PINE POINT

Seawater Flooding Adaptation Pathways for Yorke Peninsula Settlements

Stage 1 : State of Play

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Photograph of Pine Point seafront supplied by Coast Protection Branch.

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

DEM

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

EROSION

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

STORM SURGE

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

Introduction

1.1 Background and scope

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

In this report the settlement under consideration is:

Pine Point.

Figure 1:1 Location Map: Pine Point, Yorke Peninsula[1]

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

1.2 Investigative framework

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

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

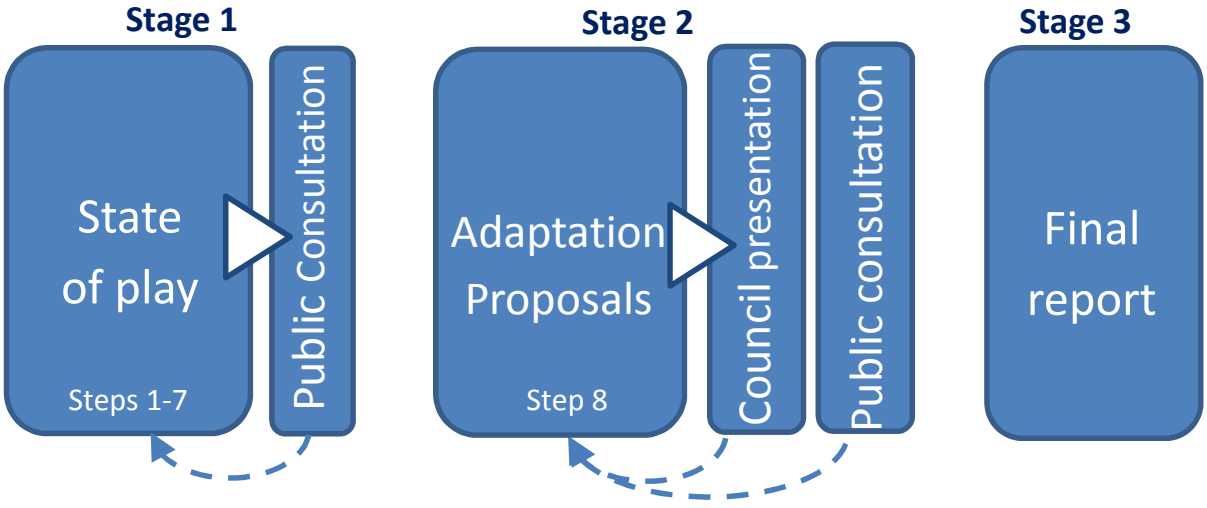
1.3 Methodology and staging

The process is to be undertaken in three main stages (Figure 1:2):

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

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

Figure 1:2 The coastal adaptation study is conducted in three stages[2]



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

Stage 2: Propose adaptation options (Step 8)

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

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

Stage 3: Final reporting

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

2. Investigative Framework

The purpose of this section is to explain the rationale and methodology for the investigation.

2.1 Establish Settlement history

A history 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. In particular in relation to coastal matters, any previous coastal studies that have been undertaken are identified and assessed.

Key assessment questions:

- When was the settlement established?
- What account was taken in relation to potential impacts from the sea?
- What previous flood studies have been undertaken?

2.2 Analyse existing sea-flood protection

Protection can be afforded a settlement in two ways: natural land forms such as dunes and headlands, and man-made protection works, such as sea walls, bunds or levees. There are two reasons for paying particular attention to man-made protection works. First, an analysis of the implementation of protection works in the past may provide a historical context to the current coastal issues. Second, a review of policies and cases around the world found that issues of public sector liability may be raised where protection works have been implemented[3]. Therefore, reviewing the circumstances of the implementation and historical performance of any existing protection works and whether maintenance obligations have been fulfilled, will help inform the question of current and future responsibilities for council and landowners.

Key assessment questions

- What existing natural protection exists?
- What existing man-made protection has been installed?
- Have the protection systems ever been breached?

[3] Balston et al (2012) *Climate change decision support framework and software for coastal councils*, Local Government Association of South Australia, Adelaide, SA.

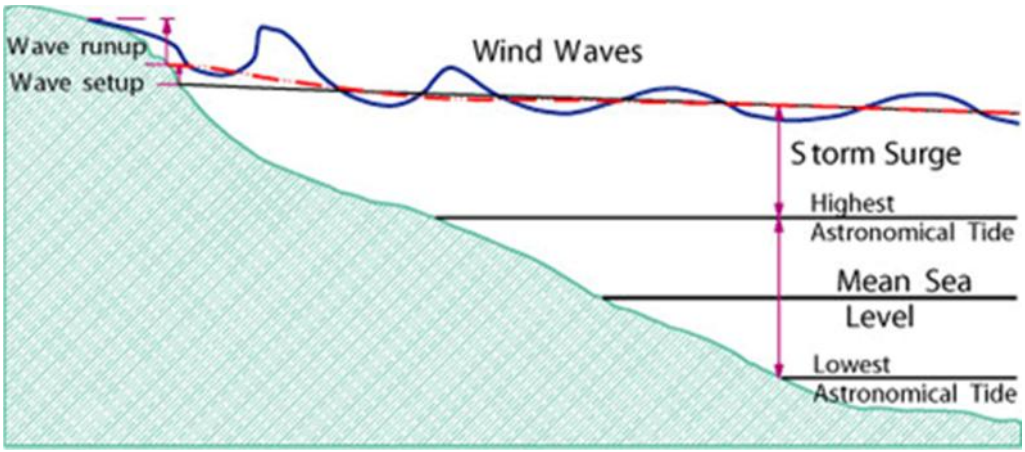
2.3 Analyse the impact of the sea upon the coast.

In accordance with the defined scope of the tender documents, the primary focus of this study is to evaluate the threat of 'sea-flooding'. However, as secondary focuses both coastal erosion and stormwater flooding from the land will be taken into account where information is available so as to provide the most comprehensive 'coastal picture' possible. Where it is not possible to deal appropriately with an erosion or storm water issue, general recommendations are made as to how to deal with these.

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

Historically planners have evaluated potential threats of 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. Water levels are expressed in terms of Australian Height Datum (AHD) which is 1.45m lower than tide charts (Chart Datum). This compounding effect is unique to each coastal location due to differing sea floor level formations and wind intensity and direction (Figure 2:1):

Figure 2:1 The factors utilised to calculate the highest likely water level



Source: http://www.ozcoasts.gov.au/climate/sd_fqa.jsp#HAT

The Average Recurrence Interval (ARI) is utilised to assess the risks associated with naturally reoccurring events such a sea-flooding. ARI 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 height. It is important to note, that the ARI calculation is just the probability that a particular event might occur, based on historical observations. There is nothing to prevent two or more 1 in 100 ARI events occurring within days or weeks of each other, though this would be unusual.

For over twenty years SA Coast Protection Board has utilised the following inputs to calculate the 1 in 100 ARI event for Pine Point (See Table 2:1).

Table 2:1 Pine Point -1 in 100 ARI storm event (current since 1994)

Storm surge (at king tide)	2.75m AHD
Wave set up	0.20m AHD
Wave run up[4]	0.30m AHD
Total Risk (total)	**3.25m AHD**

However subsequent to the findings of this study, Department of Environment and Natural Resources (CPB) has amended these sea-flood risk levels to the following (Table 2.2).

Table 2:2 Pine Point - 1 in 100 ARI storm event (amended in July, 2015)

Storm surge (at king tide)	2.6m AHD
Wave set up	0.1m AHD
Wave run up	0.1m AHD
Total Risk (total)	**2.8m AHD**

2.3.2 Predicted sea level rise

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

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

Therefore, combining the specific ARI calculation for Pine Point with Coast Protection Board policy sea level rise rates, the following table depicts the sea-flood risk for Pine Point.

Table 2:3 Pine Point - 1 in 100 annual return event, with allowance for sea level rise

	1990	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[4]	0.1m	0.1m	0.1m
Sea level rise	0.0m	0.3m	1.00m
Totals (AHD)	**2.8m**	**3.1m**	**3.8m**

2.3.3 Actual sea level rise

Since 1990, as part of the national Seaframe Project, two tidal 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

[4] Wave run up is usually applied in situations where wave action intersects with a vertical wall such as a levee or rock revetment.

