact of a 3.0m AHD flood event. The methodology utilised is known as 'bathtub' modelling and takes no account of land forms, man-made or otherwise. Bathtub modelling also does not take into account that the water is tidal and moves in from the west and then recedes within a time frame of about 2 hours. Therefore, while some roads and properties may be lower than the 3.0m event, the water may not encroach this far into the settlement unless the event was of significant duration.

Irrespective of these factors, the following assessment can be made about Webb Beach's vulnerability in a 3m event:

Within the Webb Beach settlement:

- The dune/levee system to the west would likely defend the settlement. However, the ramp at 2.90m AHD would be susceptible to overtopping due to its hard surface and less resistance to water flow.
- The east of Webb Beach is elevated at 3.00m AHD or above and no inundation is likely here. However, the access road into Webb Beach would be overtopped by 0.8m and Webb Beach would be cut off (See *Map 1d*).
- The northern side of Webb Beach is susceptible to flooding with some portions of natural defences at 2.4m AHD or lower. The shell grit levee would likely impede some water flow but may not be of sufficient compaction to withstand a large event.
- The southern side of Webb Beach is well vegetated but a 3.0 m event may enter the gully on the south-east corner of the settlement (although water would need to travel from further south and therefore the impact may be lesser).

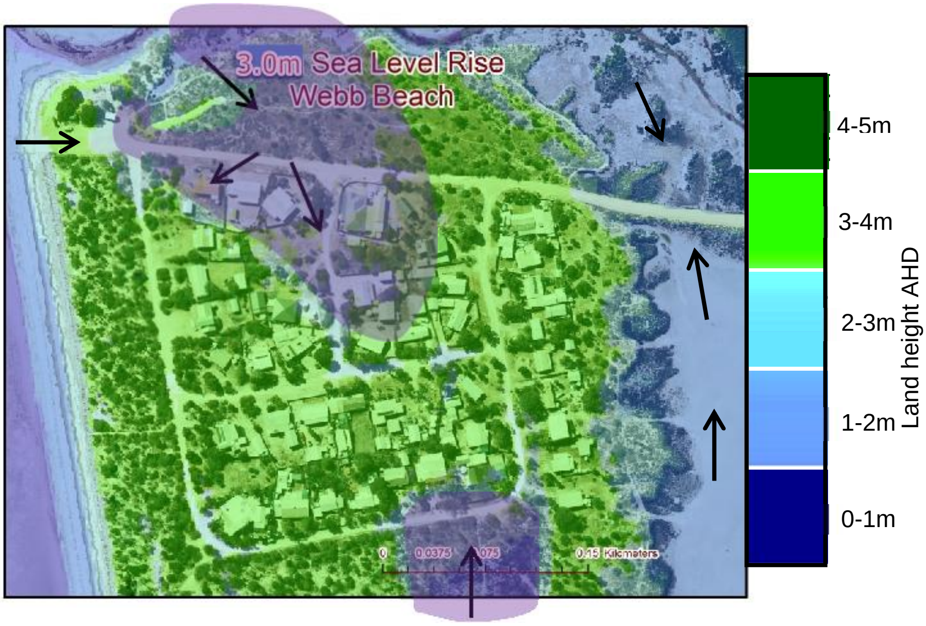

Figure 39: Possible impact of 3.0m AHD event if of significant duration

<u>Greater South of the Settlement:</u>

The area between Webb Beach and Parham has been addressed in the Parham section of the report. To the south it is likely that increased sea level will also bring increased incursion into the sand dunes between Webb Beach and Baker's Inlet. This has already been observed (See *Map 2.b*) and is predicted that without any remediation work, the recent incursion may become a new permanent inlet. If this was to occur other inlets may develop and in time begin to erode the dune. Residents confirm that in 2007 event a large volume of water traversed from the south through the dunes between Webb Beach and Baker's Inlet.

<u>What is the likely impact on the settlement for a 3.7m AHD event (2100)?</u>

If a 3.7m event were to occur with the existing defences and dune system, Webb Beach would be significantly affected as there are no defences around the town higher than 3.0m AHD and therefore the whole settlement would be inundated. It is not possible to predict whether the dune systems to the south of the Webb Beach would survive to 2100. If they did not survive then Webb Beach settlement would largely become an island surrounded by tidal flats.

4.2.4 Analyse emergency egress and access

In 3.0m AHD flood could residents move directly away from the source of flood and move to a safe place?

The grid pattern of streets would provide easy movement away from the flood source. Jury Street on the east side of the settlement is at 3.00 AHD and thus residents could retreat to this location. However, egress from the settlement may be cut off for a period of a few hours preventing residents from leaving the settlement.

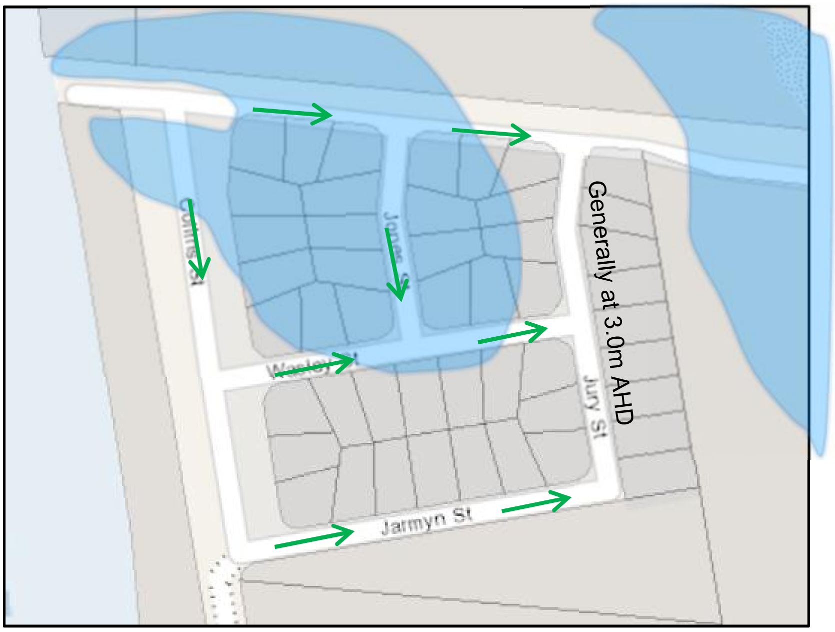

Figure 40: Potential emergency egress pattern of residents

In a 3.0m flood event could emergency vehicles access Webb Beach?

Emergency access via road would be problematic in a 3.0m AHD event as the causeway is at height 2.20m AHD and road would be submerged by 0.8m (See *Map 1.d* and Fig 41).

Table 9: Access capabilities of emergency service vehicles in 3.0m AHD sea-flood.

	Access to the settlement	**Maximum likely depth**	**Access within the settlement**	**Maximum depth of water within settlement**
SES vehicles	Yes, but may depend on driver capability.	800mm	Yes	1m in north-west corner, but generally < 0.5m elsewhere.
SA Ambulance vehicles	No	800mm	Limited.	1m in north-west corner, but generally < 0.5m elsewhere.
CFS vehicles	Yes	800mm	Yes	1m in north-west corner, but generally < 0.5m elsewhere.

Figure 41: Access road into Webb Beach is at 2.20m AHD (J. Kellett, 2013)

4.2.5 Establish profile of assets at risk

Using the methodology reported in Section 1, this section profiles the range of assets at risk in three main categories: privately owned assets, council owned assets, other owned assets. Identifying the different construction types provides appropriate data from which to offer some solutions for adaptation should these be required.

<u>Privately owned assets:</u>

1. Webb Beach - total number of allotments and profile of improvements.

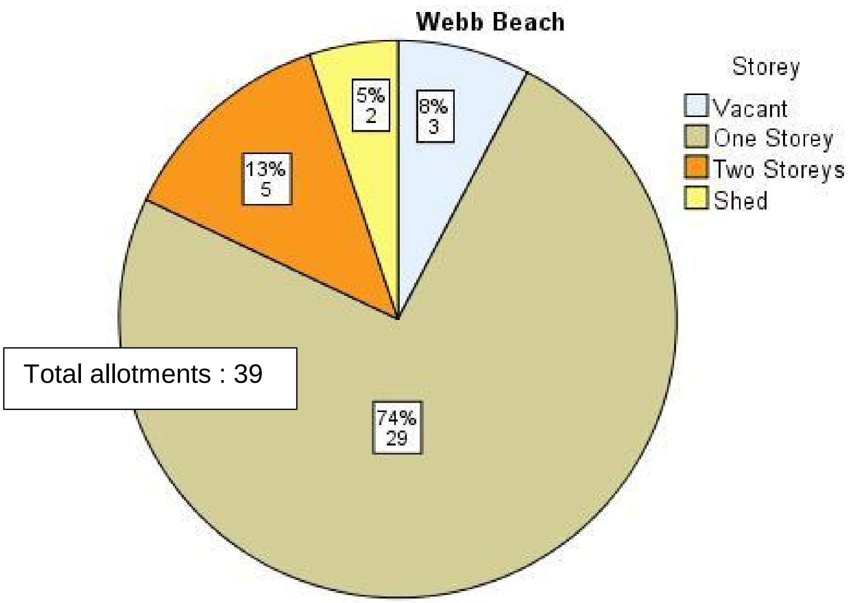

Figure 42: Webb Beach – residential allotments and profile of improvements.

DC Mallala valuation records for 2013 show that the land and buildings are valued at:

Webb Beach – value of residential assets	
Land	To be advised
Improvements	To be advised
Total capital value	$8,064,000

2. Webb Beach - residential foundation types: stump, pole, or concrete.

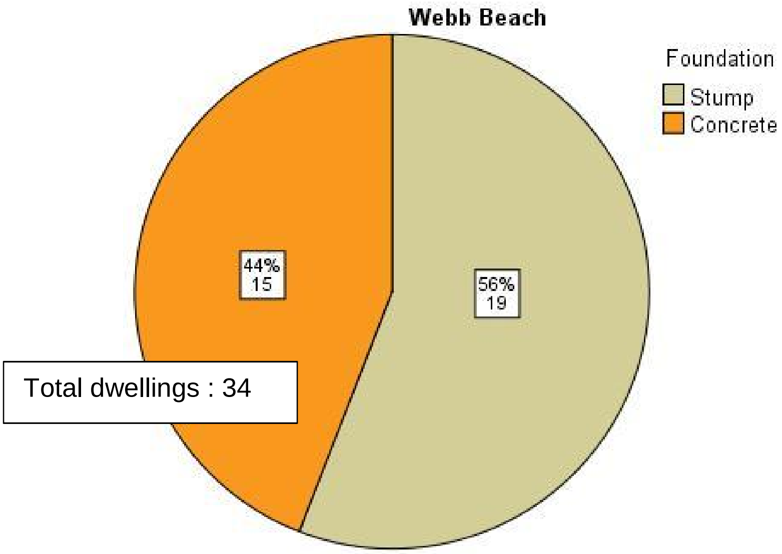

Figure 43: Webb Beach – residential foundation type.

3. Webb Beach - construction types: light weight, transportable, brick.

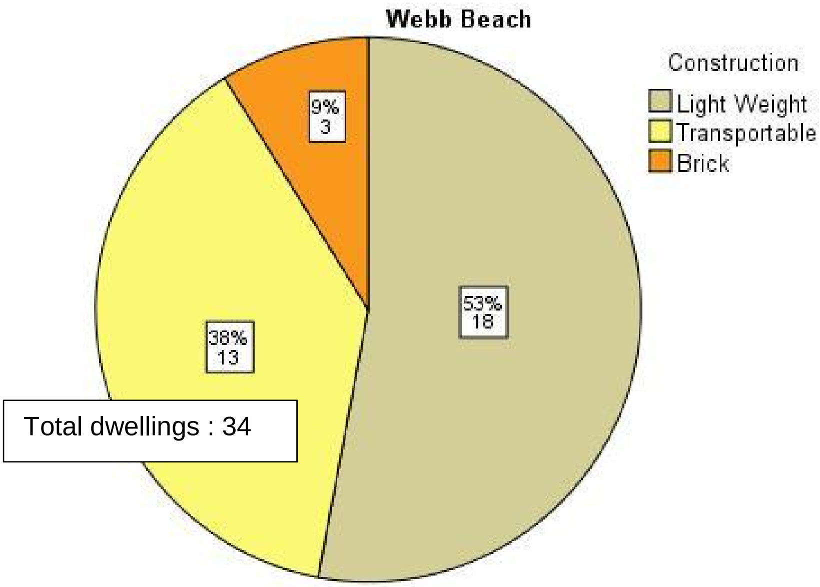

Figure 44: Webb Beach – residential construction type.

*Note: The categorisation of transportable to light weight construction may be interchangeable.

4. Webb Beach: impact on dwellings in selected sea-flood events.

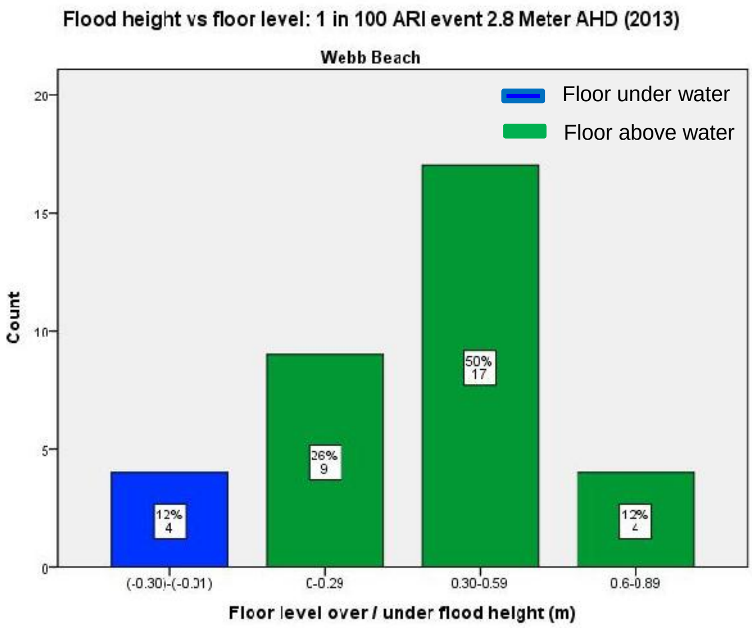

Figure 45: Webb Beach – impact of 2.8m AHD sea-flood event on dwellings.

If the predicted one in one hundred year flood event occurred in 2013, and it lasted for a significant duration of time (and not just a brief overtopping of the dunes), 4 dwellings are likely to be inundated with a potential damage cost of $24,500 (Table 10).

Table 10: Webb Beach 2.8m AHD event – potential residential damage cost.

Webb: Potential damage in 2.8m AHD sea-flood event		
Water over FFL	Number of dwellings	$ damage
<0.10	3	$13,380
<0.20	0	$0
<0.30	1	$11,150
<0.40	0	$0
	4	$24,530

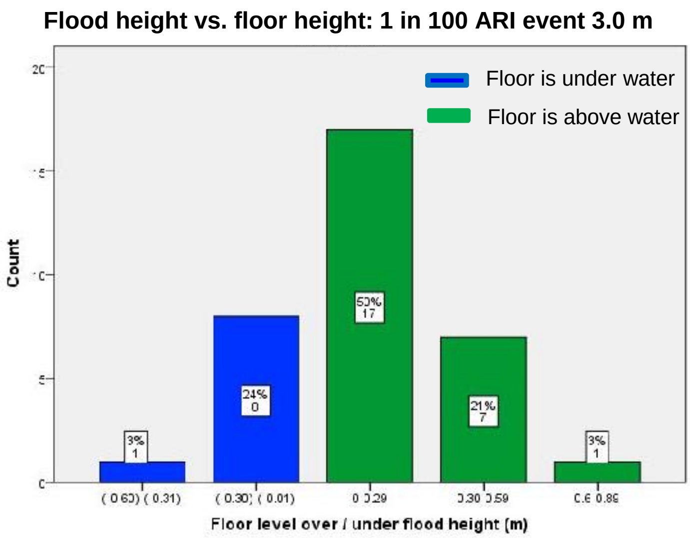

Figure 46: Webb Beach – impact of 3.0m AHD sea-flood event on dwellings.

If the predicted one in one hundred year flood event occurred in 2013, and it lasted for a significant duration of time (and not just a brief overtopping of the dunes), 9 dwellings are likely to be inundated with a potential damage cost of $79,200 (Table 11).

Table 11: Webb Beach 3.0m AHD event – potential residential damage cost.

Webb: Potential damage in 3.0m AHD sea-flood event		
Water over FFL	dwellings	$ damage
<0.10	3	$13,380
<0.20	2	$15,610
<0.30	3	$33,450
<0.40	0	$0
<0.50	1	$16,725
	9	$79,165

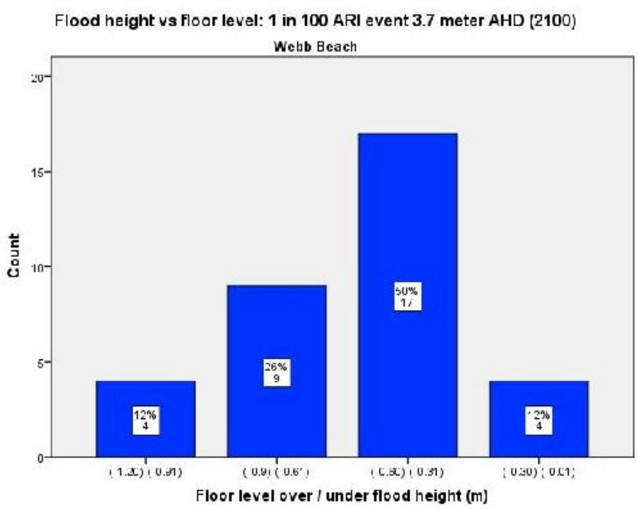

Figure 47: Webb Beach – impact of 3.7m AHD sea-flood event on dwellings.

If the predicted 1 in 100 ARI flood event for 2100 occurred, all dwellings would be likely to have water level over their floor levels, most of these at significant levels. This assessment assumes that the flood duration is significant and not just a short duration of overtopping of dunes or defences.

Council owned assets:

1. Profile of Council owned assets:

DC Mallala's assets in Webb Beach are roads, and other assets such as public toilets, shelters, picnic facilities, and water tanks. (See Appendix 2 for an itemised list of Council assets). DC Mallala's valuation records for 2013 show that Council owned assets are:

Webb Beach: Council owned assets	
Roads	$ 409,137
Facilities and infrastructure	$ 114,000
Total assets	**$ 523,137**

The value of the flood protection works in Webb Beach are not on the asset register and no record exists of their valuation.

2. Impact on assets in sea-flood event 3.0m AHD (2050).

Figure 39 shows possible flooding patterns which include the flooding of roads and other Council infrastructure. Most of the facilities and infrastructure are located behind the shell grit levee to the north-west corner of the settlement which is substantially lower than the top of the levee and inundation is likely to be significant if the levee proved to be inadequate. Ways to calculate possible cost of damage to roads is to ascertain the length of road affected by flood waters and then multiply the asset value of the road by 5% (Balston et al, 2012) or apply $8350.00 per km of length affected (Victorian Government 2000) but both of these methods appear arbitrary.

Other owned assets:

Telstra, SA Water, and SA Power Networks have infrastructure in Webb Beach and maps of these are included in Appendix 3.

Summary:

This section provides an overall picture of the assets at Webb Beach that are likely to be under threat if a 3.0m AHD inundation event occurred. Such an event may not just occur once, but could occur multiple times and therefore damage bills would also be multiple and become more prohibitive. In this sea-flood scenario, the potential damage cost to residential assets is minimal. Flood depth may be over a metre in depth in the north-west corner where most of the Council's infrastructure and facilities are situated.

However, if a 3.7m AHD event were to occur as predicted in the latter part of this century, the damage would be significant for both residential and Council owned infrastructure. Very few assets would remain untouched by this sea-flood event.

4.2.6 Discuss liability issues.

- **What obligations did Council have at the time the settlements were established in relation to assessing impacts from the sea?**

Webb Beach was sub divided in the late 1950's and the first houses were built in the mid 1960's (Source: Pat Thompson, Dublin History Group, 2013).

- **What obligation did the Council have to take into account impacts from the sea?**

Webb Beach was founded prior to 1967 at which point in time the Mallala area was not part of the Metropolitan Planning Area, and also prior to establishment of Coast Protection Act 1972. There was no overarching statutory requirement for those who established Webb Beach to take into account actions of the sea.

- **What protection works have been implemented and were they implemented in accordance with approved plans?**

Levee	Implementation Date	Responsibility and liability
Levee to north-west corner	Unknown	Council staff monitor and top up as necessary. Unlikely to have required DA.
Shell grit levee to adjoin abovementioned levee	2009	Levee was implemented under emergency conditions. DA not obtained. A possible liability to Council may exist if another event caused the levee to fail.

- **Have protection works implemented by Council been breached?**

Yes, see incidents recorded above. There may be potential liability where protection works prove not to have been installed in accordance with approvals, or if there is no inspection and maintenance procedures. It is unlikely that a Council will be held responsible per se´ if a sea-flood exceeds the levee height.

- **In the case of new development within the settlements, have appropriate planning and Coast Protection Board policies been followed?**

It has been Council policy to apply the heights of sites and buildings in accordance with Coast Protection Board advice.

- **Has the Council made available sea level rise data to residents?**

No, but upcoming community consultation will begin this process.

- **Are there any emergency warnings and/or evacuation procedures in place?**

No, and recommendations will be made in the second half of this study.

Summary

In relation to the tort based claims of nuisance and negligence where the payment of damages can eventuate, the following points are relevant to the discussion:

- Webb Beach was subdivided and settled in the late 1950s and mid 1960s so the Council has no liability stemming from the founding of the settlement.
- While there is a general statute that Councils are to act to keep their resident's safe (see Local Government Act) it is unlikely that the Council is legally responsible to implement protection works per se´ and the limit of its direct financial liability is likely be to that of its own assets.
- It is common knowledge that threats can emanate from the sea and those that choose to live near the sea personally accept that risk (similar to those who choose to live in bushfire regions or in earthquake zones).
- In relation to liability in particular to protection works, the Council is likely to have a responsibility to ensure that protection works are adequately maintained in integrity and height
- However, while there is no legal responsibility to implement protection works, Councils are likely to have a responsibility to warn their constituents of any danger. Therefore, the Council should make the findings and mapping from studies such as this one available to the public.
- Warning systems and evacuation procedures can be implemented and overseen by local resident's associations and also fulfil the Council's responsibility to ensure that residents are as safe as possible.

Administrative appeals may arise out of the solutions proposed to mitigate the threat of increased sea levels and storm surge heights. For example, if the Council were to restrict the types of development that could be approved, appeals to these decisions may be likely. However, recent trend in Court decisions indicates that the Court will take into account climate change related facets to a case.

4.2.7 Summary Table – Webb Beach

Stage	Question	Summary comment
1. Site history	When was the settlement founded?	Late 1950s to mid1960s.
	Were climate change and sea level rise issues relevant?	No, there was no requirement to take into account sea level rise.
2. Existing protection	What existing natural protection exists?	Dunes to the foreshore, ridgelines to the rear of the settlement.
	What breaches have occurred?	Several – including in 2007, 2009.
	What man-made protection works have been installed into the settlement?	A shell grit levee to protect the north-west corner (no DA required). A shell grit levee running south of the aforementioned levee (no DA).
3. Impact of storm events	What is the likely impact for a 2.8 m AHD event?	Northern dunes overtopped. Confined flooding expected of roads. Minimal flooding of 4 residential properties. Settlement cut off from mainland.
	What is the likely impact for a 3.0 m AHD event?	Northern dune and ramp overtopped. Flooding expected of roads and infrastructure. Flooding of 9 residential properties. Settlement cut off from mainland.
	What is the likely impact of a 3.7m AHD event?	Front dune, northern dune severely overtopped. Extensive flooding of roads and properties. Settlement cut off.
4. Emergency access and egress	Egress issues in a 3.00AHD event	A safe place exists on the eastern side but egress to the mainland cut off.
	Emergency vehicle access in a 3.0m AHD event.	No access.
5. Profile of assets at risk	How many residents are likely to be affected in 3.0m event?	In 2050 flood scenario 9 dwellings may be affected with damage estimated at $79k. Damage to Council assets expected to be minimal.
6. Liability issues	Does liability exist if Council fails to implement protection?	Direct financial liability likely to be limited to the value of its own assets. Check liability relating to protection works, especially those installed in recent years without any development approval.
	Have residents been warned?	Public consultation about to begin.
	Have emergency procedures been implemented?	Not yet.
	Are there conditions relating to the maintenance of protection works	None in writing, but regular maintenance/ checking required.
	Is there a maintenance regime of protection works?	Under investigation.

4.2.8 Webb Beach – other issues raised in public consultation

Residents indicated that they perceived their settlement to be most vulnerable at the boat ramp and west of Jarmyn Street.

Note: The DEM indicates that the elevation of the ground west of Jarmyn Street is at 3.0m AHD or higher but this aspect needs to be followed up.

4.3 Thompson Beach

4.3.1 Site history

- **When was Thompson Beach established?**

Thompson Beach was founded in the late 1980s. Development Applications 312/162/83 related to the southern portion of Thompson Beach and Stage 2, 312/D033/85 is assumed to relate to the were considered under the Planning Act 1982 and against the provisions of the DC Mallala Development Plan. Photographs taken in 1983 provide a view of Thompson Beach in its natural state (Figure 48 and 49) .

Figure 48: Thompson Beach looking south-west, 1983 (Source: DC Mallala)

Figure 49: Thompson Beach looking north-west, 1983 (Source: DC Mallala)

- **What obligation did the Council have to take into account impacts from the sea?**

The planning authority was the DC Mallala[7]. An Environmental Impact Study (EIS) was completed in two stages, the first on 8th May 1985, and in response to the submissions received in the consultation process, the developer issued a supplement to the original EIS dated 29th November 1985. Flooding issues were addressed in both of these documents

[7] Despite the Planning Act 1982 stating that in the case where an Environmental Impact Study was commissioned then the SA Planning Commission would be the planning authority, DC Mallala was the planning authority. (It is possible that due to the original application being lodged in 1983 that the Planning Act 1982 did not have this statute at the time).

and a system of flood mitigation was detailed in the second one. As part of the process, the EIS was referred to the Coast Protection Board. The Planning Act 1982 in Section 49 (7) states that the planning authority must have 'regard' to any EIS that is officially recognised by the Minister before giving consent. There were powers for the Minister to make amendments to the EIS but this right was not exercised. A submission by Bone and Tonkin Planners dated 1st August 1985 explains how the EIS and approval system operated at the time and conclude 'the planning authority then having regard to the EIS, is to determine whether consent should be granted to the development and if consented to, what conditions should be applicable to that consent'. An interview with Rob Tucker (Coast Protection Board, 13th August, 2013) affirmed that the Council had a responsibility to take 'advice' only. He also confirmed that planning authorities did not need to take account of sea level rise until 1994 under Development Act 1993.

In summary, the Council was required to take into account flooding potential as part of the EIS process but had the authority to make its own determination. There was no statutory requirement to take sea level rise into consideration at the time of approval. This matter is explored further under Section 4.3.6 below.

4.3.2 Analysis of existing protection - natural and man-made

The following assessment of natural and man-made land forms that provide Thompson Beach with protection from the sea is to be read while viewing the companion maps that append this report. Heights are expressed in metres AHD but often the acronym AHD is assumed in the context of the report.

Thompson North (North of Ruskin Road)

What existing sea-flood protection exists in Thompson Beach (North) ?

To the west:

Map 3.a Thompson (North) - shows that Thompson (North) has the following landforms:

- The Esplanade Road north of Ruskin Road is generally at height of 3.00m AHD to 3.4m AHD with one section on the northern end being at 2.80m AHD.
- Protection from the west is provided by a substantial natural dune having a maximum height in excess of 4m in the north and 3.0m or over near Ruskin Road in the south. The dune is well vegetated (Figure 50).

Figure 50: Esplanade and dune (Thompson North) (Google Maps Street view 15.08.13)

- Traversing inland, the level of land remains above 3.0m AHD, but declines in height east of Kestrel Ave (See *Map 3.a*). The green colour on the map below shows elevations of 2.80m AHD and above and gives a picture of the general topography of the settlement (Figure 51).

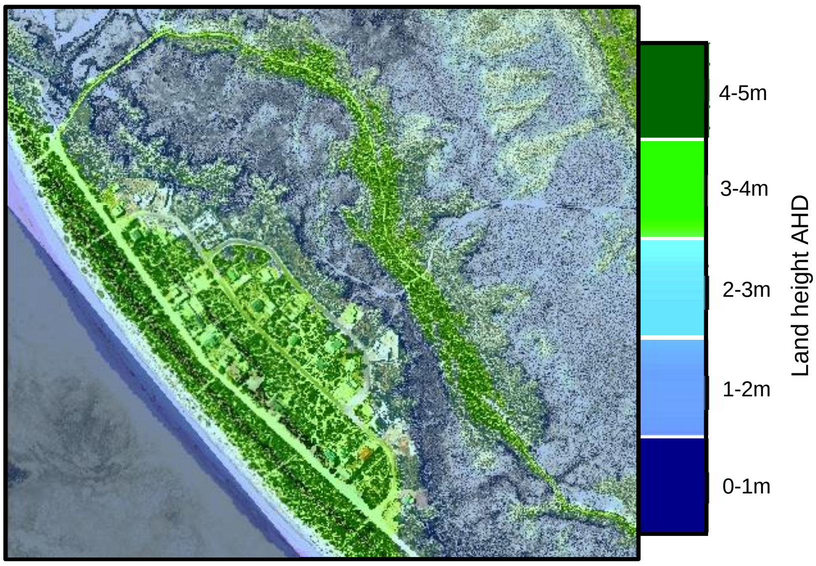

Figure 51: General topography Thompson Beach (North). Settlement is at 2.8m or above, apart from houses to the eastern side

<u>To the east (See *Map 3.d*):</u>

- To the east of the Thompson Beach (North) are samphire mudflats generally at 1.6m AHD. Across the mudflats to the east of Thompson Beach North is a natural dune system generally at heights 3.00AHD but with some lower spots (*Map 3.a)*.
  .
- *Map 3.d -Thompson Beach (Levee system North)* shows the man-made levee that connects the Thompson Beach settlement with the natural dune to the east (See Figure 52) . The plans for the settlement show that some sections of the natural dune were to be raised so as to ensure that protection was at constant height of 3.0m AHD but some of these sections appear to be lower than this at 2.70m or 2.60m AHD.