1990 to 2010 has been an average of 4.3mm per year (Figure 2:2). 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 an average of 1.5mm per year. This data indicates that sea levels in the region are rising and that the rate of rise has increased over the last twenty years.

If the current rate of sea level rise remained 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 300mm (0.3m) rise that SA Coast Protection Board has incorporated into its policy framework.

Figure 2:2 Tidal gauges at Thevernard and Pt Stanvac have recorded an average rise of 4.3mm[5]

Recognising that the sea has been rising since 1990 levels the current risk levels for 2015 are calculated by including a 0.1m rise[6] (Table 2:4).

Table 2:4 Pine Point - 1 in 100 annual return event, with allowance for sea level rise

	1990	2015	2050	2100
Storm surge (at king tide)	2.6m	2.6m	2.6m	2.6m
Wave set up	0.1m	0.1m	0.1m	0.1m
Wave run up	0.1m	0.1m	0.1m	0.1m
Sea level rise	0.0m	0.1m	0.3m	1.0m
Totals (AHD)	**2.8m**	**2.9m**	**3.1m**	**3.8m**

[5] Bureau of Meteorology, 2013
[6] 4.3mm x 25 years = 107.5mm (rounded to 0.1m).

2.3.4 Which sea level rise scenario?

The storm surge and sea level rise event calculated for the year 2050 will be primarily utilised in stage one, the State of Play report 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 degree of confidence in the policy levels 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 also assist in identifying whether coastlines are eroding, and at what rates.
- 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.

2.3.5 Key assessment questions

- What is the likely impact on the settlement of the 2015 sea-flood scenario?
- What is the likely impact on the settlement of the 2050 sea-flood scenario?
- What is the likely impact on the settlement of the 2100 sea-flood scenario?

2.4 Analyse emergency access and egress.

Historically sea-flood events in Pine Point have been of low velocity and low wave height. However, this observation does not imply that these events carry no risk to people. Vulnerable members of the community, the aged, disabled, or young, may be in danger, especially if an event was to occur at night and access ways flooded. 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. The purpose of this investigation is to provide a filter through which a preliminary assessment can be made regarding personal safety.

Key assessment questions:

- In the event of 2050 sea-flood event, are emergency services able to access the settlement?
- In the event of a 2050 sea-flood event, are people able to move directly away from the place where flooding is occurring (egress)?

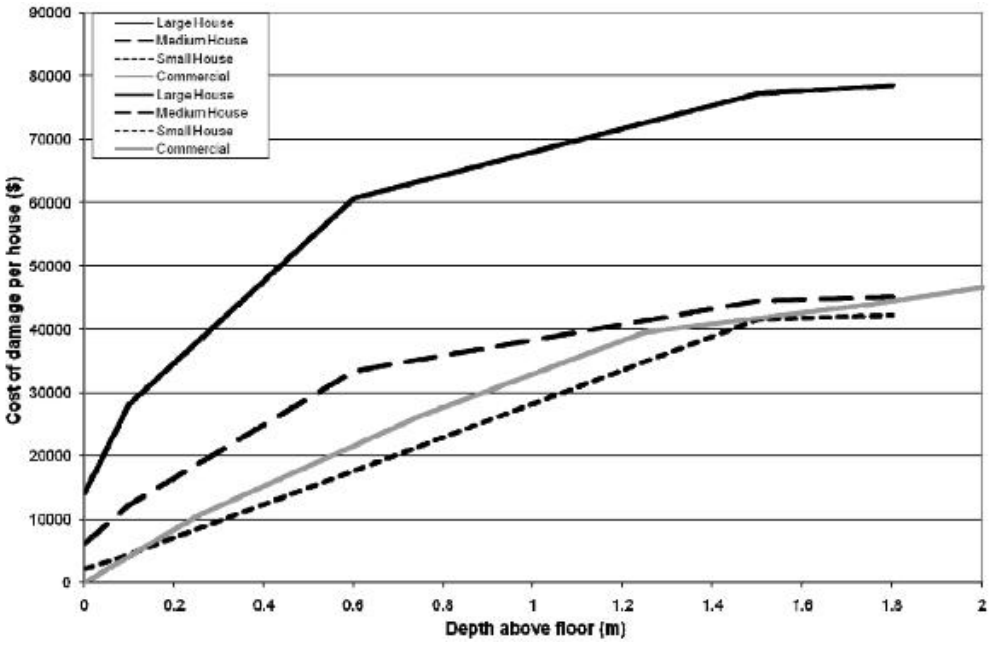
2.5 Establish profile of assets at risk

The assets under investigation in this study are those that are privately owned (houses and land), or owned by the Council (buildings, roads, shelters, public toilets, playgrounds, and equipment).

Assets owned by Telstra, SA Power Networks, and SA Water are not a focus of this study[7].

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 flood damage. Figure 2:3 depicts the flood depth/damage curve that is utilised in this study[8]. The 'small house' scenario has been chosen from the curve for Pine Point.

Figure 2:3 Flood/damage curve utilised in the study (adapted from ANUFLOOD,2008[9])



[7] The intention is to forward reports from this study to other asset owners.

[8] 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 (12% approx) from ABS and an extra 8% due to the number of medium size houses in the area. There are some larger houses in the Pine Point area, but these are generally newer and constructed at higher floor levels.

[9] Sinclair, Knight, Merz, 2008, Assessment of flood risk to the township of Barmah, prepared for Goulbourn Broken Catchment Management Authority.

2.6 Identify existing policy framework.

Step six of the investigative framework is to review the existing policy framework within which the Council manages the coastal environment. This study will review the strategic planning policy that is found in the *Yorke Peninsula Regional Land Use Framework (2007)* and the *Yorke Peninsula Council Strategic Plan*, and the policy found within the *Yorke Peninsula Council Development Plan* as the key statutory document against which all development applications are assessed. The two main reasons to review the existing policy framework are to understand the current parameters by which Council makes its development decisions, and to analyse whether the existing policy settings are appropriate to deal with potential sea level rise.

Key assessment questions:

- What are the key strategic planning policies in relation to coastal matters?
- What are the key development assessment policies for applications to develop in the coastal areas?
- How has Yorke Peninsula Council been operating within the statutory planning environment?

2.7 Explore liability issues.

It is important to recognise that this section is designated an 'exploration' rather than as definitive legal advice. The reason for including it is to provide the reader with a full range of the issues that need to be considered when dealing with coastal matters. Where there is any doubt about particular circumstances, these should be referred to the Council's legal advisors[10].

2.7.1 In what ways can a council 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 relating to that asset from affected parties. If liability has not been clearly established such claims may result in legal action where both the Council and affected parties 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. 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.

2.7.2 In what ways can a 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.

Administrative Appeals

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 have not been adequately addressed, or when Councils make amendments to the Development Plan that may restrict the types of development permitted 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 in Australia to date have been administrative appeals.

Tort based claims

There are two types of tort based claims where Council can be liable to pay damages namely, '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' which was Byron Shire Council v Vaughan in NSW.

[10] 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.

2.7.3 Possible legal defences

In common law, the defence of 'voluntary assumption of risk' provides that the defendant is not liable 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 would 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 fact. 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 put in place 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.

In what circumstances is a council vulnerable 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 council has not advised residents of the risk or does not have emergency action plans in place to deal with possible risk.

2.7.4 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, the absence of legal liability does not mean that the Council need not take any action to implement protection works and strategies. However, these actions need to be implemented carefully and include public awareness strategies to avoid the creation of new potential liabilities to council.

Key assessment questions:

- What obligations did Council have to assess impacts from the sea at the time the settlements were established?
- 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 sea level rise data available to residents?
- Are there any emergency warnings and/or evacuation procedures in place?

3. Community consultation process – Pine Point (Part 1)

The community consultation process in Stage 1 reports *to* the public about the potential for sea level rise but also actively requests information *from* the public to create the full 'sea-flood risk picture'. In the first instance, the purpose is to communicate the framework in which coastal planners manage coastal risk so as to build a common understanding within the community, and also to communicate the specific findings of the study. In the second instance, the community is considered to be a source of historical knowledge that will add to the flood picture. In particular photographs, videos or anecdotes are valuable sources of information which can be checked against the current Digital Terrain Model (DEM) to assist in ascertaining the likely height of previous flood events. The public consultation strategy included three main facets.