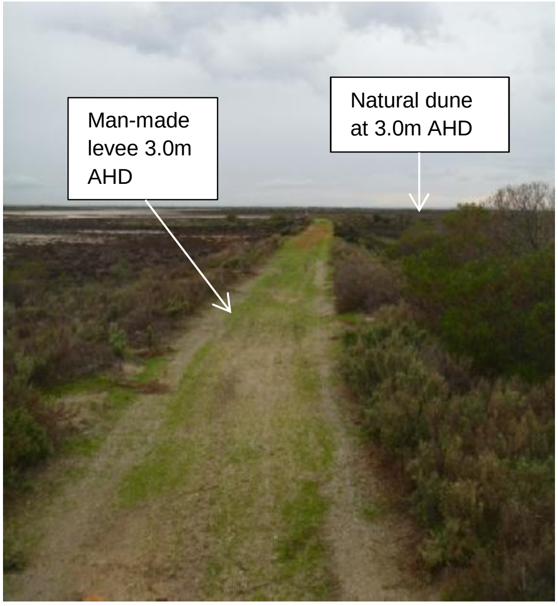

Figure 52: Man-made levee connects the settlement with natural dune system to the east.

- Ruskin Road to the south encloses the levee system so that the rear of Thompson Beach (North) is generally protected at 3.0m AHD. This system protects the rear of Thompson Beach settlement and although dwellings appear to be inundated by the bath tub flood modelling, they are not likely to be subject to inundation.

To the north (See *Map 3.f*):

- *Map 3.f -Thompson Beach (Greater North)* shows that approximately 400m north of the northern levee the dune on the coastal front narrows, and is less vegetated. Generally the height of the dune is at 2.5m AHD but there is one opening at 1.7m AHD through which higher tides may be entering (in excess of 3.0m Chart Datum). Residents confirm that water enters through this inlet, but suggest there are two inlets between Thompson Beach and Baker's inlet, with a second inlet 1km further north of Thompson Beach settlement.

Thompson Beach South (south of Ruskin Road)

What existing sea-flood protection exists in Thompson Beach (South)?

- **General topography**

The green colour on the map below shows a height 2.80m AHD and above, and gives a general picture of the topography of the settlement south of Ruskin Road (Figure 53).

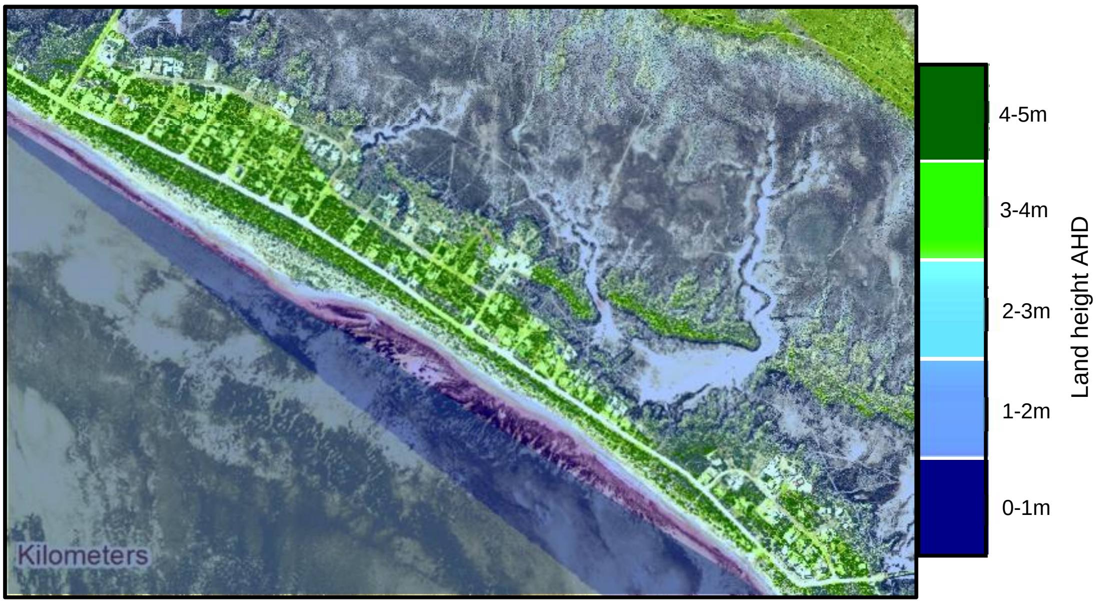

Figure 53: General topography of Thompson Beach (south of Ruskin Rd).

- **Proposed flood protection levees**

The EIS Supplement dated 1st May 1985, specified two basic construction methods for a levee along the foreshore: the first where the height required to be raised was less than 0.5m above the natural dune, and the second where the height required was more than 0.5m. A third method was detailed to be used on the 'Southern Road' section (See Figures 54, 55, and 56). The levees were to be constructed in the road reserve and not encroach into the Crown land on the foreshore (p. 11,12).

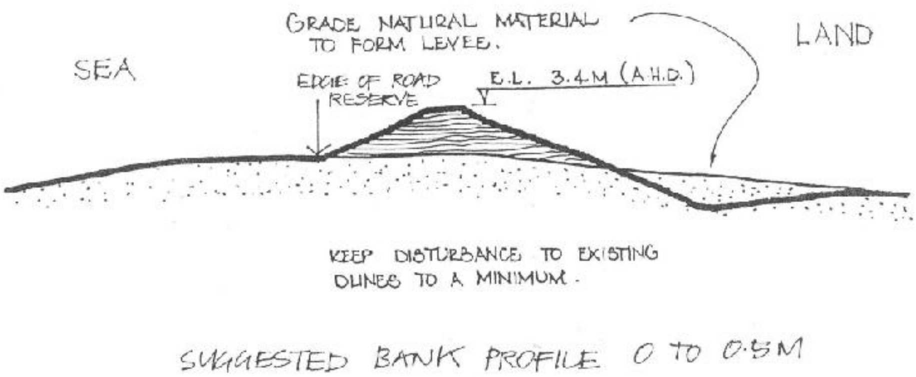

Figure 54: Construction method when raising by less than 0.5m above natural dune. Note R.L. height of 3.4m AHD and the methodology was to 'grade natural material' to the 'edge of the road reserve'.

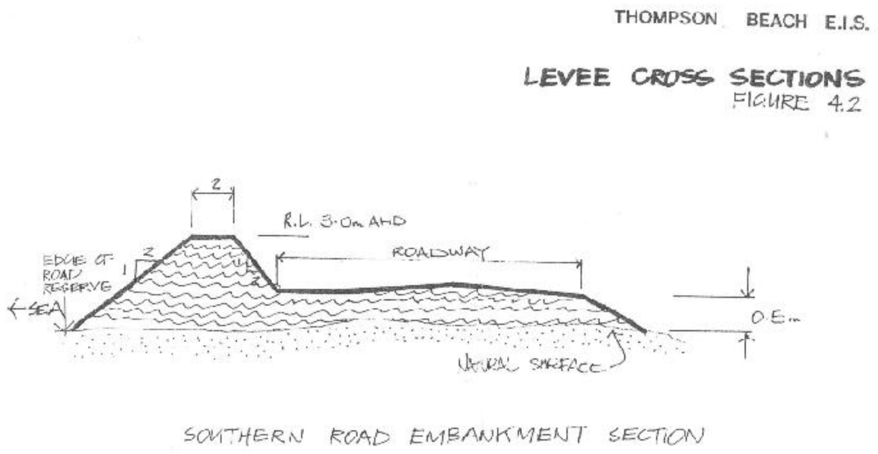

Figure 55: Construction method to be utilised for the 'Southern Road Embankment' when raising by less than 0.5m above the natural dune but in this diagram the road is also raised 0.5m. Note R.L. height of 3.0m AHD for the top of the levee. It is not entirely clear where the 'southern road' embankment section is located.

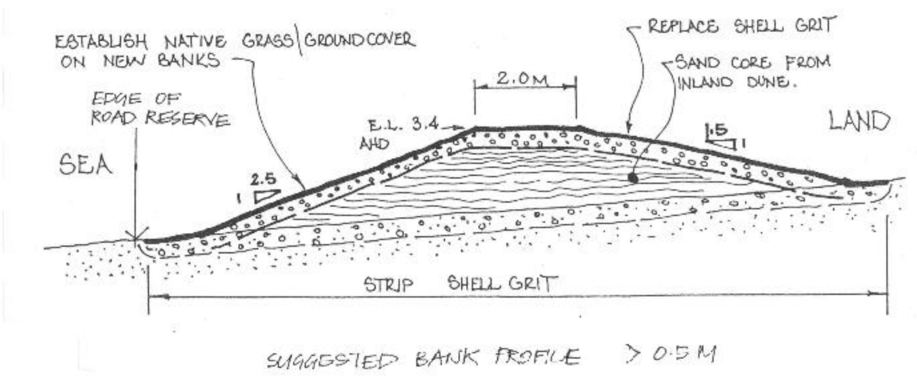

Figure 56: The second construction method was to be utilised when the required levee height is greater than 0.5m. Note that 3.4 AHD is the proposed height. Also note that the construction is more intensive. Shell grit was to be stripped from the dune, new material imported from an inland dune as a 'core', and shell grit then replaced on top of the levee.

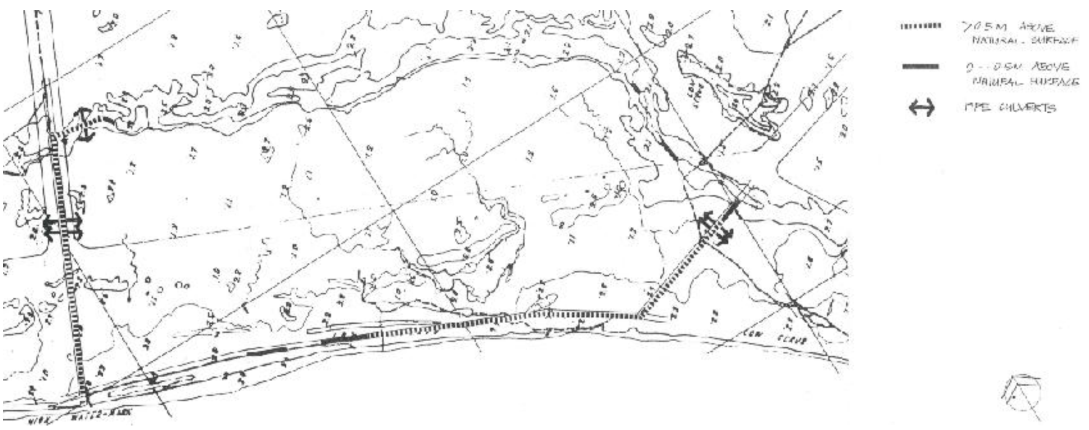

Figure 57:The levee plan from the EIS Supplement shows that a vast proportion of the levee bank was to be installed at the > 0.5m above natural surface, ie construction method 2.

The EIS Supplement states that original advice from the Coast Protection Branch was that, while the original proposed levee in the draft EIS 'approached a safe height', it "may be prudent to allow an additional 0.2 to 0.3m for settlement and for construction inadequacies, and also to take account of the slightly higher tide figures, and for wave action'. The EIS then states that 'the proponent has decided to accept that advice and err on the side of caution in adopting a 3.4m AHD height for the frontal levee' (p. 12). The EIS states that 3.0m AHD would be adopted for the inland levee because the great majority of the natural dune was at that height or above.

- **How was the levee system installed?**

Plans marked as DA 312/162/83 and held at DC Mallala (undated and unstamped) show that the R.L. height AHD of all levees is specified at 3.0m AHD. The correspondence between the developer[8] and various Government departments indicates that subsequent to the submission of the EIS Supplement, the developer showed intent over a number of years to install the levee at a height of 3.0m AHD. There are also at least two references by the developer stating that if the levees were to be constructed higher than 3.0m AHD, significantly more vegetation would need to be removed. This would indeed be the case, as to raise the levee higher than 0.5m above the natural dune, construction 'method two' would have to have been utilised. This method required the removal of shell grit and vegetation (Figure 56). The photo below taken in 1992 demonstrates that the developer was utilising 'method one' in this section of the levee but the width of the top of the levee does not appear to be 2m as specified. The conclusion is that the levee to the front dune was installed at height of 3.0m AHD (Figure 57).

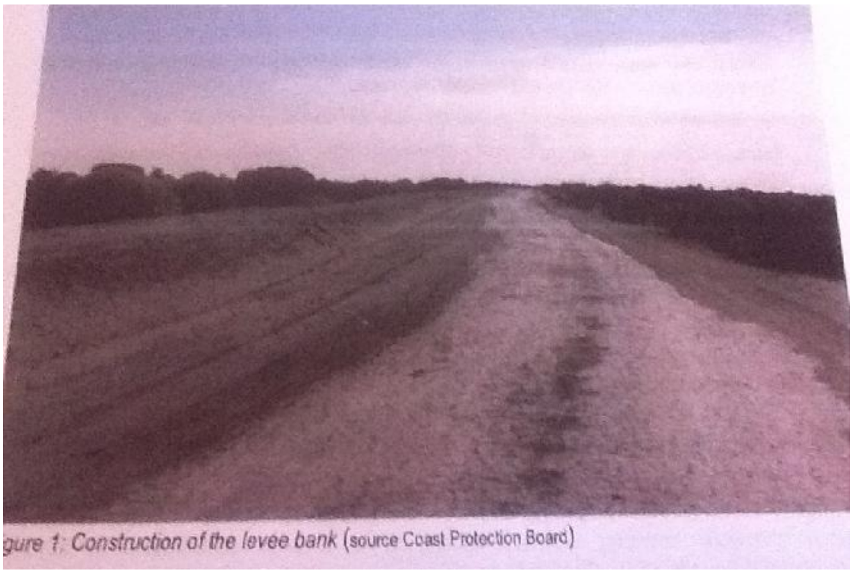

Figure 57: Construction of levee bank in 1992 (Source: Pat Thompson, Dublin History Society).

[8] The term 'developer' in this study refers to Cape Investments Pty Ltd, or its directors, or any personnel acting for the developer (such as a consultant).

- **Review of survey in 2008**

The results of a survey from Ruskin Road to the southern end of the Esplanade commissioned by DC Mallala in 2008 support the notion that the developer only used construction method one (See Appendix 4). From Ruskin Road corner to Sandpiper Drive corner (southern end) the main dune on the foreshore is at 3.0m AHD and above and there is no evidence of a roadside levee. From Sandpiper Drive corner (southern end) to the next walkway to the south there is no roadside levee and the dune in places may be as low as 2.60m AHD. The Esplanade rises in height to 2.80m AHD as it approaches the Petrel corner and this is also the place that the roadside levee begins. The roadside levee is generally at height of 3.0m AHD for the rest of the Esplanade to the south, with only a few sections dropping to 2.80m AHD. The conclusion drawn from this survey is that the developer installed a levee at height 3.0m AHD along the road reserve using construction method one. It is unlikely that any work was done in the main dune.