3.1 Public awareness campaign

The following activities were undertaken to raise awareness about the flood study:

- Three Newspaper articles were run in the Yorke Peninsula Country Times (2nd March, 12th May, 19th May, 2015).
- The Council contacted the Pine Point Progress Association to garner their support in attendance and assisting with public consultation meetings.
- The Council provided information about the flood study on its website.
- A 'fact sheet' and invitation to attend a workshop at Pine Point Town Hall was direct mailed to all land holders in week of 13th April, 2015 (See Appendix A).
- Two ABC regional radio interviews were conducted with the lead consultant.
- Pegs were installed on 20th April to the foreshore of each settlement with markers indicating the current and future flood risks (Figure 3:1).

Figure 3:1 Public awareness - flood risk pegs were installed to the foreshore

Photograph: M. Western, 2015

3.2 Informal consultation

Whenever data collection in and around the Pine Point settlement was underway, the consultant (Mark Western) made informal connections with numerous residents. In this informal process, often the main concerns of the settlement were identified, and residents also contributed photographs or anecdotes that improved the overall understanding of the coastal issues. With this preliminary information already gathered, the formal consultation meeting could be much better targeted.

3.3 Formal consultation

A formal meeting was held at Pine Point Town Hall at 2.30pm on 13th May, 2015 at which thirty-one residents from Pine Point attended. Mark Western presented the framework that coastal planners utilised in catering for coastal risks, and the findings from the flood mapping and other investigations. In the second half of the meeting, group facilitators[11] encouraged participants to answer prepared questions and to provide marks and comments on the provided map of Pine Point (Appendix B).

3.4 Public consultation reporting

Rather than devoting an extensive section within the report to public consultation, contributions from the public are integrated within the flow of the report utilising green font. Where permission was not specifically obtained from those that contributed to the study in the informal part of the public consultation process, these contributors are noted as *Pine Point Resident #* within the report. A list of names and addresses (where obtained) have been provided to Council so that the necessary validation of data can occur if required in the future.

Any public consultation issues that are not covered within the flow of the report using the green font methodology are reported at the end of the next section.

[11] Group facilitators for the consultation meeting were Professor Jon Kellett (Adelaide University), Natasha Hall (Central Region Climate Change Officer), and Stephen Goldsworthy (Yorke Peninsula Council).

4. Findings of the investigation (Pine Point)

The remainder of this report represents Stage 1, the 'State of Play' as described in the previous sections. The initial context for the investigation is given in the Yorke Peninsula Council request for quote which states that 'Pine Point (Billy Goat Flat) has a number of shacks in low lying areas. There has been previous seawater flooding events with water inundation into rear of properties'[12].

4.1 Settlement History

4.1.1 When was the settlement established?

Pine Point was established in 1874 but settlers were attracted to this region well before this date. Livestock was moved into the Pine Point area as early as 1846. Later, agriculture arrived on the peninsula and Pine Point became one of the many small ports where ketches could be loaded directly from drays. In the 1920s a wharf was constructed at Pine Point and was in use until 1967 and is still in place about 400 m south of Billy Goat Flat (lower Pine Point)[13].

Figure 4:1 Pine Point Wharf

Photograph: Coast Protection Board, 2014

[12] Yorke Peninsula Council (2015) Request for Quote, p.15

[13] http://www.samemory.sa.gov.au/site/page.cfm?u=1240

4.1.2 What obligation did Government have to take into account impacts from the sea?

Pine Point was founded well before any Acts of Parliament were established that relate to planning and management of the coast. Therefore, there was no overarching statutory requirement for the founders of Pine Point to take into account actions of the sea.

4.1.3 What previous coastal investigations have been conducted?

The purpose of this section is briefly identify any previous coastal investigations to ensure that the current study appropriately builds upon any relevant former work. The works listed below are referenced throughout the remainder of the report where relevant.

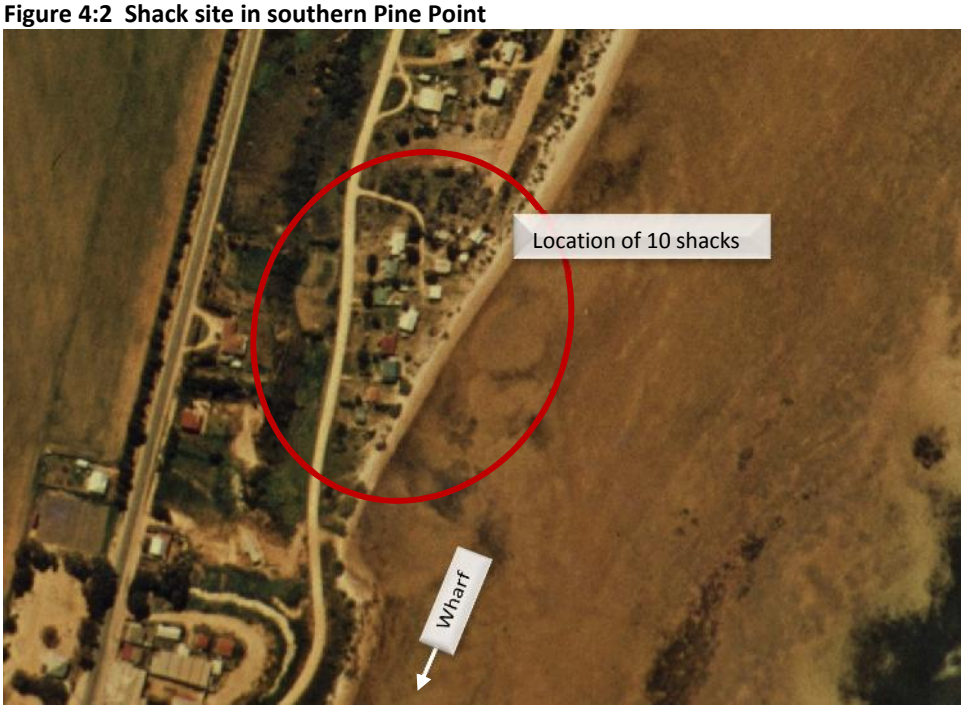
Shack Coastal Hazard Study 1994 – a report for the shack site freeholding committee[14].

In 1994 at the request of a ministerially appointed 'shack site freeholding committee' a study analysed a list of shacks at over fifty settlements that were situated on the three peninsulas and Kangaroo Island. The sites and shacks were assessed against set criteria[15] and categorised into three main groups:

- Shacks which conform on both flooding and erosion criteria (or easily made to conform)
- Sites which could be made to conform (with set-backs, protection, and/or filling)
- Sites which could not be made to conform without unacceptable physical impacts on the coast.

Ten shacks in the south and three shacks in the north[16] were assessed in Pine Point settlement.

Figure 4:2 Shack site in southern Pine Point



Photograph: Coast Protection Board, 1976

[14] Prepared by Department of Environment and Natural Resources 1994
[15] Criteria unknown – not supplied with Shack study.
[16] The latter not within the scope of this study. Note: There appears to be eleven or twelve shacks in the photograph but this photograph taken in 1976 and much earlier than the 'Shack Study' in 1994.

The report concluded that 'none of the shacks comply' with tide and wave inundation criteria, and none of the shacks complied with erosion susceptibility criteria (if no account was taken of the existing sea low stone wall[17]). The report notes that building sites would need to be raised by about 1m. The report also noted that the low stone wall was causing the beach to the north to erode and canvassed the idea of 'removing the sea wall and relocating the shacks…to enable the beach at Pine Point to be retained, perhaps for many years until coastal recession threatened freehold development to the north'[18]. If this proposal was not instigated, the report suggested that protection may eventually be needed for the whole area, 'and the existing wall, suitably upgraded could become a part of this'.

Report on Coast Protection Board (CPB) field trip of Yorke Peninsula in 2002

The report on the CPB field trip also included a 'Guide to Policies on Protection for Shack Sites' to assist shack owners in the processes involved in the development and implement of a protection strategy for shack sites that minimise future coastal erosion and flooding damage to the existing development. The CPB's policies in relation to new development, including protection works, were aimed at structures which:

- Will not damage beaches or the coastal environment
- Minimise coast protection costs, and
- Minimise the state's future liability for unwise coastal development.

Specifically this report relates to the three shacks[19] on the southern-most part of Pine Point that were freeholded in the 'third round' and included land management agreements that ensured the owners (and subsequent owners) bear the responsibility and cost for any protection works.

The main points of the assessment of Pine Point were:

- Existing protection… consists of dumped paddock limestone and small stone which is 'very haphazard and not very attractive' but doesn't appear to be having any detrimental impact on the coastal processes.
- The elevation of the shacks is declared to be 'level with the surrounding land' and that water enters along the road reserve and inundates the land behind the reserve and houses.
- In relation to the stability of foreshore, the report concludes there is minimal longshore drift and that the coast has eroded and is being held by existing rock revetment. Further to the north the coastal reserve is eroding and in time will become a flooding threat to the coastal portions of residential settlement.

[17] Not visible in the 1976 CPB aerial photograph.
[18] p. 103
[19] This was originally the 'ten shack' site. What has occurred with the other shacks is not clear. It is likely some were removed and some retained but were freeholded in an earlier round.

The report lists the factors to be considered in determining and erosion and flooding protection policy for this site:

- Sediment loss is most probably due to natural sediment transport to the north,
- Sediment supplies from the south are lower and resulting in sediment loss to the southern end of Rogues Point,
- Wave energy along this coast is low and predominantly from the southeast,
- Improved rock revetment would have little additional impact of coastal processes,
- There is a flooding and erosion risk to the main residential area of Pine Point,
- Protection costs will be the responsibility of the shack owners, because the settlement was part of the latest round of shack freeholding,
- The preferred location for the revetment is 2 metres from the seaward coastal boundaries to provide pedestrian access to defined beach access locations,
- Flooding and erosion strategies will need to be in accordance with Council's flooding and erosion minimisation principles contained in its Development Plan.

One main recommendation of the report was that a strategy be devised that results in a flooding and protection strategy for the three shacks at the southern end of Pine Point and the coastal portion of the residential township of Pine Point.

Yorke Peninsula settlement vulnerability study[20] (2012).

The Yorke Peninsula settlement vulnerability study concurs with the findings of the 2002 Coast Protection Board report on the nature of the erosion and flooding in the Pine Point settlement.

It also notes the existing levee was built in 2003 and protects a single parcel of land held under life lease arrangement but this levee also provides a level of protection to the township allotments. The three freehold shacks are not protected in any way[21]. The levee was built by DC of Yorke Peninsula and was partly funded by Coast Protection Board. The levee is built on Unalienated Crown Land but there is no agreement of licence attached to the crown land parcel to record to indicate this. Council as the authority constructing the levee, became the owner of the asset.

The study notes the following issues:

- Levee bank needs upgrading, the beach shows increasing erosion scarps, and there are possible stormwater management issues.
- Paddock stone has been placed at the top of the beach (before 2006) without any authorisation, and these have been spread across the beach in subsequent years.

The study also reports that a resident at Pine Point has reported that the levee was close to overtopping. This is unlikely to be correct because it was confirmed in public consultation meeting of 13th May that water is able to flow around the levee at the road end but this is at a much lower level than the general top of the levee.

[20] Coast Protection Board

[21] The three shacks were freeholded but due to their location in a 'conservation zone' the new owners were required to implement land management agreements that are noted on land titles.

Sea flood risk mapping of selected locations on Yorke Peninsula, Australian and State Governments (2007-2011)

The objective of this project was to improve the coastal hazard information base for low-lying land on the Yorke Peninsula by producing a digital elevation model (DEM) and associated flood mapping for settlements deemed as a high priority. The project utilised a risk identification strategy to identify those settlements most at risk by assigning a number from 1-3 in a range of categories. Pine Point was not assessed for the project.

National Climate Change Coastal Vulnerability Assessment: Yorke Peninsula Case Study, South Australia, Australian Water Environments et al (2009)

This federally funded project was one of six case studies conducted around Australia to assess the climate change impacts on coastal settlements of Yorke Peninsula and to provide tools to begin developing appropriate adaptive responses. The study utilised Marion Bay, Moonta Bay, and Port Broughton/Fishermans Bay as the subject sites. The study had a wider scope than this current study and was to take into account the impact of climate change generally upon the coastal environments which included both built assets and natural habitats. The study implemented a risk assessment methodology, evaluated relevant legislation and policy, and suggested adaptive actions for each of the settlements.

4.2 Analysis of existing flood protection

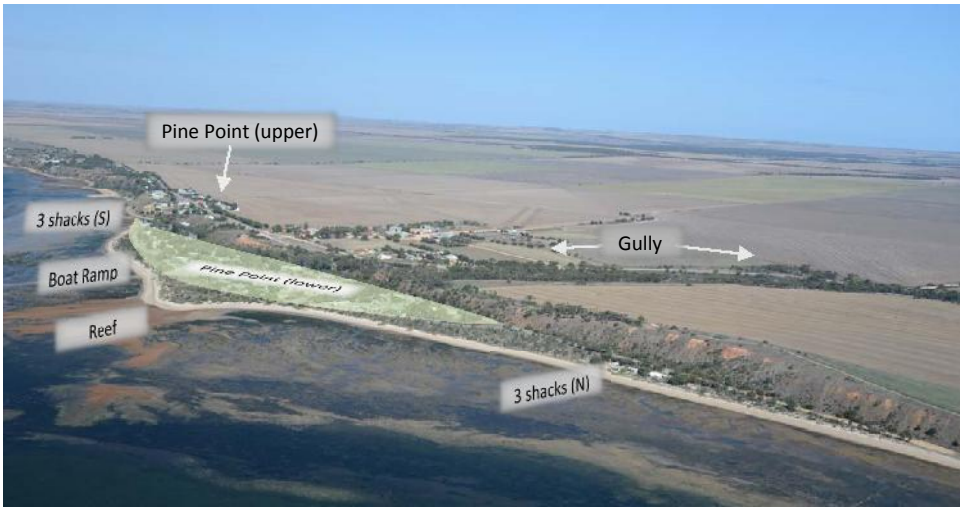
The primary purpose of this section is to analyse the existing protection from sea flooding. However, in an effort to provide the fullest 'flood picture' possible, potential for inland flooding is also reviewed where these factors are known.

4.2.1 What existing natural protection exists?

Coastal environment

Figures 4:3 and 4:4 show that Pine Point is situated on a low plain adjacent the sea and runs in a narrow strip of land in the formation of a capital 'D'. The area is also known as 'Billy Goat Flat'. The three shacks in the northern section of Pine Point are those shacks mentioned in the 'Shack Coastal Study' and likewise the three shacks in the southern section are those remaining from the assessment area of ten shacks (see p. 20-22)

Figure 4:3 The nature of Pine Point coastal region



Photograph: Coast Protection Board (2014)

Figure 4:4 The nature of Pine Point coastal region

Photograph: Coast Protection Board (2014)

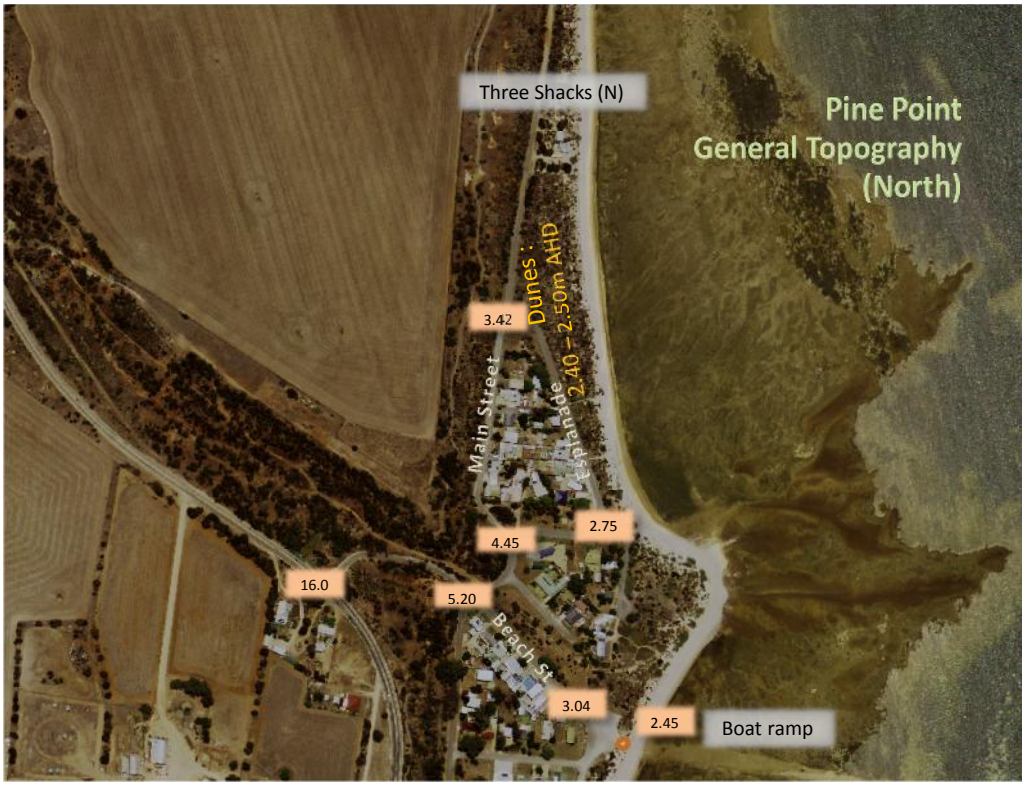
Natural topography of Pine Point settlement