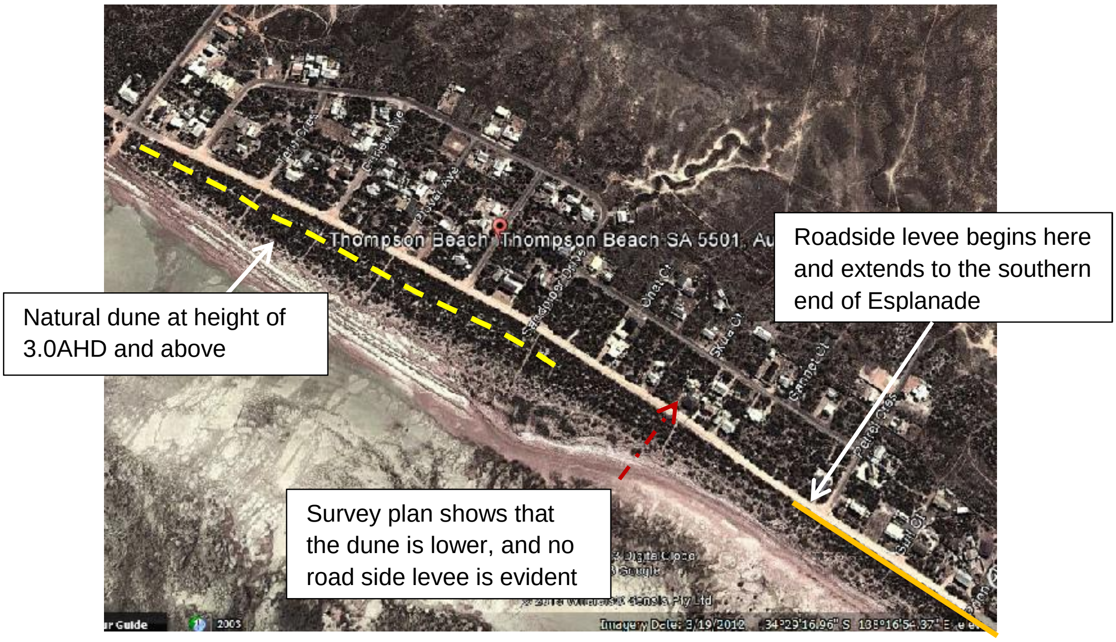

Figure 58: Dune and levee configuration south of Ruskin Road (Google Maps, 16.08.13).

Figure 59: Dune and roadside levee at corner of Petrel and Esplanade (Google Maps, 16.08.13)

- **Review of Digital Elevation Map (DEM)**

Map 3.d confirms that the levee height is above 3.0m AHD from corner of Ruskin Road to Sandpiper Road(southern end). Between Sandpiper Road and Petrel Road the map is less certain although there are significant green patches that indicate 2.90m to 3.0m AHD or above. The DEM does not have enough resolution to verify the height of the roadside levee.

To the east (*Map 3.e – Thompson Beach (Levee system South)*):

- Behind the settlement is similar ecology and topography to the northern side of Ruskin Road but the distance back to the natural dune to the east is 600m.

- Ruskin Road acts as a levee to the north. The natural dune system south of Ruskin Road and 600m east of the settlement is mostly at height 3.0m with some spots a little lower at 2.60m AHD (See *Map 3.e)*. The original plans show that this dune system was to be elevated in places. A levee on the southern end of Thompson Beach connects the settlement with the natural dune to the east. The levee is at 2.5m AHD, despite the plans detailing a height of 3.0m AHD (Figure 60).

Picture 60: Man-made levee at 2.5 m AHD connects to natural dune (M. Western, 2013)

To the south (*Map 3.g – Thompson Beach (Greater South)):*

- *Map 3.g* shows that an extensive dune of approximately 150m wide is situated directly to the south of the settlement at heights between 2.60m and 2.80m AHD. Still further south, about 1.5kms from Thompson Beach settlement is Third Creek inlet (not shown on Map 3.g). It is not known if water has ever traversed from Third Creek inlet to the southern man-made levee (Figure 60). Residents indicate that water has traversed from Third Creek 'four times in twenty years'.

What flooding incidents have occurred?

There have been no reports of any breaches of the defences since the establishment of the settlement. However, some incidents may come to light in the public consultation process. Residents recalled the large 'tide surge in 2007 and minor one in 2009'. In 2007 event, fence on foreshore between Stint Ave and Sandpiper Drive was washed away. Water entered through dunes north of Thompson Beach and 'undermined the track' but stopped at dune line north of Thompson Beach Esplanade. Water also traversed to the rear of the settlements (but not immediately behind which is protected by a natural and man-made levee. The se breached the levee bank 'south of Shingleback Road and came up north to inundate the area behind the southern settlements and between Heron Crescent and Prion Court (See Map in Appendix 6).

Residents indicated that water gets 1/3 of way up boat ramp about 3-4 times in the past 20 years (this may mean annually) and foam comes 'over the top of the boat ramp every 4 years'.

4.3.3 Analyse the impact of sea level rise

<u>What is the likely impact on the settlement for a 2.8m AHD event (2013)?</u>

By way of comparison, the flood event of 4th July, 2007 was at height of approximately 2.50m AHD at which time some flooding in the south occurred. The following issues would be likely in Thompson Beach if such an event were to occur:

- The settlement north of Ruskin Road (Thompson North) is unlikely to be affected although sea water would expect to enter through the tidal inlets to the north and traverse as far as the northern levee which is at 3.0m AHD.
- The section of dune between Sandpiper Road and Petrel Road is vulnerable to inundation as the dune may be as low as 2.60m AHD in places and a roadside levee is not installed in this location (See *Map 3.d* and Figure 58*)*.
- The main dune is low between Petrel and the southern end of the Esplanade but a narrow roadside levee generally at 3.0m AHD exists with some spots lower at 2.80m AHD. However, the condition of the levee is not known and further investigation is warranted to ascertain if it would withstand a 2.8m sea-flood.
- The southernmost levee is at height 2.5m AHD. As the 2007 traversed the dune and the levee, significant flooding would occur to the rear of Thompson Beach South but whether the level be great enough to reach dwellings is unknown.

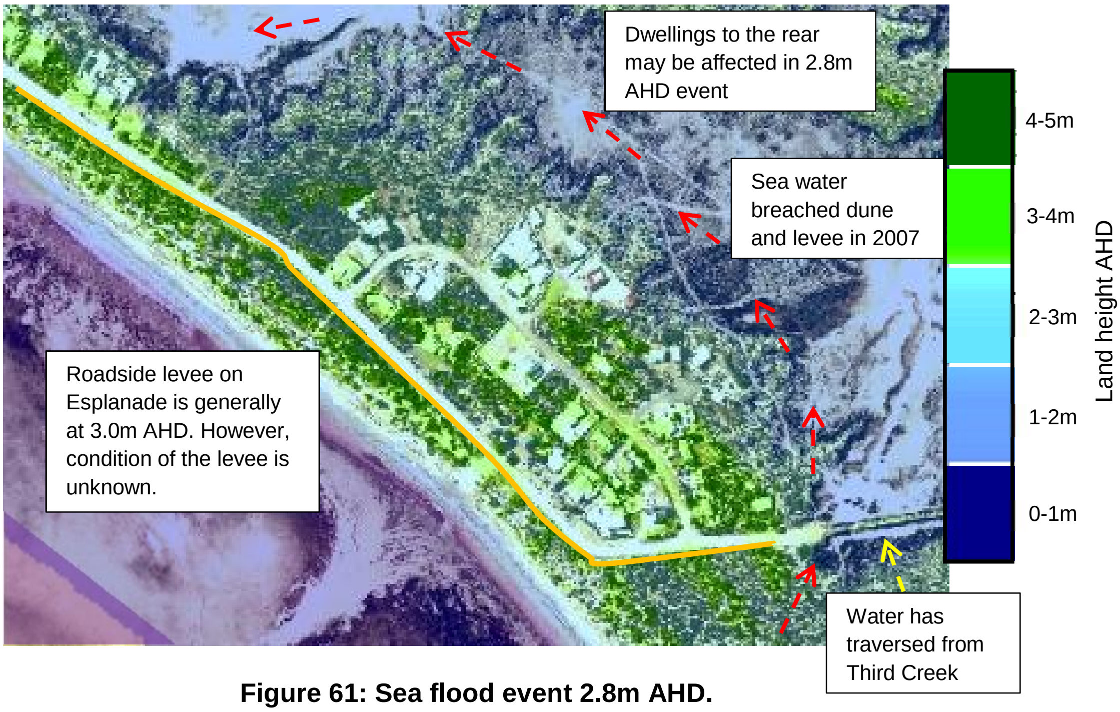

Figure 61: Sea flood event 2.8m AHD.

<u>What is the likely impact on the settlement for a 3.0m AHD event (2050)?</u>

The flood *Maps 3.a to 3.d* illustrate the impact of a 3.0m flood event. The methodology utilised is known as 'bathtub' modelling and takes no account of land forms, man-made or otherwise. Bathtub modelling also does not take into account that the water is tidal and moves in from the west and then recedes within a time frame of about 2 hours. Therefore, while some roads and properties may be lower than the 3.0m event, the water may not encroach this far into the settlement. Irrespective of these factors, the following assessment can be made about Thompson Beach's vulnerability in a 3m event:

<u>Within the Thompson Beach settlement:</u>

- Thompson Beach north of Ruskin Road would be unlikely to be affected as the dune system in this area is 3.0m AHD to over 4.0m AHD. Even if sea water entered from the north (See *Map 3.f*) the levee system would protect the settlement to the rear.
- The section of dune between Sandpiper and Petrel Road is vulnerable to inundation as the dune may be as low as 2.60m AHD in places and a roadside levee is not installed in this location (See *Map 3.d)*. Figure 62 shows a ridgeline of 3.0m AHD that is likely to prevent the water from inundating the rear of Thompson Beach. Most of the houses appear set on areas 3.0m AHD but water could flow within the Esplanade.

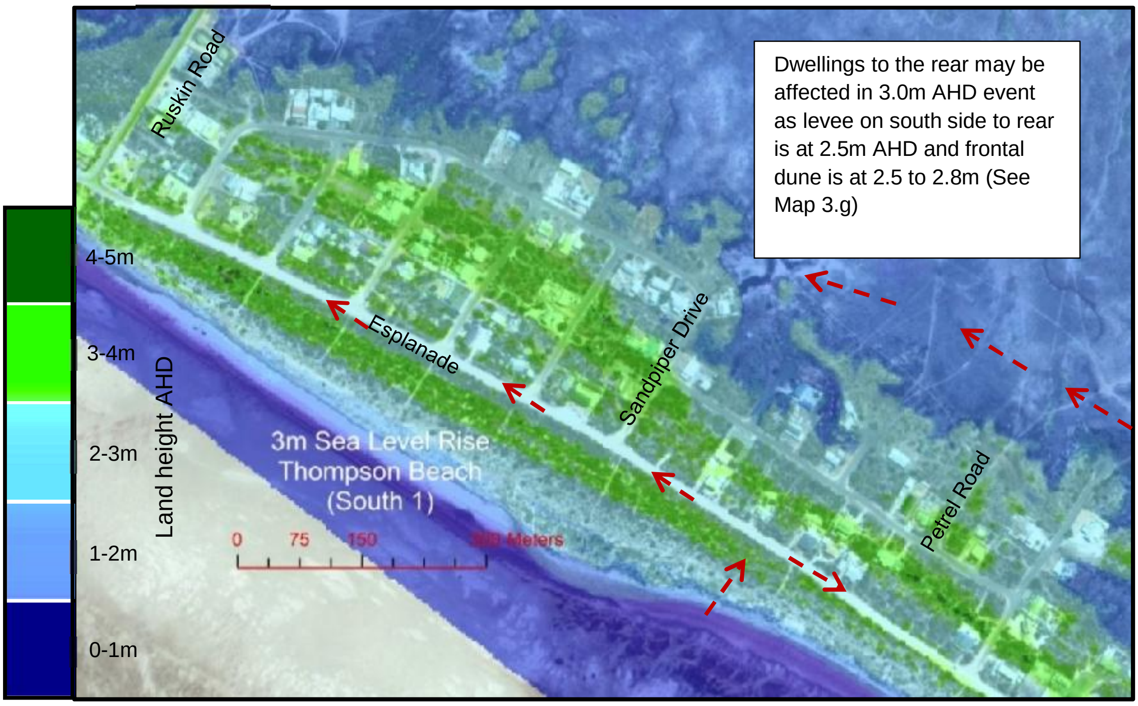

Figure 62: Sea flood event 3.0m AHD.

- The main dune is low between Petrel Road and the southern end of the Esplanade but a narrow roadside levee generally at 3.0m AHD exists with some sections lower at 2.80m AHD. However, the condition of the levee is not known. Should water begin to flow through the low sections, scouring may occur and the levee may not hold (Figure 61).
- The southernmost levee is at height 2.5m AHD. Residents report that the flood event of 2007 breached this levee and that sea water has traversed from Third Creek about 4 times in 20 years (but not breached the southern levee).

Greater North and Greater South of the Settlement:

It appears likely that in a 3m event sea water would flow inland north and south of the settlement. (see *Maps 3.c to f*). The dunes to the north of the settlement appear low, are more sparsely vegetated, and has an existing incursion for sea water to enter in high tides. Over decades this dune may erode away. The same issue exists in the south although this dune system is higher, is more densely vegetated and has no evidence of incursions by the sea. Residents report that sea water did traverse the dune to the south of the settlement in the 4th July 2007 event at approximately 2.5m AHD. The existing levee in the north should protect the settlement from inundation but the dune and levee in the south does not afford the same amount of protection.

What is the likely impact on the settlement for a 3.7m AHD event (2100)?

It is not possible to predict whether the dune systems to the north and the south of the Thompson Beach settlement would survive to 2100. However, if a 3.7m event were to occur with the existing defences and dune system, Thompson Beach would be significantly affected as there are virtually no defences around the town higher than 3.7 m and the topography of the entire internal part of the settlement is less than 3.7m AHD (See *Map 3.h*).

4.3.4 Analyse emergency egress and access

In 3.0m AHD sea-flood event are residents able to move away from the source of flood to a safe place?

Thompson (North)

Thompson Beach north of Ruskin Road is not likely to be affected with a 3.0m AHD flood event and the Esplanade Road is generally at 2.80m to 3.0m AHD in this location. Ruskin Road is generally at 3.0m AHD or above.

Thompson (South)

There are two main problems with egress from the southern end of Thompson Beach. The first is that the flood map of the 3.0m AHD event shows that almost the entire Esplanade is lower than this height, in some places as low as 2.35m AHD. This suggests that a sea-flood event of any duration will inundate the Esplanade for a considerable length. The second problem is that there is only one way to exit the settlement, and that is along the Esplanade to Ruskin Road (See Figure 63). Residents may be able to move away from the place of inundation to higher ground but unable to egress the settlement.

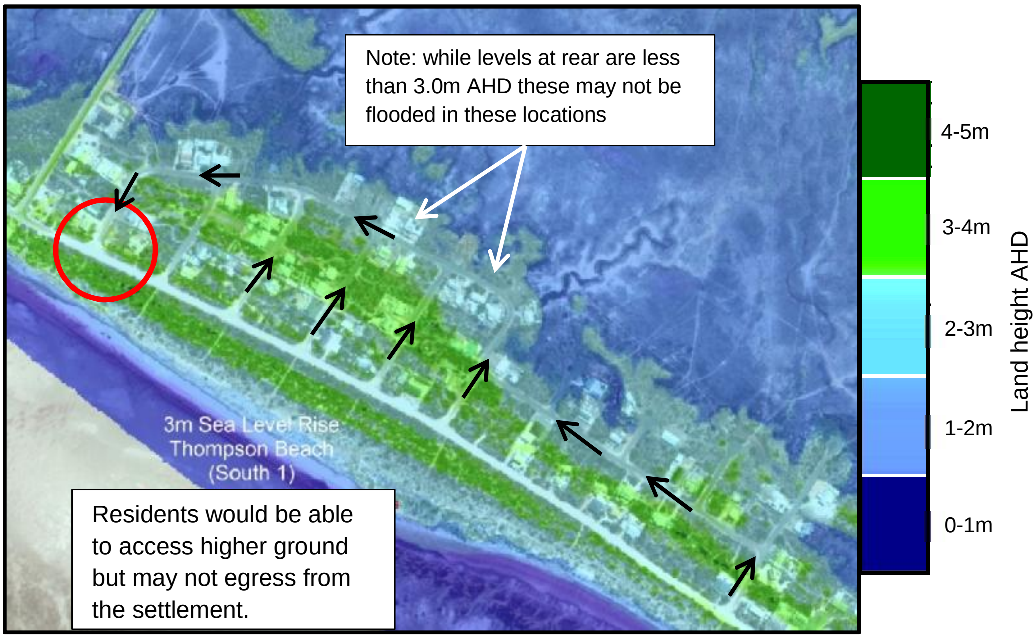

Figure 63: Emergency exit pattern from 3.0m AHD flood event at Thompson Beach South.