The lower settlement is bordered on the west side by an escarpment. On top of the escarpment the service and community centre of Pine Point is situated at elevation 20m - 22m AHD.

At the base of the escarpment, Main Road acts as the spine of the lower settlement (the back of the 'D') at predominant heights of 3m to 4m AHD, but is at height 2.5m AHD on the southern end.

The road that forms the curve of the 'D' is The Esplanade and this road ranges in height from 2.40m to 3.53m, at its highest point near the boat ramp area. The dunes to the front of the front of the settlement provide protection generally at heights 2.40 to 2.50m AHD.

Figure 4:5 Natural topography of Pine Point (north)



Aerial photograph: Department of Environment Water and Natural Resources, 2015

Figure 4:6 Natural topography of Pine Point (south)

Aerial photograph: Department of Environment Water and Natural Resources, 2015.

4.2.2 What existing man-made protection has been installed?

While the focus of this study is 'sea-flooding' in an effort to provide the greatest context possible for future decision making, this section also provides an overview of the rain flood protection system that is currently installed at Pine Point.

Storm water management: General Scheme

In the centre of Pine Point a storm water gully is situated into which water from the upper region of Pine Point flows (Figure 4.7). However, practically this gully would service very little of Pine Point and as there are no other drainage structures in Pine Point, storm water run-off must drain away into the subsoil. At present the mouth of the gully is blocked by sand dunes[22].

Resident Bob Hawes recollects that in the 1960s the path of the storm water gully exited at the end of Earl Street. In the 1960s the path of storm water flow was changed to exit adjacent to Beach Road (its current path).

[22] Some residents held the view that Council had blocked off the exit point of the gully. Council's response was that this did not occur.

Figure 4:7 Pine Point storm management (general scheme)

Aerial photograph: Department of Environment Water and Natural Resources, 2015

Sea flooding management: General Scheme

Two sea-flood protection works have been installed to Pine Point. The first is an earthen levee constructed in 2003 in the southern section between the three southern shacks and the remainder of the settlement to the north (Figure 4:8 and 4:9). The levee is predominantly at heights 2.70m - 2.80m AHD but tapers down to 2.40m AHD where it meets Main Road.

The second protection measure is a rock revetment constructed from limestone paddock rocks installed to the front of the southern shacks to prevent further erosion. The height of the rock revetment is predominantly at 2.0m to 2.1m AHD. The revetment is not of sufficient length to join the earthen levee section but generally the land elevation between the two is 2.0m AHD.

Figure 4:8 Protection works constructed in southern area of Pine Point

Photograph: Coast Protection Board, 2014

Figure 4:9 Levee constructed in southern region of Pine Point

Photograph: M. Western, 2015

General condition of protection

Earthen levee in southern section

The earthen levee was constructed at 2.70m to 2.80m AHD and only 2.40m AHD at the western end. The Development Approval granted in 2003 required the height of this levee to be 3.25m AHD. Most sections of the levee are in solid condition but some erosion is scouring the levee where it is vulnerable to wave action from the southeast.

Figure 4:10 Earthen levee in south Pine Point shows signs of erosion

Photograph: M. Western, 2015

Rock revetment

The rock revetment is constructed of smaller paddock rock and is in fair condition. The wall was constructed by the owners of the shack sites and remains their responsibility to maintain.

Beach Stability

In circa 1980 Coast Protection Board compared 1972 photography of Pine Point with photography in the 1940s and concluded that erosion had been 0 m and there was 'no change' to the coastline[23]. This long term stability changed from 1994 onwards, with reports noting increasing problems with erosion[24].

As a contributor to this study Australian Water Environments (AWE) recently undertook an assessment of the historical and current coastal erosion issues at Pine Point using aerial photography from 1976, 2004, 2012 and 2014 (See full report Appendix C). With appropriate qualifications AWE concluded:

- There appears to be consistent recession for the time period 1976 -2004
- Between 2004 and 2012 recession in the southern area increased significantly but there was no evidence of recession near the boat ramp.
- From 2012 to 2014 the rate of recession in the southern area continued at an increased rate, but the rate of recession near the boat ramp also accelerated.

Taking into account all of the evidence it is likely that Pine Point was a stable beach from the 1940s through to the mid 1990s from which time the rate of erosion has escalated, first in the south, and more recently around the boat ramp area. AWE concluded 'as the shoreline is already at the base of the southern extent of the levee, and with the rate of recession appearing to be increasing, it is likely that the levee could potentially be in danger of failing within a 10 year timeframe without further intervention'.

Residents reported increasing rates of erosion in the last few years of 6m (Group 7) and 10-15m (Group 6) in between the rock revetment and the levee (See Figure 4:8). Dozens of photographs were submitted with one example of erosion in the south of the settlement in Figure 4:11.

Figure 4:11 Erosion occurring south of Pine Point settlement

[23] Coast Protection Board, 1980, Appendix K – Changes in Coastline Position

[24] See pp. 18-21: Shack Coastal Hazard Study, 1994; CPB field trip report, 2002; Yorke Peninsula Vulnerability Study, 2012.

4.2.3 What is the nature of sea-flooding events that have occurred in Pine Point?

The following questions are relevant to this section and were also put to the public in the consultation process:

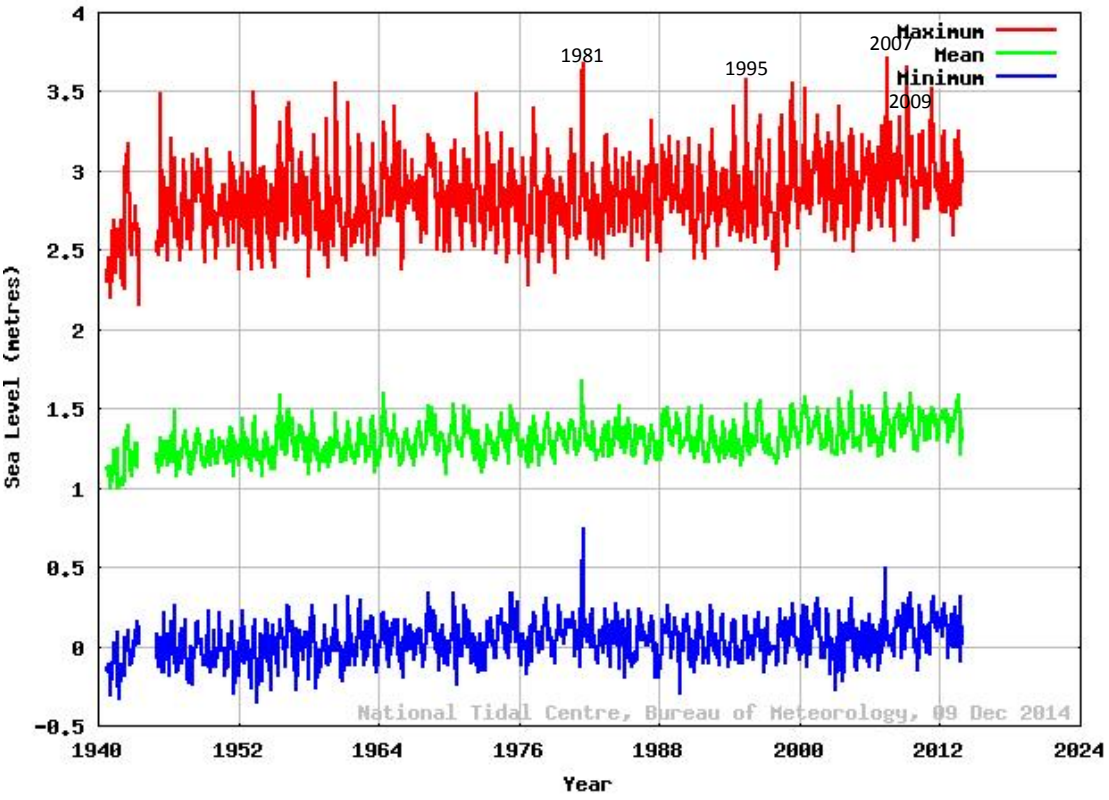
- What sea-flood events have occurred in the past?
- What is the nature of the wave action in sea-flood events?
- What wind direction accompanies high water events?