Those residents from the southern end would fare worse as there is no way to access land further north that is above 3.0m AHD apart from using the Esplanade.

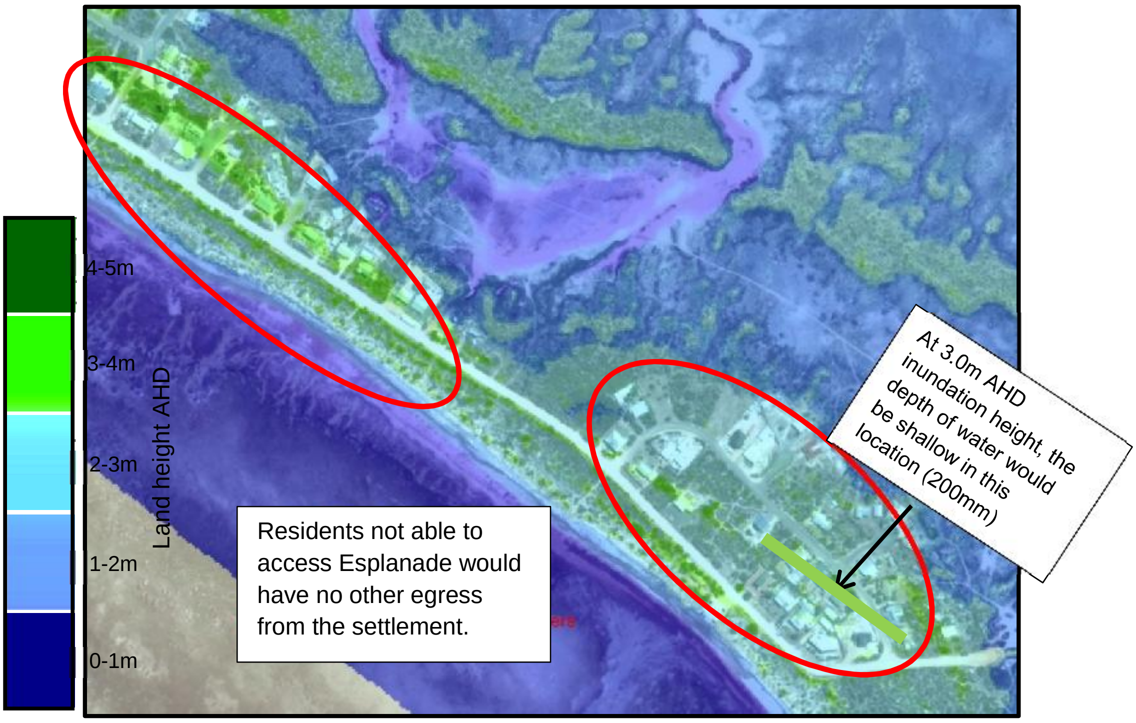

Figure 64: Emergency exit pattern from 3.0m AHD flood event at Thompson Beach South.

In a 3.0m AHD sea-flood event could emergency vehicles access Thompson Beach?

Thompson Beach (north of Ruskin Road)

Ruskin Road which is the main entrance into Thompson Beach is at 3.00AHD or higher and the Esplanade to the north is likely to be accessible by all vehicles.

Thompson Beach (south of Ruskin Road)

Depending on the duration of the flood event will dictate how far the Esplanade is flooded. In a significant sea-flood, emergency vehicles may not be able to access any further south than Ruskin Road. In a smaller sea-flood access may be open to the corner of Petrel Crescent which is 2.80m AHD. Table 12 assumes a flood of significant duration.

Table 12: Access capabilities of emergency service vehicles in 3.0m AHD sea-flood.

	Access to the settlement	Maximum likely depth	Access within the settlement	Maximum depth of water within settlement
SES vehicles	Yes	0	Yes, but dependent on driver capabilities	0.8m at sections of Esplanade (see Map 3(b)(c)
SA Ambulance vehicles	Yes	0	No – Esplanade close to Ruskin is at 2.5m AHD	0.8m at sections of Esplanade (see Map 3(b)(c)
CFS vehicles	Yes	0	Yes	0.8m at sections of Esplanade. (See Map 3(b)(c)

Residents report that there has been one incident where an ambulance was unable to access the community but this was due to the driver attempting to access Thompson Beach along Thompson Beach Road to the south of the settlement.

4.3.5 Establish profile of assets at risk

This section profiles the range of assets at risk in three main categories: privately owned assets, council owned assets, other owned assets. An accurate profile of assets will assist in decision making in the solutions stage of the project.

Privately owned assets:

1. Thompson Beach- residential allotments and profile of improvements.

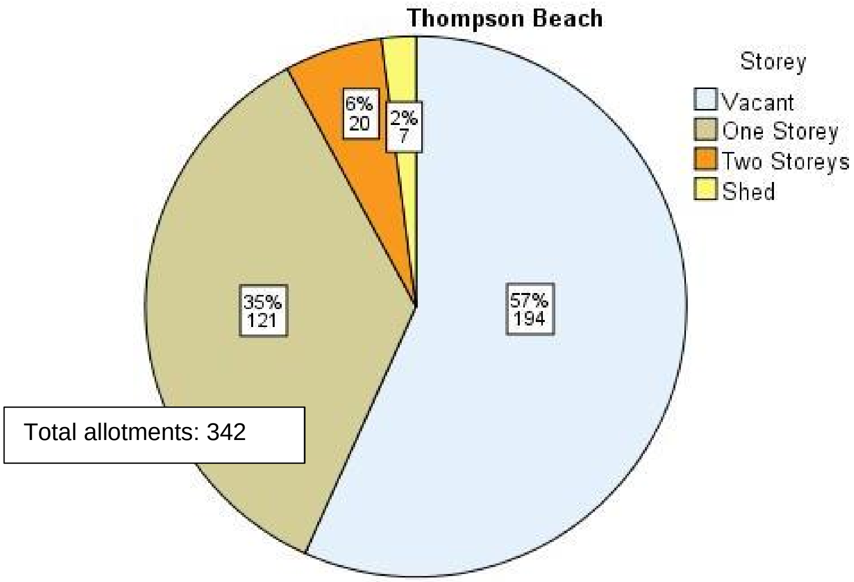

Figure 65: Thompson Beach – residential allotments and profile of improvements.

DC Mallala Council valuation data for 2013 show that the land and buildings at Thompson Beach are valued at:

Thompson Beach – value of residential assets	
Land	$23,197,000
Improvements	$13,133,500
Total capital value	$36,330,500

2. Thompson Beach: residential foundation types – stump, pole, or concrete.

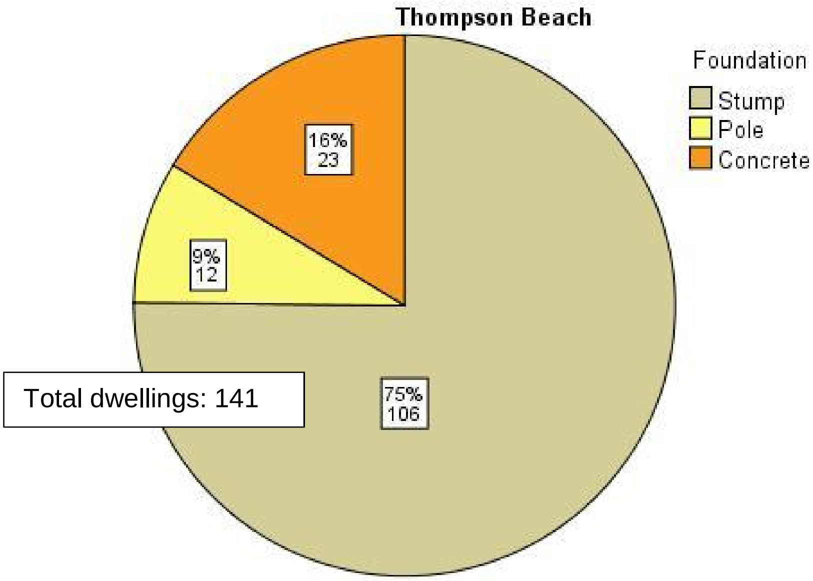

Figure 66: Thompson Beach – residential foundation types.

3. Thompson Beach: residential construction types

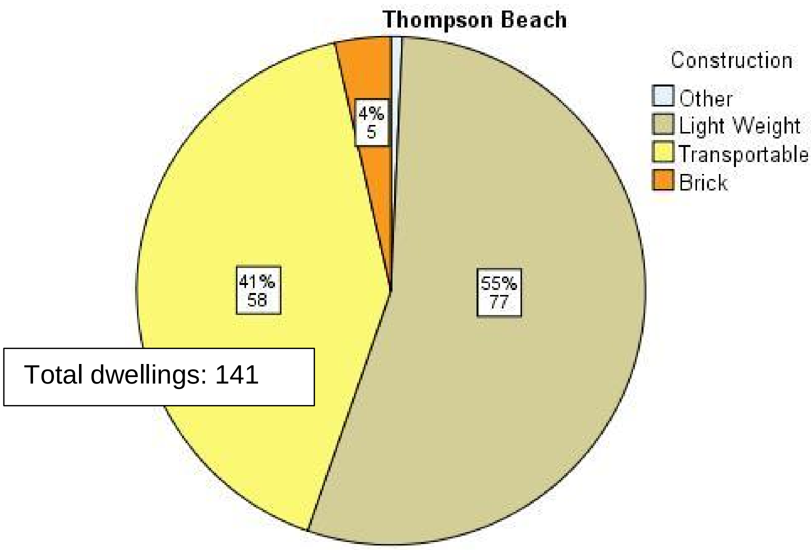

Figure 67: Thompson Beach – residential construction types.

*Note: Light weight construction dwellings are likely to be over categorised. However, the main point here is that generally light weight construction and transportable houses are on stumps or poles.

4. Thompson Beach: impact on dwellings in selected sea-flood events.

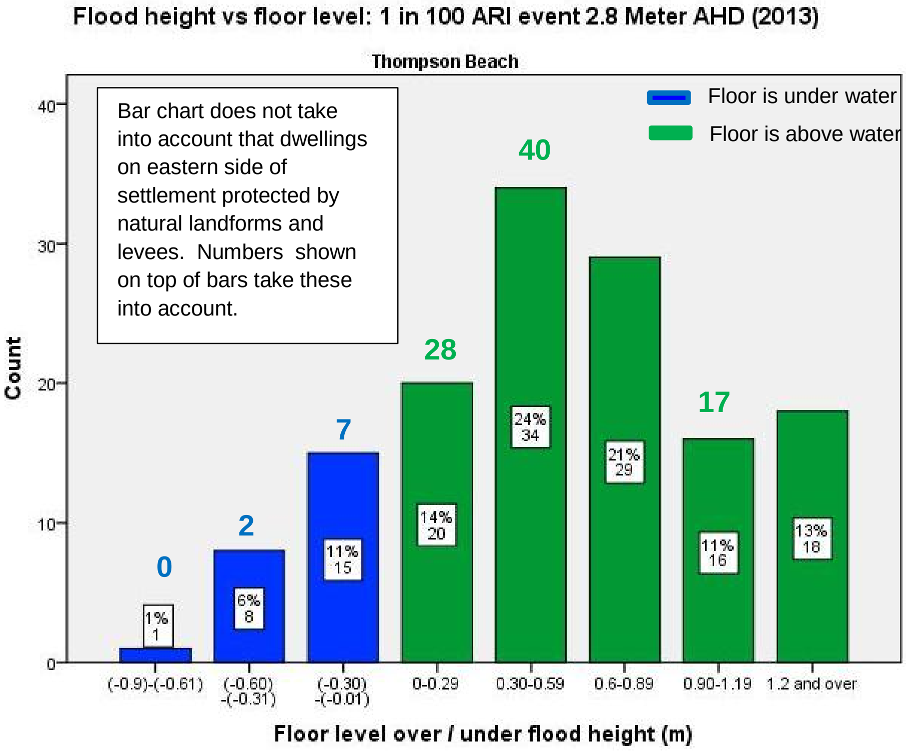

Figure 68: Thompson Beach – impact of 2.8m AHD sea-flood event on dwellings.

If the predicted one in one hundred year flood event occurred in 2013, and it lasted for a significant duration of time (and not just a brief overtopping of the dunes), the spread sheet calculation indicates that 24 dwellings are likely to be inundated. However, when the dwellings on the eastern side are removed from the calculation the actual number of dwellings affected drops to 9 at an estimated damage cost of $75,800 (Table 13).

Table 13: Thompson 2.8m AHD event – potential residential damage cost.

Thompson: Potential damage in 2.8m AHD sea-flood		
Water over floor	Dwellings	$ damage
<0.10m	2	$8,920
<0.20m	6	$46,830
<0.30m	0	$0
<0.40m	0	$0
<0.50m	0	$0
<0.60m	1	$20,070
Total	9	$75,820

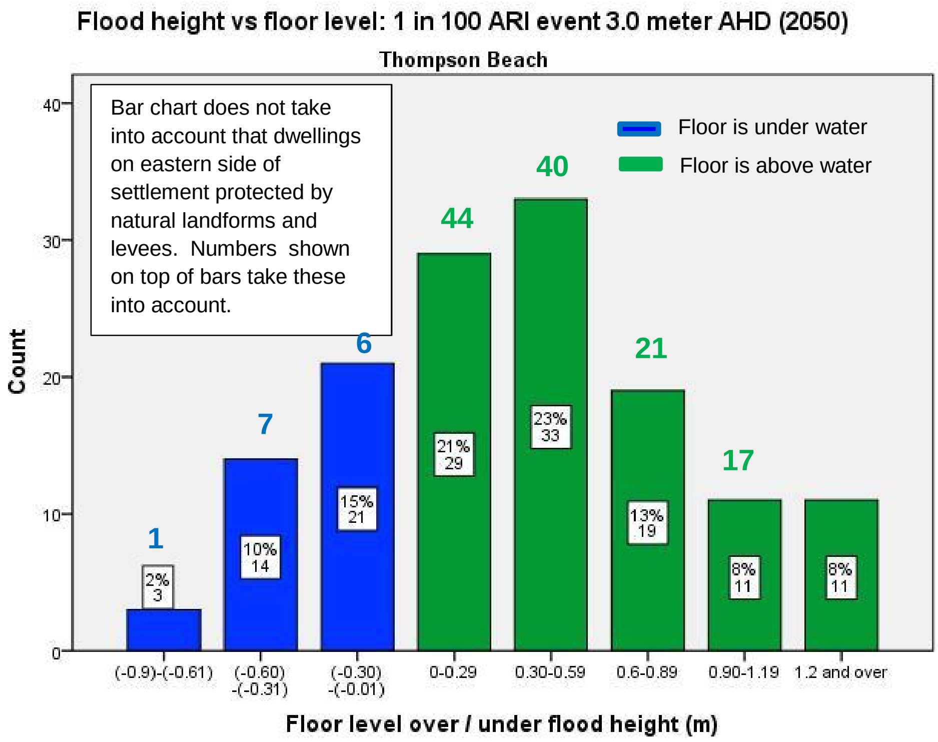

Figure 69: Thompson Beach – impact of 3.0m AHD sea-flood event on dwellings.