What sea-flood events have occurred in the past?

Flood events in Gulf St Vincent

The tidal gauge at Port Adelaide provides over eighty years of data from 1940 until current day (Figure 4:12). The location of Pine Point in the upper regions of Gulf St Vincent means that any elevated water experienced in that region must be contingent upon elevated waters further down the Gulf. While local meteorological factors can influence the way the storm surge is experienced in different locations, the shallowness of the water in the Pine Point region makes any significant increases in storm surge heights unlikely. It is therefore expected that these large storm surge events would play a significant role in the history of flooding at Pine Point.

Figure 4:12: Tidal record from Port Adelaide (1940 – 2015)



Source: http://www.bom.gov.au/ntc/IDO70000/IDO70000_61600_SLD.shtml

The four highest recorded flood levels at Port Adelaide since 1940 are:

- 1981 – June 3.579m (2.129m AHD) and July 3.679 (2.229m AHD)
- 1995 – July 13th, 3.569m (2.119m AHD)
- 2007 – July 4th, 3.707m (2.257m AHD)
- 2009 – April 25th, 3.654m (2.062m AHD)

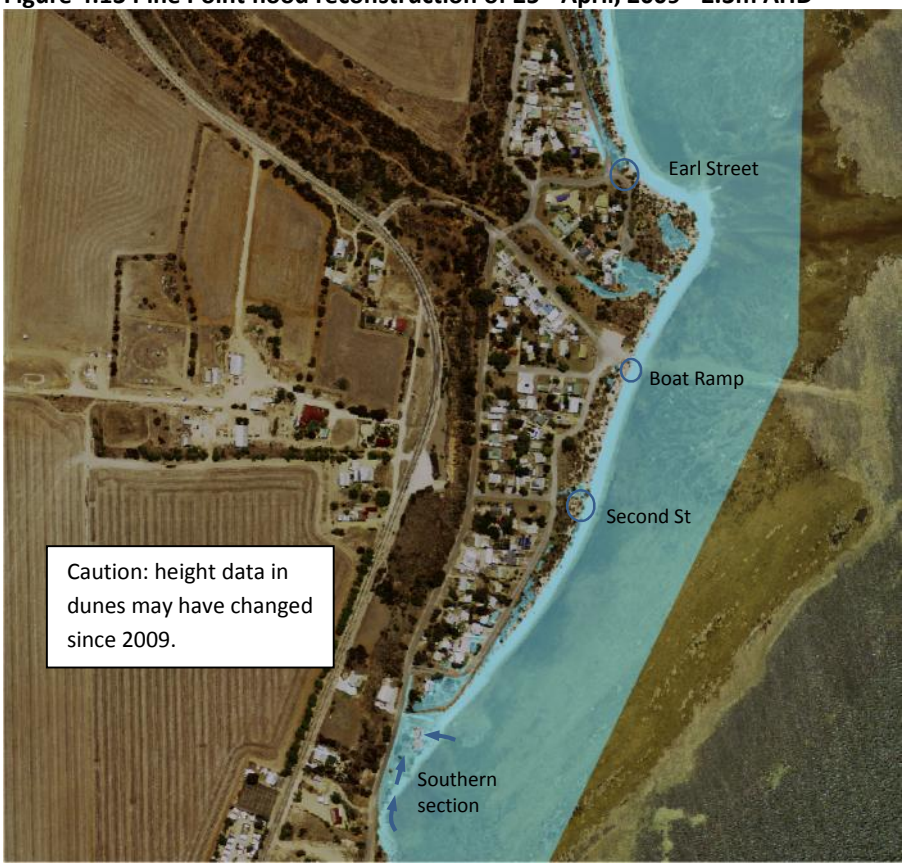
Flood events in the Pine Point region

The request for quote states that 'Pine Point (Billy Goat Flat) has a number of shacks in low lying areas. There has been previous seawater flooding events with water inundation into rear of properties'.

In community consultation two groups noted 2009 as the worst flooding they had experienced in Pine Point. The factors about this event are recorded below and reproduced in Figure 4:13:

- Water *almost* overtopped the dunes at the walkway at the end of Earl Street,
- Water moved between the dunes at the boat ramp,
- Water entered through the dunes at the end of First Street,
- In the south, water entered the road reserve and traversed north behind the three shacks (but no mention of water traversing past the levee where it meets Main Road).

Figure 4:13 Pine Point flood reconstruction of 25th April, 2009 - 2.3m AHD



DTM flood reconstruction: M. Western, 2015

A flood height of 2.30m AHD provides the best rendering of all of the known factors on the 25th April, 2009 flood event.

Many photographs were submitted of the king tide event on 5th May, 2015[25] with one example provided below. In this example water is just overtopping the rock revetment wall in the south. A reconstruction of this event using the DEM indicated that 5th May was approximately 2.0m AHD (including wave height).

[25] No flood photographs were received of any other flooding event.

Figure 4:14 Pine Point flood reconstruction of 5th May, 2015

Photograph: Fay (resident Pine Point), 5th May, 2015

What is the nature of the wave action in sea-flood events?

In formal community consultation the firm feedback received from the audience was that the wave action that brought the erosion was driven by winds from the south-east but this action was not accompanied by extreme high water events. It was generally conceded that the high water events were accompanied by calm water. Figures 4:15 and16 provide examples of the two actions:

Figure 4:15 Pine Point with winds from southeast and lower water levels

Photograph: Pine Point resident (provided at community consultation meeting)

Figure 4:16 Calm water associated with high water events (5th May, 2015)

Photograph: Fay (resident Pine Point), 5th May, 2015

What wind direction accompanies high water events?

Residents in formal consultation did not answer this question in a comprehensive manner:

Group 5: 'Difficult to be sure. Off the land'.
Group 6: 'South winds pushes up the gulf'

4.2.4 What rain flooding events that have occurred in Pine Point?

The purpose of this section is not to provide a full analysis of rain flooding events in the Pine Point region, but rather to establish the likelihood that rain flooding might cause overland flow and compound the problems experienced in sea flooding events. As a general note, previous work by Australian Water Environments and Tonkin Consulting has demonstrated that 'storm surge and high rainfall events are independent for this region' (ie, the Yorke Peninsula region)[26]. In other words, the weather systems that produce storm surge events are deemed to be unrelated to the weather systems that produce high rainfall events. Residents in public consultation processes made no correlation between the two events.

Residents did recall two events:

- In 1947 there was a large 'land flood' (Group 5),

[26] Australian Water Environments (2009) National Climate Change Coastal Vulnerability Assessment: Yorke Peninsula Case Study, SA, p. 25

- In recent years (and discussed openly at community consultation meeting) a rain event occurred that saw water accumulate on the upper level of Pine Point due to the blockage of storm water pipes. The water overtopped the escarpment and flowed down and out to sea, cutting a large channel adjacent a dwelling situated on the upper road.