If the predicted one in one hundred year flood event for 2050 occurred, and it lasted for a significant duration of time (and not just a brief overtopping of the dunes), the spread sheet calculation indicates that 38 dwellings are likely to be inundated. However, when the dwellings on the eastern side are removed from the calculation the actual number of dwellings affected drops to 14 at an estimated damage cost of $172,800 (Table 14).

Table 14: Thompson 3.0m AHD event – potential residential damage cost.

Thompson: Potential damage in 3.0m AHD sea-flood (excluding eastern dwellings)		
Water over floor	dwellings	$ damage
<0.10m	1	$4,460
<0.20m	4	$31,220
<0.30m	1	$11,150
<0.40m	6	$80,280
<0.50m	0	$0
<0.60m	1	$20,070
<0.70m	0	$0
<0.80m	1	$25,645
	14	$172,825

Using the same scenario as Table 14 but incorporating the dwellings to the eastern side, and assuming that the water level reached 3.0m AHD the potential damage costs are calculated in Table 15 at $461,600.

Table 15: Thompson 3.0m AHD event – potential residential damage cost.

Thompson: Potential damage in 3.0m AHD sea-flood (including eastern dwellings)		
Water over floor	dwellings	$ damage
<0.10m	4	$17,840
<0.20m	9	$70,245
<0.30m	7	$78,050
<0.40m	7	$93,660
<0.50m	2	$33,450
<0.60m	6	$120,420
<0.70m	1	$22,300
<0.80m	1	$25,645
<0.90m	0	$0
<1.00m	0	$0
	37	$461,610

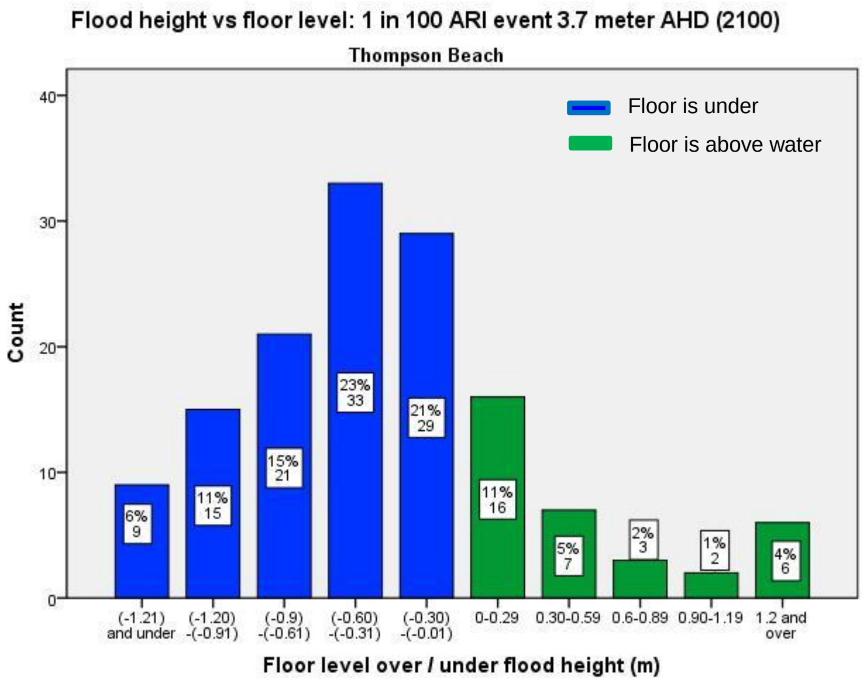

Figure 70: Thompson Beach – impact of 3.7m AHD sea-flood event on dwellings.

If the predicted 1 in 100 ARI flood event for 2100 occurred, most dwellings would have water level over their floor levels as the defences and topography of the settlement is generally less than 3.7m AHD. This assessment assumes that the flood duration is significant and not just a short duration of overtopping of dunes or defences.

Council owned assets:

DC Mallala's assets in Thompson Beach are roads, and other assets such as public toilets, shelters, picnic facilities, and water tanks. (See Appendix 2 for an itemised list of Council assets). DC Mallala's valuation records for 2013 show that Council owned assets are:

Thompson Beach: Council owned assets	
Roads	$ 1,482,000
Facilities and infrastructure	$ 409,000
Total assets	**$ 1,891,000**

The value of flood protection works in Thompson Beach are not on the asset register and no record exists of their valuation.

2. Impact on assets in sea-flood event 3.0m AHD (2050).

Maps 3.b,c,d show possible flooding patterns that include the flooding of roads and other Council infrastructure. Ways to calculate possible cost of damage to roads is to ascertain the length of road affected by flood waters and then multiply the asset value of the road by 5% (Balston et al, 2012) or apply $8350.00 per km of length affected (Victorian Government 2000) but both of these methods appear arbitrary.

Other owned assets:

Telstra, SA Water, and SA Power Networks have infrastructure in Thompson Beach and maps of these are included in Appendix 3.

Summary:

This section provides an overall picture of the assets in Thompson Beach that are likely to be under threat if a 3.0m AHD inundation event occurred. Such an event may not just occur once, but could occur multiple times and therefore damage bills would also be multiple and become more prohibitive. In this sea-flood scenario, the potential damage cost to residential assets is minimal provided that water did not inundate the rear of the settlement.

However, if a 3.7m AHD event were to occur as predicted in the latter part of this century, the damage would be significant for both residential and Council owned infrastructure. Very few assets would remain untouched by this sea-flood event.

4.3.6 Explore liability issues.

- **What obligations did Council have at the time the settlement was established in relation to assessing impacts from the sea?**

As the development was established in the late 1980's the application was assessed through the Environmental Impact Assessment process of Planning Act 1982. A review of correspondence and reports at DC Mallala and at Coast Protection Board (CPB) are included at Appendix 4. The following summary points explore the issues relating to the approval of the settlement:

- CPB initially recommended that the application be refused because the EIS did not sufficiently address inundation issues. However, it also stated that should appropriate engineering solutions be devised that this position was to be reviewed.

- CPB gave advice that the height of the front levee at 3.0m was approaching 'safe levels' but that it was preferable to add 0.2m or 0.3m to that level to allow for subsidence and/or deficient construction.

- CPB conceded that subsequent to the production of the EIS supplement, that protection measures were adequate. However, CPB eventually recommended 'refusal' for the application but on other grounds, such as the proposal being at odds with the provisions of the DC Mallala Development Plan that was in place at the time.

- In the supplement to the EIS the developer volunteered protection measures for the front dune at 3.4 and for the rear levees at 3.0m.

- SA Planning Commission also conceded that the engineering proposals would satisfactorily reduce the risk of flooding but also recommended that the Minister refuse the application mainly because of its noncompliance with the Development Plan .

- DC Mallala had a responsibility to have 'regard' to the submissions from all parties and as designated planning authority under the Act it had the right to make a decision. (It could be argued that DC Mallala did approve an application that may have been outside some of the provisions of its own Development Plan but that issue is of no consequence here). DC Mallala did take advice that the proposal in the EIS supplement was generally accepted by CPB and others as adequate protection from flooding.

- No written advice can be sourced that states the CPB stipulated that rising sea levels were to be taken into account but this was likely to be incorporated into the CPB's advice for 3.2m or 3.3m AHD. The assessment by SA Planning Commission does note that CPB gave advice on this issue.

- Irrespective of whether this advice was given, DC Mallala had no statutory responsibility to incorporate sea level rise. To also provide a contextual point, the International Panel on Climate Change first met in 1988 so it could be reasonably deduced that sea level rise was unlikely to be a matter considered at local government level. CPB is regarded as a world leader in the matter of rising sea levels (Balston et al. 2012)

- **What protection works have been implemented and were they implemented in accordance with approved plans?**

The following points explore the issues surrounding the implementation of the protection works:

- The reports and correspondence indicate that the CPB (and possibly other agencies) was under the assumption that the protection works were to be installed as per the EIS supplement dated 29th November, 1985.

- However, from 21st April 1986 through to the installation of the levees, the developer made it clear he intended to install the levees to 3.0m AHD in a letter to the SA Planning Commission. (Approvals were issued by DC Mallala on the same date as this letter). There are numerous examples of this intention in the correspondence thereafter. In a transcript of a meeting with Council members in November 1989, the developer states while referring to the whole process, including the EIS, ‘it was agreed that 3m should be the level’ and this assertion remained unchallenged.

- Plans held at DC Mallala show levees to be constructed at 3.0m to the frontal and rear levees but are unstamped as being received or approved.

- A letter from the Council to the developer in October 1989 acknowledges that the levees were being constructed at 3.0m.

- Late in December 1989, CPB sent a letter to the Council reminding the Council of the construction details of the levees and its responsibility to ensure that they were constructed properly.

- A letter from the Council to the developer in October 1989 indicates that the Council was aware that the levees were being implemented at 3.0m.

- There appears to be difficulty in getting the developer to fulfil the conditions of approval on other matters that were still under discussion at an onsite meeting on 13th February 1990 at which time the levees were under construction.

In summary, it is difficult to ascertain whether the levee system was installed in accordance with the approved plans. The plans held at DC Mallala indicate that the levee system was to be installed at 3.0m AHD whereas the EIS Supplement states 3.4m AHD. The southern levee to the rear has been installed at 2.5m AHD.

- **Have protection works implemented by Council been breached?**

No.

- **In the case of new development within the settlements, have appropriate planning and Coast Protection Board policies been followed?**

Council has followed CPB advice which has varied over time in relation to site heights and floor levels due largely to the issue of levee height.

- **Has the Council made available sea level rise data to residents?**

No, but upcoming community consultation will begin this process.

- **Are there any emergency warnings and/or evacuation procedures in place?**

No, and recommendations will be made in the second half of this study.

<u>Summary</u>

In relation to the tort based claims of nuisance and negligence where the payment of damages can eventuate, the following points are relevant to the discussion:

- Thompson Beach was subdivided in the late 1980s and impacts of the sea had to be considered as part of the establishment of the settlement.
- While there is a general statute that Councils are to act to keep their resident's safe (see Local Government Act) it is unlikely that the Council is legally responsible to implement protection works at ever increasing heights.
- It is common knowledge that threats can emanate from the sea and those that choose to live near the sea personally accept that risk (similar to those who choose to live in bushfire regions or in earthquake zones).
- In relation to liability of the implementation of the protection works, it appears that the developer worked on a different installation height than they volunteered in the EIS. However, generally the levee has been installed at the height on the plans held by DC Mallala with the exception of the southern levee at the rear of the settlement. The question of who knew at Council of the discrepancy between the height in the EIS and that of plans at the Council offices is unknown.
- There have been no reports of inundation and there are few houses that are affected by 2.8m or 3.0m AHD storm events (unless an event is of significant duration). Further confirmation of the floor heights of houses in areas susceptible to inundation may confirm the situation.
- Councils are likely to have a responsibility to warn their constituents of any danger. Therefore, the Council should make the findings and mapping from studies such as this one available to the public.
- Warning systems and evacuation procedures can be implemented and overseen by local resident's associations and also fulfil the Council's responsibility to ensure that residents are as safe as possible.
- Protection at 2.8m AHD is the current planning sea-flood bench mark for the region and a preliminary review finds that most of the settlement is protected at this level.

Administrative appeals may arise out of the solutions proposed to mitigate the threat of increased sea levels and storm surge heights. For example, if the Council were to restrict the types of development that could be approved, appeals to these decisions may be likely. However, recent trend in Court decisions indicates that the Court will take into account climate change related facets to a case.

4.3.7 Summary Table – Thompson Beach

Stage	Question	Summary comment
1. Site history	When was the settlement founded?	Late 1980s
	Were climate change and sea level rise issues relevant?	No, there was no requirement to take into account sea level rise.
2. Existing protection	What existing natural protection exists?	Dunes to the foreshore, dunes to the rear of the settlement.
	What breaches have occurred?	None.
	What manmade protection works have been installed into the settlement?	Around 1990, a levee was installed to the foreshore in the road reserve, a levee on each end of the settlement to join with natural dune systems to the east. More research is required to ascertain the strength of the frontal levee. There is a question of which were the 'approved plans'.
3. Impact of storm events	What is the likely impact for a 2.8 m AHD event?	The section between Sandpiper and Petrel is vulnerable.
	What is the likely impact for a 3.0 m AHD event?	As for 2.8, but additional places are low and the integrity of the levee is unknown.
	What is the likely impact of a 3.7m AHD event?	All defence systems overtopped and the vast majority of the settlement inundated.
4. Emergency access and egress	Egress issues in a 3.00AHD event	Egress is ok in the north, impeded in the south.
	Emergency vehicle access in a 3.0m AHD event.	Access is clear in north but could be severely impeded in the south.
5. Profile of assets at risk	How many residents are likely to be affected in 3.0m event?	14 dwellings, if no water enters behind the settlement.
6. Liability issues	Does liability exist if Council fails to implement protection?	Unlikely to be any general liability
	Have residents been warned?	Not yet.
	Have emergency procedures been implemented?	Not yet.
	Are there conditions relating to the maintenance or upgrade of protection works	Yes, levees may be too low. Legal advice is required. However, 2.7m to 2.8m AHD is the current 1 in 100 ARI flood event and Thompson Beach appears to be appropriately defended for that event (perhaps with some minor remedial work).
	Is there a maintenance regime of protection works?	Under investigation.
	Other	Research will be undertaken in the next stage to ascertain what advice can be applied to plan for sea-flood planning for 2050.

4.3.8 Thompson Beach – other issues raised in public consultation

Thompson Beach residents made significant contributions. Those relating the State of Play report are included here. The remainder of the contribution is contained in Appendix 6.

- Residents see that Thompson Beach is vulnerable to flooding from the inlet 'just short of Baker's Creek and Third Creek at South – but would have to breach existing levees. Massive water storage capacity at east side of Thompson's so considerable amount of water would be required'.
- Residents have identified ground water issues with 'seepage with the tide behind Gulf and Prion Courts' and three residents are monitoring depth of sea water below ground level and are recording depth of seawater at Heron Crs 10 feet below to Shingleback Road at 6 feet below.
- Residents noted that seaweed creates a dam and stops water going over the foreshore on king tides.
- Weather events are short lived and therefore not a long term threat.
- Local erosion between Prion Court and Heron Court.
- Rainwater does collect behind the settlement but does drain away so 'not a problem'.
- Residents noted that sea grass has built up.

4.2 Middle Beach

4.4.1 Settlement history

- **When was the settlement established?**

Middle Beach is likely to have been established in the 1950s (to be confirmed). The land on the foreshore was originally leasehold to the State Government, so the establishment may not have been overseen by DC Mallala.

- **What obligation did the Council have to take into account impacts from the sea?**

Middle Beach was founded prior to 1967 at which point in time the Mallala area was not part of the Metropolitan Planning Area and also prior to establishment of Coast Protection Act 1972. There was not any overarching statutory requirement for those who established Middle Beach to take into account actions of the sea.

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4.4.2 Analysis of existing protection - natural and man-made

The following assessment of natural and man-made land forms that provide Middle Beach with protection from the sea is to be read while viewing the State of Play (Maps) that append this report. Heights are expressed in metres AHD but often the acronym AHD is assumed in the context of the report.

What existing natural protection exists in Middle Beach?

To the west (See *Map 4.a*).

On the western side are dwellings that have direct frontage to the shoreline and thus have no engineered system of protection (Figure 71). Further west a substantial mangrove colony is growing in the shallow water that may provide some buffer from the sea in relation to wave and tidal action. The only gap in the mangroves is for the tidal inlet of Salt Creek (*Map 4.a*).