4.2.5 Conclusions

The following preliminary conclusions can be made in relation to the protection scheme at Pine Point:

- The general topography of Pine Point (Billy Goat Flat) is at 3.0 to 5.0m AHD adjacent the base of the escarpment, and generally at 2.50m to 3.50m along the Esplanade.
- The highest level of flood water in the last 20 years is likely to have been around 2.30 m AHD on 25th April, 2009. There are no photographs of major flooding events, and no recollection of other major events (apart from two mentions to 1940s, 1950s).
- Available evidence suggests that Pine Point was a stable beach from the 1940s to the 1990s, but since then is experiencing erosion at increasing rates. Analysis suggests that the southern levee may be compromised within 10 years.
- The lower section of Pine Point (south of the levee) floods readily (as it only requires inundation at 2.0m AHD to be overtopped). Water traverses from the south around behind the three shacks and between the three shacks and the levee bank. The water threatens to flow around behind the levee bank which is at a lower height where it meets Main Road.

4.3 Analyse the impact of sea-flood scenarios

4.3.1 Coastal Processes

In Gulf St Vincent

Modelling study

Work begun by Easton (1970), and Noye (1998) was built upon by Grzechnick[27] whose modelling study in 2000 found that elevated storm surges in Gulf St Vincent are unable to be generated by tide, wind or currents alone (with the exception of a southwest wind which has the 'longest reach' from the Southern Ocean through Investigator Strait and can raise water levels at Port Adelaide). Elsewhere in the gulf he contends that storm surges are contingent on the presence of larger swells coming through Investigator Strait that are generated by weather conditions in the Great Australian Bight.

Observations

Flinders Ports operates seven ports in South Australian waters and make the following observations on water patterns in the gulf regions[28]:

> The shape of the two gulfs and Investigator Strait..contribute to the wind effects. At Port Adelaide, north westerly winds cause the highest tides, raising the sea level up to 1 metre above normal, while south easterly winds depress it as much as 0.5m.
>
> In the northern part of Spencer Gulf[29] the most marked weather effects on the tide occur with the passage of a deep depression across the Southern Ocean. As the barometer starts falling and with the onset of northerly winds the tides are below prediction, but as the wind backs to the north-west, an increase in level occurs, with a gradual build-up if the wind remains steady. A strong gusty north-westerly wind, with such as depression , backing to the west south-west at about the time of low water, will cause a storm surge of maximum amplitude, and heights may be expected from 1m to 2m above prediction. These high levels will continue until the barometer starts to rise, and the wind backs rapidly to the south east within 12 hours, and with a rapidly rising barometer the tides return to normal (or below) in about that time.

In Pine Point region

In the weather conditions described above, either the north-west, west or south-west wind blows off-shore from Pine Point. A south-west wind would blow more obliquely across the region, but certainly wouldn't be 'on-shore', and Pine Point is also sheltered by Black Point spit

[27] Grzechnick M P (2000) Three-Dimensional Tide and Surge Modelling and Layered Particle Tracking Techniques Applied to Southern Australian Coastal Seas, Doctoral Thesis, University of Adelaide.
[28] http://www.flindersports.com.au/pdf/PtUserGuideGeneralInfo.pdf
[29] Note: the context here is Spencer Gulf, but the weather pattern described is also related to Gulf St Vincent region.

to the south. Therefore the storm surge events described above (by Flinders Ports) are always accompanied by calm water, a factor supported by residents in community consultation[30].

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 in anticipation of flooding determines how prepared the community can be, and the topography of the settlement will influence how easily people are able to enter or leave the settlement. The general characteristics of a sea-flood in Pine Point are shown in Table 4:1.

Table 4:1 Sea flood characteristics for Pine Point coastal region.

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

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 of the flood can be given, and how experienced is the community in dealing with floods. Some of this factoring is illustrated in Table 4:2

Table 4:2 Proposed ratios of actual : potential damages[31]

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 such factoring has been applied, but the rationale is included here to emphasize the advantages of the Pine Point region in dealing with potential flooding.

[30] A review of all photographic evidence for Clinton, Price, Pine Point and Coobowie which are situated on the eastern side of Yorke Peninsula demonstrates that all incidents of extreme high water events were accompanied by calm water, the one exception being in Coobowie in the June 1981 event.

[31] Victorian Government (2000) Rapid Appraisal Method (RAM) for Floodplain Management.

4.3.3 Likely impacts in selected sea-flood scenarios

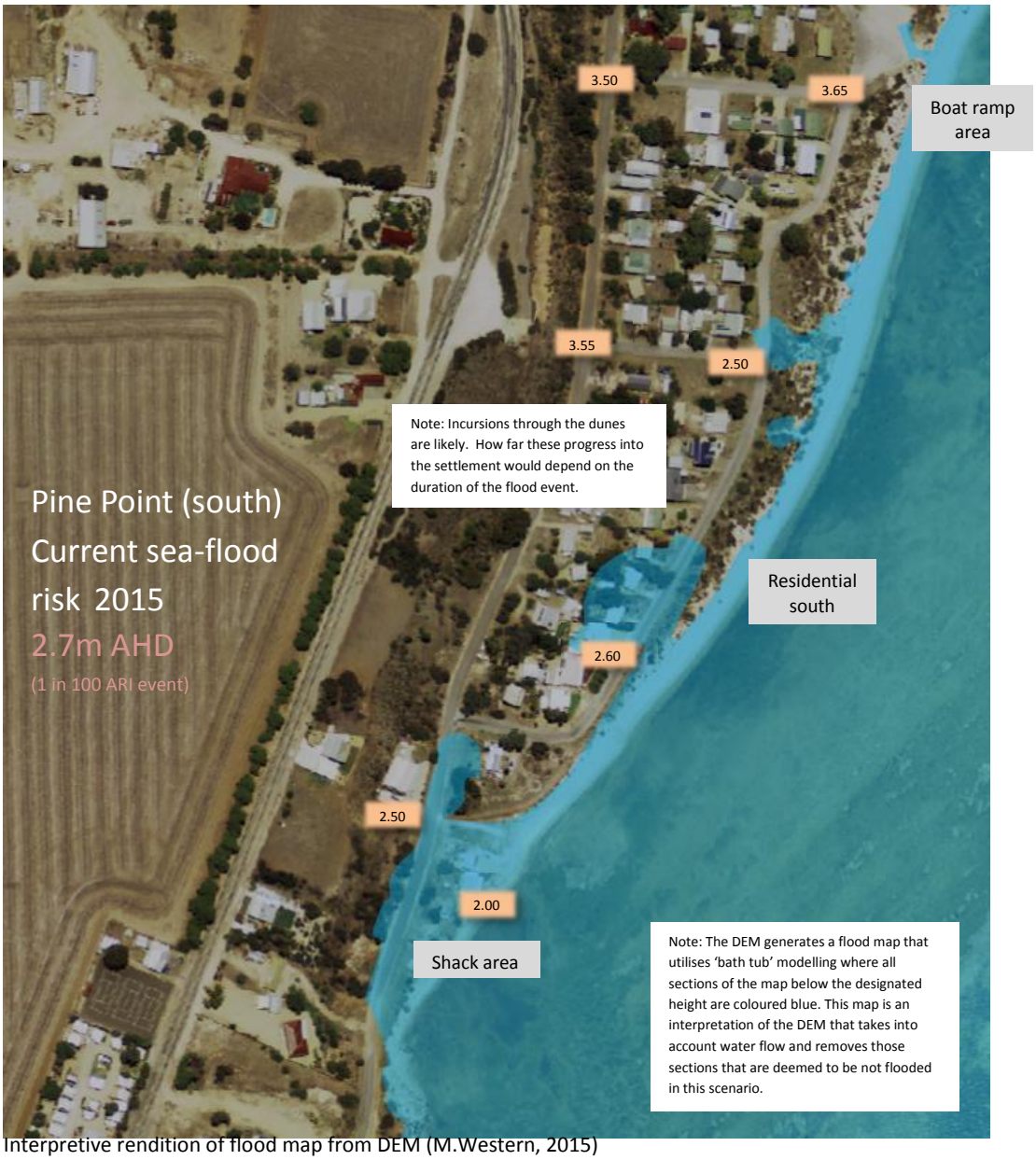
What is the likely impact on Pine Point of a 2.7 m AHD[32] event (2015 sea-flood scenario)

- **Pine Point (south of boat ramp)**

General Possible Impact

The flood mapping generated from data from the DEM gives a broad overview of the impact of a 2.7m AHD flood to Pine Point (south), if the event was of significant duration and not just a short overtopping of the defences. It is also important to recall that this flood scenario is the 1 in 100 ARI event, and therefore an extremely rare event.