Figure 71: Middle Beach shore line looking south (J. Kellett, 2013)

<u>To the south</u>

Salt Creek forms the southern-most border of Middle Beach at which a boat ramp has been installed (Figure 72).

Figure 72: Middle Beach boat ramp on the southernmost end of Middle Beach Road (M. Western, 2013)

A historical comparison is observed with photograph from the 1920s below.

Figure 73: Middle Beach Creek circa 1920 (Pat Thompson, Dublin History Group)

To the east:

On the eastern side of the Esplanade is a second row of eleven houses (Figure 74).

Figure 74: Middle Beach – two rows of houses (M. Western, 2013) .

The Salt Creek inlet swings around behind the Middle Beach settlement allowing water to inundate the eastern side of the settlement (See *Map 4.a,b)*.

To the north

On the northern most tip of Middle Beach is the privately owned Middle Beach Education and Recreation Centre. Another tidal creek passes close by this centre to the north, and water flows into the flats to the east of the settlement (See *Map 4.a,b*).

Figure 75: Northern end - Middle Beach Education and Recreation Centre and tidal creek (M. Western, 2013).

What flooding incidents have occurred?

There have been numerous incidents reported to the Council Depot but only 4th July 2007 and 25th April 2009 are covered in this report. Screen captures from video taken on 4th July 2007 (pictures from 29.53) by John Kneuitt provide a valuable insight to the flow of water.

Figure 76: Water flowed into the car park over the front levee (J. Kneuitt, 2007)

Figure 77: Looking west toward the car ramp to Beach (J. Kneuitt, 2007)

Figure 78: Looking north-west towards the southernmost house on the shoreline (J. Kneuitt, 2007).

Figure 79: Water flowed north along Middle Beach Road and joined flood waters coming between the houses on the shore front (J. Kneuitt, 2007).

A large volume of water also travelled up the Salt Creek and filled up the area behind the settlement and entered into the resident's back yards on the second row (Figure 80,81).

Figure 80: Looking east behind the settlement (J.Kneuitt,2007).

Figure 81: Water entered the backyards of houses on second row with minor inundation of some sheds (J. Kneuitt, 2007).

Figure 82: Video taken from the same location as Figure 80 but now facing west demonstrates that water almost covered the peninsula (J. Kneuitt, 2007).

Figure 83: Markers such as these suggest the AHD height of the water was 2.4-2.5m (J.Kneuitt,2007)

Damage in this event included the ripping out of stumps under a house at Lot 1785 as the tide receded. The receding tide also eroded a gully which took two semitrailer loads of sand to refill (Source: Keith Earl, DC Mallala).

Figure 84: Location where water flowed between houses (Keith Earl, 5.07.07)

Water also cut across Middle Beach Road further inland possibly from both the north and the south (*See Map 4.c*)

Residents at community consultation indicated that there have been two major events: 13th July 1995 and 25th April 2011 (perhaps 25th April, 2009) where water entered several houses. Residents inform that two sink holes developed (one is pictured at Figure 84, see Map in Appendix 6 for the other). In these two events, Middle Beach Road was underwater from Hatherly Road towards Two Wells. Water traversed from north of the caravan park and water traversed from the south at Salt Creek and the two floods met.

Water came up boat ramp in 2011 and came within 7 metres of the toilet block.

What man-made protection works have been installed in Middle Beach?

Working from south to north, man-made protection works include:

- Loose rock armament to the southern tip, adjacent the boat ramp, installation date unknown (Figure 85).

Figure 85: Rock armament to southern tip of settlement (M. Western, 2013).

- Subsequent to the events of 2007 and 2009, a concrete block wall was installed along the western side of the car park (Figure 86).

Figure 86: Concrete block wall to Western side of car park (M. Western, 2013).

- Further north protection is entirely an individual matter and the following photographs illustrate the range of measures utilised (Figures 87-90).

Figure 87: Car park block wall joins the wall of the southernmost house (M.Western, 2013).

Figure 88: Double concrete block retaining with elevated stump floor (M. Western, 2013).

Figure 89: Elevated floor – stump foundation (M. Western, 2013)

Figure 90: Earthen levee – common along the frontage at varying heights (M. Western, 2013).

- On the eastern side at the rear of the second row of houses dirt levees/ mounds have been installed (date unknown).
- To the south of the second row of houses is a ridge of land with some points with height above 3.0m AHD (See *Map 4.a*). This ridge may be a combination of natural ridge and man-made structure with the installation date unknown.
- On the northern end of the settlement Middle Beach Education and Recreation Centre is surrounded by levees approximately 2.80 m to 2.90 m high (*See Map 4.b*)

4.4.3 Analyse the impact of sea level rise

<u>What is the likely impact on the settlement of a 2.8m AHD event (2013)?</u>

By way of comparison, the flood event of 4th July, 2007 was at height of approximately 2.4m AHD. The following issues would be likely in Middle Beach if such an event were to occur:

- While the new concrete block wall and levee at height 2.80m AHD approx may not be overtopped, water would enter the car park over the top of the boat ramp.
- Knowing that the access road (unsealed) at the rear of the front row of dwellings is generally at 2.0m, and in some places lower, it is logical to assume that water would flow between buildings where protection works were lower than 2.80m.
- Water would enter behind the settlement by way of Salt Creek and the tidal creek north of the recreation centre and cross the main entry road, overtopping it by 0.8m.
- The levees at the recreation centre at the northern end is unlikely to be overtopped.

<u>What is the likely impact on the settlement for a 3.0m AHD event (2050)?</u>

The flood maps (*Maps 4.a, 4.b, 4.c*) illustrate the impact of a 3.0m flood event. The methodology utilised is known as 'bathtub' modelling and takes no account of water flow in relation to land forms, manmade or otherwise. Bathtub modelling also does not take into account that the water is tidal and moves in from the west and then recedes within a time frame of a few hours. Irrespective of these factors, the following assessment can be made about Middle Beach's vulnerability in a 3m event:

- The concrete blocks and levee system to the western side of the car park would be overtopped.
- Knowing that the access road (unsealed) at the rear of the front row of dwellings is generally at 2.0m, and in some places lower, it is logical to assume that water would flow between buildings where protection works were lower than 3.0m.
- Water would enter behind the settlement by way of Salt Creek and the tidal creek north of the recreation centre and inundate the entire settlement. The levee system to the east (and north of 'Row 2) has numerous entry points lower than 2.8m, with one main one at 1.6m AHD.
- The access road into Middle Beach would be overtopped by 1.0m water.
- The levee system around the recreation centre at the northern end would be overtopped as height of levee is generally 2.80m AHD.

<u>Greater South of the Settlement:</u>

No review has been undertaken of topography further south as the Salt Creek inlet is the extremity of the flood mapping.

<u>Greater North of the Settlement:</u>

The mangrove colony and inlets are substantially lower than the Middle Beach settlement and it could be expected that increased amounts of water will encroach further inland.

<u>What is the likely impact on the settlement for a 3.7m AHD event (2100)?</u>

As Middle Beach has very low topography a 3.7m AHD event would completely submerge all land forms. Some dwellings on stilts may be higher than 3.7m but they would be cut off from all contact with land.

<u>In relation to Salt Creek:</u>

A review of Coast Protection Board records and reports on 13th August, 2013 found that there has been some concern that Salt Creek is increasing in silt levels. This issue was first raised in 1982, at which time Coast Protection Board stated, 'inward growth of mangroves has had no effect on siltation process occurring at Middle Beach but is a consequence of it'. The report notes that the work of Penrice Soda was 'accelerating' the process but the silting was mainly due to a 'long term natural process'. A further report (source needed) that the main cause of siltation was the die back of seagrass meadows south-west of Middle Beach with a large 'slug' of sand gradually moving northwards. The mangrove colonies thrive in water that has little movement and this would account for the increase in mangrove colonies in the area. Taking a still broader view, John Cann states that rapid sedimentation in the northern areas of both gulfs is taking place which may account for the ongoing silt increase in Salt Creek.

John Drexel has studied Salt Creek and has a different view to the reason that it is silting up (refer Salt Creek Management Plan, DC Mallala, date unknown).

4.4.4 Analyse emergency egress and access

In 3.0m AHD sea- flood could residents move away from the source of the flood to a safe place and/or egress the settlement?

The only land form higher than 3.0m AHD is the ridgeline to the south of ‘Row 2’ (see *Map 4.a).* However, it is unlikely that access to the ridge in flood conditions is available because of a ditch that runs between the road and the ridge. History shows that the water is likely to first enter the car park and the Council drainage easement, and therefore cut off access to any residents south of this point. Egress from the settlement via Middle Beach Road would be compromised with water covering this road by 1.0m.

In a 3.0m flood event could emergency vehicles access Middle Beach?

Emergency vehicle access into the settlement via Middle Beach Road in a 3.0m flood event would need to pass through waters at depth of 1.0m (Table 15) (See also *Map 4.c*).

Table 15: Access capabilities of emergency service vehicles in 3.0m AHD sea-flood.

	Access to the settlement	Maximum likely depth	Access within the settlement	Maximum depth of water within settlement
SES vehicles	Dependent on ability of driver	1.0	Dependent on ability of driver	1.0m to 1.1m
SA Ambulance vehicles	No	1.0	No	1.0m to 1.1m
CFS vehicles	Yes	1.0	Yes	1.0m to 1.1m

Residents note that in flood events Middle Beach Road becomes impassable to sedans, but possible with four wheel drives. John Drexel (resident) suggested that in the 2011 event (2009?) the road was inundated for 2 hours.

4.4.5 Establish profile of assets at risk

Using the methodology reported in Section 1, this section profiles the range of assets at risk in three main categories: privately owned assets, council owned assets, other owned assets. Identifying the different construction types provides appropriate data from which to offer some solutions for adaptation should these be required.

Privately owned assets:

1. Middle Beach- residential allotments and profile of improvements.

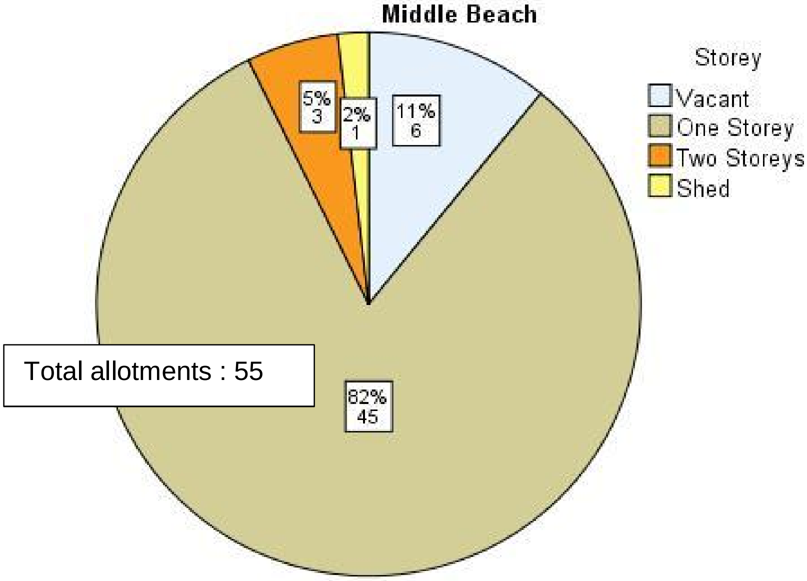

Figure 91: Middle Beach – residential allotments and profile of improvements.

DC Mallala valuation records for 2013 show that the land and buildings are valued at:

Middle Beach – value of residential assets	
Land	To be advised
Improvements	To be advised
Total capital value	$20,668,000

2. Middle Beach: foundation types – stump, pole, or concrete.

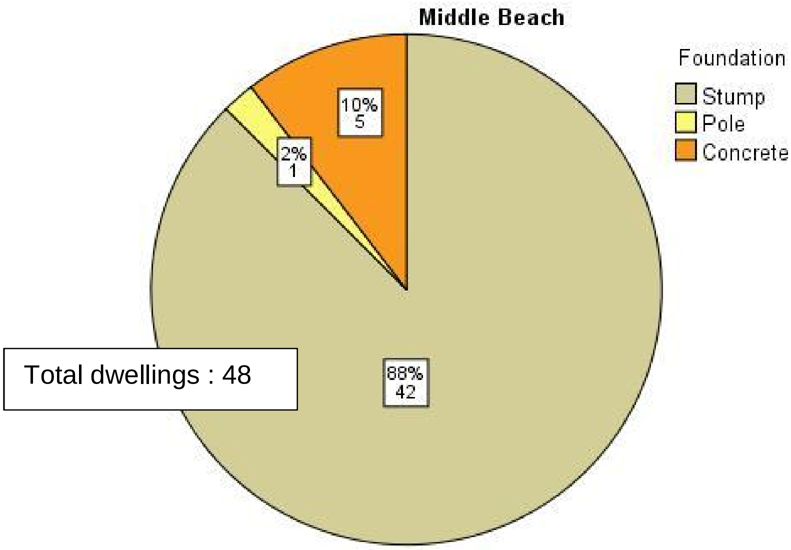

Figure 92: Middle Beach – residential foundation types.

3. Middle Beach- Construction types* - lightweight, transportable, brick

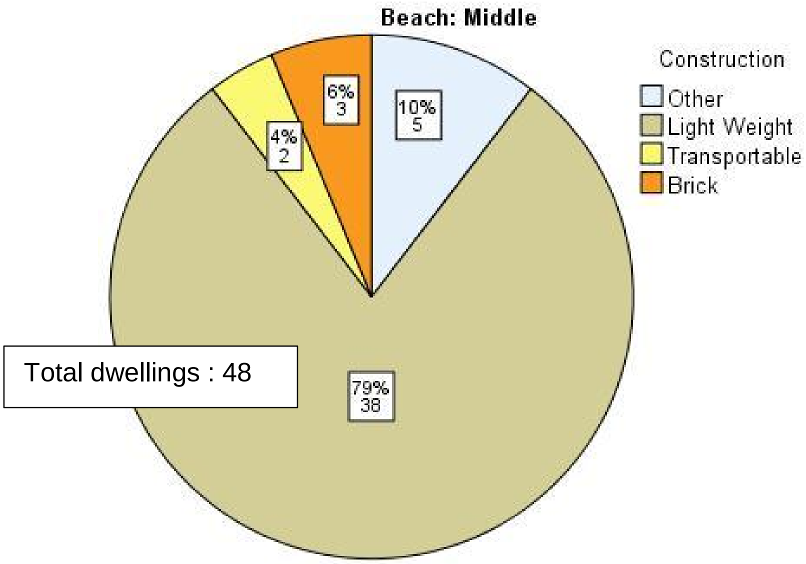

Figure 93: Middle Beach – residential construction types.

*****The 'lightweight' category has likely been over applied and 'transportable' under applied. The basic issue is whether the dwelling could be raised.

4. Middle Beach: impact on dwellings of selected sea-flood events

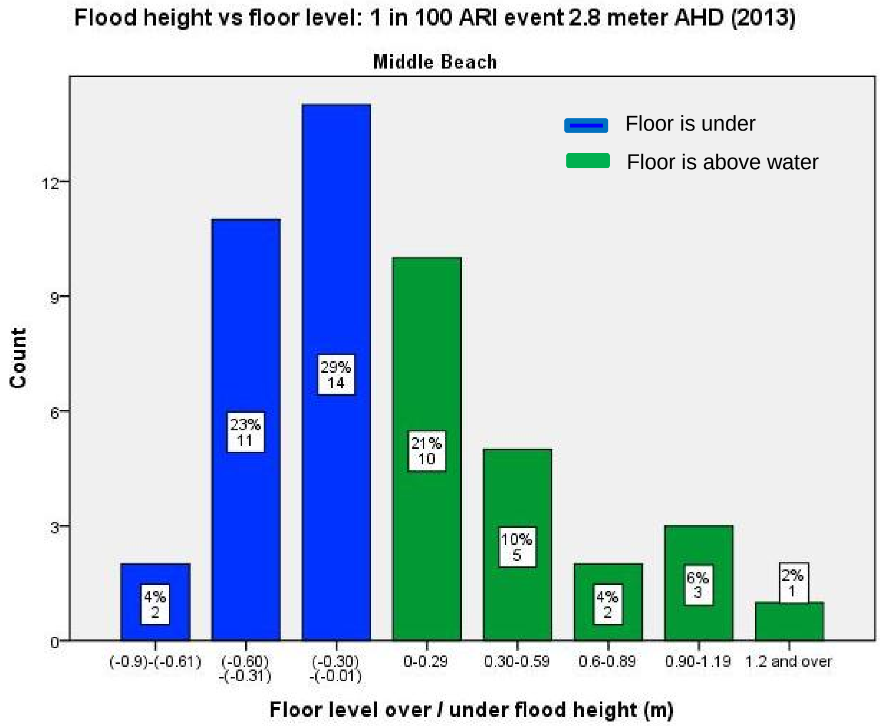

Figure 94: Middle Beach: impact of 2.8m AHD sea-flood event on dwellings.

If the predicted one in one hundred year flood event occurred in 2013, and it lasted for a significant duration of time (and not just a brief overtopping of the dunes), 27 dwellings are likely to be inundated with a potential damage cost of $351,200 (Table 16).

Table 16: Middle Beach: 2.8m AHD event – potential residential damage cost.

Middle: Potential $ damage in 2.8m AHD sea-flood		
Water over floor	Dwellings	$ damage
<0.10m	3	$13,380
<0.20m	5	$39,025
<0.30m	8	$89,200
<0.40m	1	$13,380
<0.50m	4	$66,900
<0.60m	5	$100,350
<0.70m	0	$0
<0.80m	0	$0
<0.90m	1	$28,990
<1.00m	0	$0
	27	$351,225

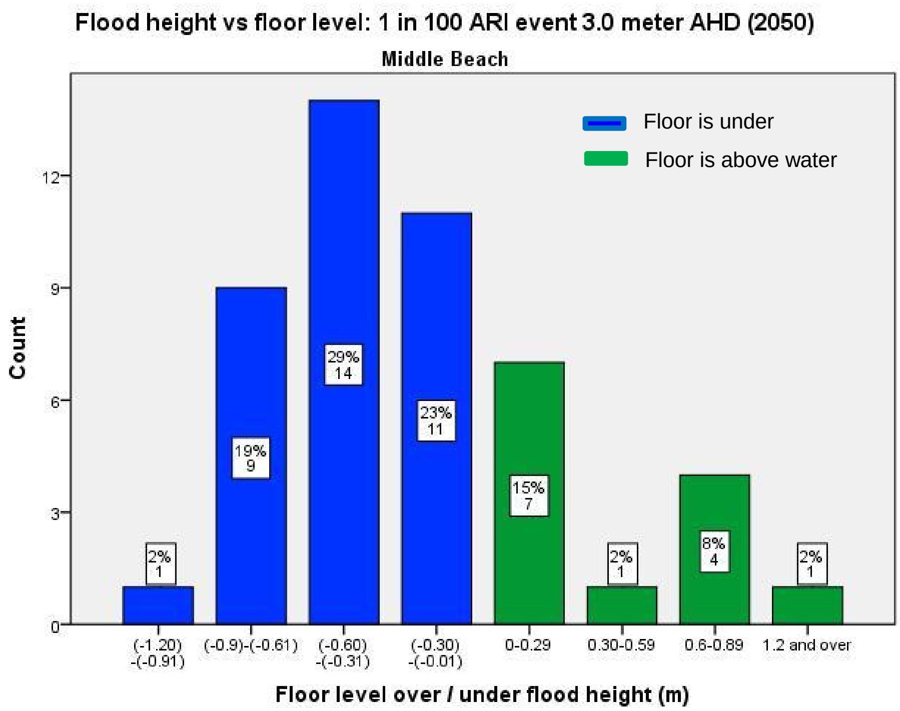

Figure 95: Middle Beach: impact of 2.8m AHD sea-flood event on dwellings.

If the predicted one in one hundred year flood event for 2050 occurred, and it lasted for a significant duration of time (and not just a brief overtopping of the dunes), 35 dwellings are likely to be inundated with a potential damage cost of $549,700 (Table 17).

Table 17: Middle Beach: 3.0m AHD event – potential residential damage cost.

Middle: Potential $ damage in 3.0m AHD sea-flood		
Water over floor	dwellings	$ damage
<0.10m	5	$22,300
<0.20m	3	$23,415
<0.30m	3	$33,450
<0.40m	5	$66,900
<0.50m	8	$133,800
<0.60m	1	$20,070
<0.70m	4	$89,200
<0.80m	5	$128,225
<0.90m	0	$0
<1.00m	1	$32,335
	35	$549,695

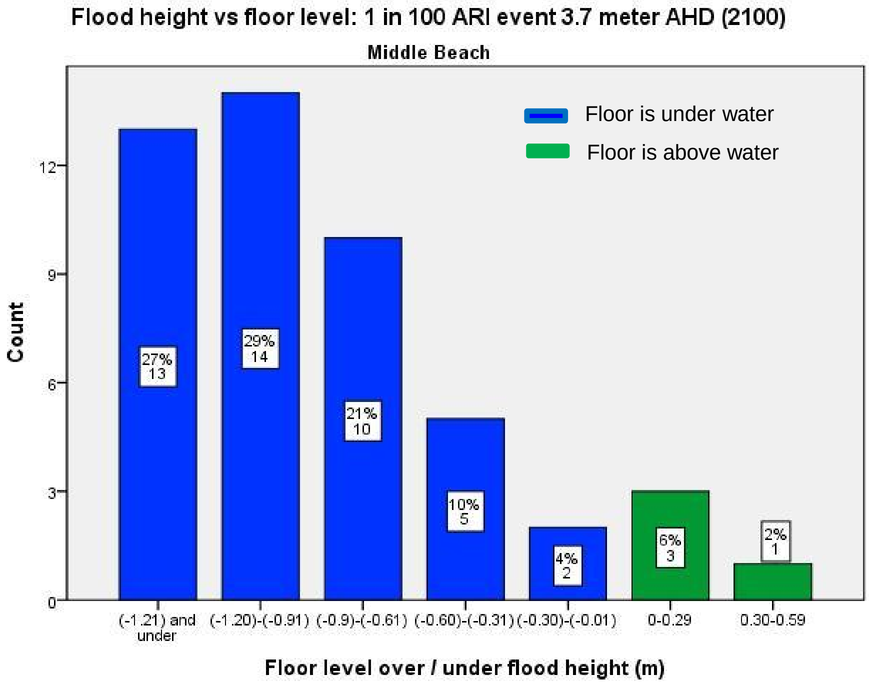

Figure 96: Middle Beach: impact of 3.7m AHD sea-flood event on dwellings.

If the predicted 1 in 100 ARI flood event occurred for 2100, the spread sheet calculation indicates that only 4 dwellings would have floor levels higher than 2.7m AHD.

1. Profile of Council owned assets:

DC Mallala's assets in Middle Beach are roads, and other assets such as boat ramp, public toilets, shelters, picnic facilities, and water tank. (See Appendix 2 for an itemised list of Council assets). DC Mallala's valuation records for 2013 show Council assets as:

Middle Beach: Council owned assets	
Roads	$ 812,092
Facilities and infrastructure	$ 409,000
Total assets	**$ 1,221,092**

The value of the flood protection works in Middle Beach are not on the asset register and no record exists of their valuation.

2. Impact on assets in sea-flood event 3.0m AHD (2050).

Maps 4.a – 4.d show possible flooding patterns which include the flooding of roads and other Council infrastructure. Most of the facilities and infrastructure are located around the boat ramp in the south which will be significantly impacted by any sea-flood event. However, with the flood being of short duration, minimal damage may be expected to Council assets. Ways to calculate possible cost of damage to roads is to ascertain the length of road affected by flood waters and then multiply the asset value of the road by 5% (Balston et al, 2012) or apply $8350.00 per km of length affected (Victorian Government 2000) but both of these methods appear arbitrary.

Other owned assets:

Telstra, SA Water, and SA Power Networks have infrastructure in Middle Beach and maps of these are included in Appendix 3.

Summary:

This section provides an overall picture of the assets at Middle Beach that are likely to be under threat if a 3.0m AHD inundation event occurred. Such an event may not just occur once, but could occur multiple times and therefore damage bills would also be multiple and become more prohibitive. In this sea-flood scenario, the potential damage cost to residential assets is minimal.

However, if a 3.7m AHD event were to occur as predicted in the latter part of this century, the damage would be significant for both residential and Council owned infrastructure. Very few assets would remain untouched by this sea-flood event.

4.2.6 Discuss liability issues.

- **What obligation did the Council have to take into account impacts from the sea at the time of settlement?**

Middle Beach was founded prior to 1967 at which point in time the Mallala area was not part of the Metropolitan Planning Area, and also prior to establishment of Coast Protection Act 1972. There was no overarching statutory requirement for those who established Middle Beach to take into account actions of the sea. In 2002, the entire front row of dwellings were transferred from leasehold to free hold Torrens Title. Land management agreements were enacted for each owner that moved liability entirely to the owners to mitigate their own risks.

- **What protection works have been implemented and were they implemented in accordance with approved plans?**

Levee	Implementation Date	Responsibility and liability
Concrete block wall to car park	2011	No development application but general responsibility to maintain. Possible liability if the concrete wall was to fail in a storm event.
Levee to south of Row 2 dwellings (north-east of settlement)	Unknown	Unknown when or how this levee was installed, or even if it was intended to act as a levee. No responsibility or liability likely for council.
Levees and protection works (some ad hoc) to the front of Row 1	Various	No responsibility and no liability to Council.
Levees around the recreation centre	Unknown	Likely no responsibility and no liability to Council as the park is privately owned.
Ad hoc protection to the rear of dwellings on row 2	Unknown	Likely no responsibility to council as these are installed by others.

- **Have protection works implemented by Council been breached?**

The original protection to the car park was over-topped in 2009 and the block wall installed after that. The wall has not be over-topped since then.

- **In the case of new development within the settlements, have appropriate planning and Coast Protection Board policies been followed?**

Council has had a policy of applying the heights of sites and buildings in accordance with Coast Protection Board advice.

- **Has the Council made available sea level rise data to residents?**

No, but upcoming community consultation will begin this process.

- **Are there any emergency warnings and/or evacuation procedures in place?**

No, and recommendations will be made in the second half of this study.

Summary

In relation to the tort based claims of nuisance and negligence where the payment of damages can eventuate, the following points are relevant to the discussion:

- Middle Beach was subdivided and settled in (to be advised)the Council has no liability stemming from the establishment of the settlement.
- While there is a general statute that Councils are to act to keep their resident's safe (see Local Government Act) it is unlikely that the Council is legally responsible to implement protection works per se, and have no responsibility in relation to those allotments under a land management agreement enacted in 2002.
- It is common knowledge that threats can emanate from the sea and those that choose to live near the sea personally accept that risk (similar to those who choose to live in bushfire regions or in earthquake zones).
- In relation to liability in particular to protection works, the Council is likely to have a responsibility to ensure that protection works that have been installed more recently are adequately maintained in integrity and height.
- However, while there is no legal responsibility to implement protection works, Councils are likely to have a responsibility to warn their constituents of any danger. Therefore, the Council should make the findings and mapping from studies such as this one available to the public.
- Warning systems and evacuation procedures can be implemented and overseen by local resident's associations and also fulfil the Council's responsibility to ensure that residents are as safe as possible.

Administrative appeals may arise out of the solutions proposed to mitigate the threat of increased sea levels and storm surge heights. For example, if the Council were to restrict the types of development that could be approved, appeals to these decisions may be likely. However, recent trend in Court decisions indicates that the Court will take into account climate change related facets to a case.

4.2.7 Summary Table – Middle Beach

Stage	Question	Summary comment
1. Site history	When was the settlement founded?	Prior to 1960.
	Were climate change and sea level rise issues relevant?	No, there was no requirement to take into account sea level rise.
2. Existing protection	What existing natural protection exists?	None.
	What breaches have occurred?	Several – eg. 2007, 2009.
	What manmade protection works have been installed into the settlement?	Low block wall to car park by council. Other works by others.
3. Impact of sea-flood events	What is the likely impact for a 2.8 m AHD event?	Flooding expected for roads, and 27 dwellings affected at est. cost $351k. Settlement cut off from mainland at depth 0.8m
	What is the likely impact for a 3.0 m AHD event?	Flooding expected for roads, and 35 dwellings affected at est. cost $550k. Settlement cut off from mainland at 1m.
	What is the likely impact of a 3.7m AHD event?	All land forms to be overtopped. Settlement cut off from mainland at depth 1.7m. All dwellings but 4 to be affected.
4. Emergency access and egress	Egress issues in a 3.00AHD event	No egress from settlement and no safe land to which to retreat.
	Emergency vehicle access in a 3.0m AHD event.	No access.
5. Profile of assets at risk	How many residents are likely to be affected in 3.0m event?	35 affected with damage cost est $550k.
6. Liability issues	Does liability exist if Council fails to implement protection?	Unlikely to be any general liability
	Have residents been warned?	No.
	Have emergency procedures been implemented?	No.
	Are there conditions relating to the maintenance of protection works	No.
	Is there a maintenance regime of protection works?	Under investigation.
Other		

Note: Further research is required to ascertain the long term impact of the siltation processes underway at Middle Beach in relation to flooding. If the land is aggrading and prograding as may be occurring, then these factors may tend to mitigate the impact of future sea level rise.

4.2.7 Middle Beach – other issues raised in public consultation

Public consultation question (10th September, 2013): Where do you see that Middle Beach is vulnerable to flooding from the sea?

- REFER TO MAP (drawn at public consultation meeting)
- Middle Beach Road Flooding (2010 and 1995) from north-west direction.
- southern end of Esplanade flooded in 2010 and 1995 mainly on roads and surrounding areas

Rain water is not an issue- shell grit allows quick soakage. Some small pockets of rainwater pooling on entry road but of no concern.

5. Conclusion

Stage one and two of the Coastal Settlements Adaptation Study have now been completed and the findings are contained in this report. In stage one, the coastal settlements of Parham, Webb Beach, Thompson Beach and Middle Beach were assessed utilising the first six steps of the investigative 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 assets at risk.
6. Explore liability issues.

In stage two, the information that was gathered was presented to the public on 10th September, 2013 and placed on D C Mallala's website for public response. Submissions were invited from the public and the findings of those submissions incorporated into this report.

The overarching purpose of conducting the investigation is to provide a basis to make recommendations for adaptation options. These options can be categorised as:

- **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, 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.

An analysis of these adaptation options will be the focus of Stage 3 of the project, and Step 7 in the investigative framework, and bring the study to a conclusion.

6. References

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Appendices:

Appendix 1 – Exploration of general legal issues.

Appendix 2 – Council infrastructure records.

Appendix 3 - Other infrastructure maps (SA Water, SA Power Networks, Telstra)

Appendix 4 - Review of survey of Thompson Beach.

Appendix 5 - Thompson Beach settlement history review.

Appendix 6 - Findings from public consultation 10th September, 2013.

Appendix 7- Submission by A. Jenkins, king tide on 26th September, 2013.