Figure 4:16 Flood mapping for 1 in 100 ARI event of 2.7m AHD (2015 sea-flood scenario)



Interpretive rendition of flood map from DEM (M.Western, 2015)

[32] Wave run-up of 0.1m has been omitted from this sea-flood scenario.

Specific possible impacts

Using the visual representation of the DEM, and the surveying points of the surveyor, the likely impacts of a sea flood of 2.7m AHD are listed in Table 4.3 below.

Table 4:3 Location and nature of breaches (Sea-flood scenario 2.7m AHD, 2015)

Location	Location and nature of breaches	Notes	Depth over defences/ dunes	Depth Esplanade	Depth Main Road
Southern shack area	Water would over-top the rock revetment wall and southern shack area by 0.7m, and inundate Main Road by 0.2m.	Water would flow north alongside Main Road and traverse the levee on the western end	0.7 m	NA	0.2 m
Residential south	Water is unlikely to traverse the levee, but may traverse the sand dunes further north and inundate portions of the residential area at depths 0.2m to 0.3m. How far the flood progressed would depend on the duration of the event.		0.2- 0.3m over-topping of frontal dunes	0.1–0.2 m	0 m
Boat ramp area	The boat ramp area is the highest point in Pine Point. Water would just encroach into the car park.		0 m	0 m	0 m

Summary:

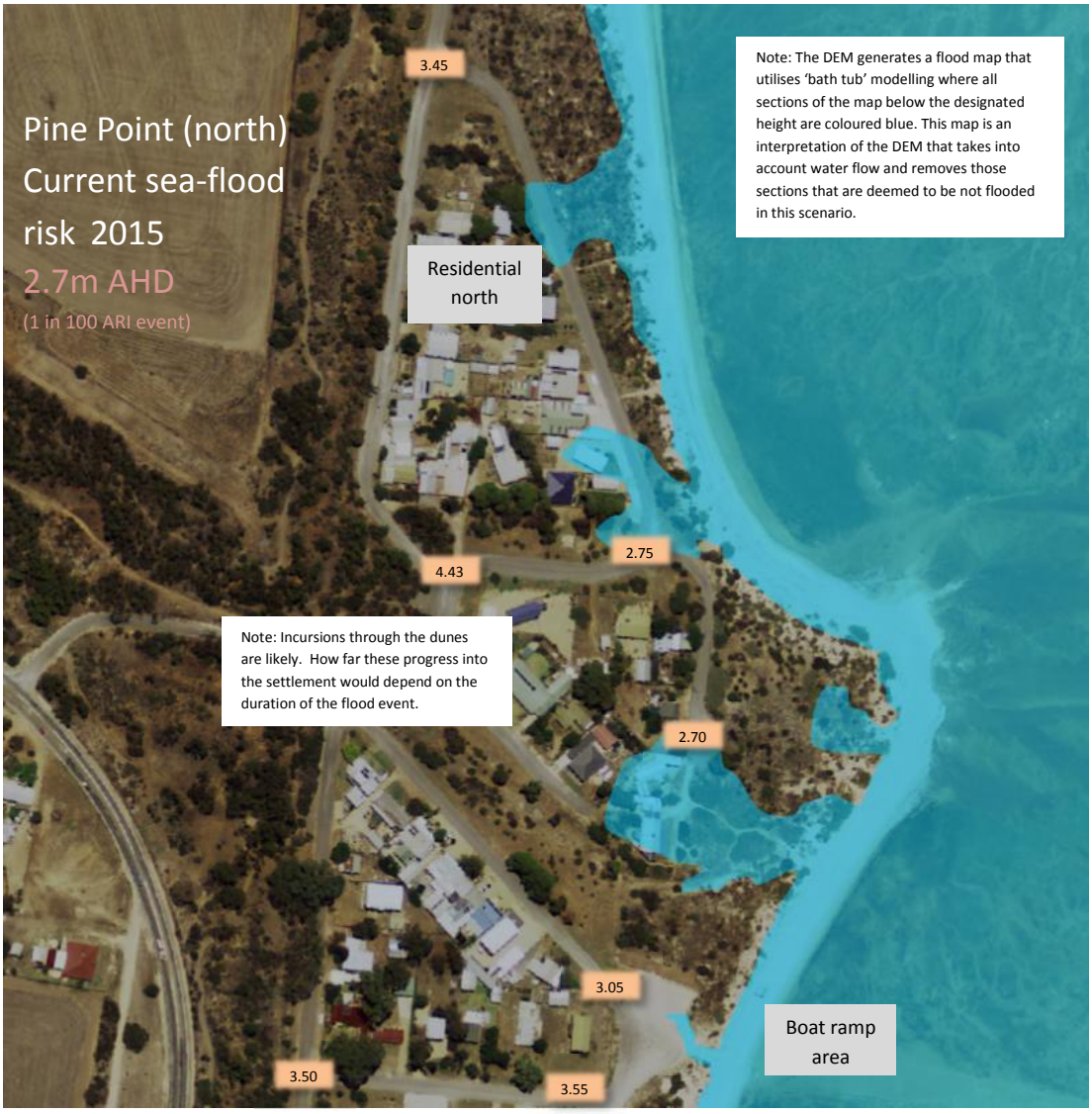
If a 2.7m AHD sea-flood event occurred of significant duration the impact of the flood on the southern shack area would be significant, but a more minor impact would be felt in other places further north towards the boat ramp area, inundating road and residential areas at depths less than 0.3m.

- **Pine Point (north of boat ramp)**

General Possible Impact

The flood mapping generated from data from the DEM gives a broad overview of the impact of a 2.7m AHD flood to Pine Point, if the event was of significant duration and not just a short overtopping of the defences. It is also important to recall that this flood scenario is the 1 in 100 ARI event, and therefore an extremely rare event.

Figure 4:17 Flood mapping for 1 in 100 ARI event of 2.7m AHD (2015 sea-flood scenario)



Interpretive rendition of flood map from DEM (M.Western, 2015)

Specific possible impacts

Using the visual representation of the DEM, and the surveying points of the surveyor, the likely impacts of a sea flood of 2.7m AHD are listed in Table 4.4 below.

Table 4:4 Location and nature of breaches (Sea-flood scenario 2.7m AHD, 2050)

Location	Location and nature of breaches	Notes	Depth Of water over defences/ dunes	Depth Esplanade	Depth Main Road
Boat ramp area	Slight encroachment through dunes into boat ramp car park. Dunes over-topped in a few places and water filling gullies behind frontal dune system.		0.2 m	0.0	0.0 m
Residential north	Water would encroach through the dunes at end of Earl, and further north where Main Street meets the Esplanade. How far the flood progressed would depend on duration of the event.	Minor flooding of residential area at depths 0.1m to 0.2m	0.2- 0.3m over-topping of frontal dunes	0.3–0.4 m	0 m
Shack area (north)	Two houses surveyed at 2.60m AHD. Sites would be inundated to 0.2m to 0.3m	Not pictured on Figure 4.17	0.1 m	NA	0 m

Summary:

If a 2.7m AHD sea-flood event occurred of significant duration the impact of the flood on the northern area cause minor flooding to roads and residential areas.

What is the likely impact on Pine Point of a 3.0 m AHD[33] event (2050 sea-flood scenario)

- **Pine Point (south of boat ramp)**

General Possible Impact

The flood mapping generated from data from the DEM gives a broad overview of the impact of a 3.0m AHD flood to Pine Point, if the event was of significant duration and not just a short overtopping of the defences.

Figure 4:17 Flood mapping for 1 in 100 ARI event of 3.0m AHD (2050 sea-flood scenario)

Rendition of flood map from DEM (M.Western, 2015)

[33] Wave run-up of 0.1m has been included in this scenario.

Specific possible impacts

Using the visual representation of the DEM, and the surveying points of the surveyor, the likely impacts of a sea flood of 3.0m AHD are listed in Table 4.5 below.

Table 4:5 Location and nature of breaches (Sea-flood scenario 3.0m AHD, 2050)

Location	Location and nature of breaches	Notes	Depth over defences/ dunes	Depth Esplanade	Depth Main Road
Southern shack area	Would over-top the rock revetment wall and southern shack area by 1.0m, and inundate Main Road by 0.5m.		1.0 m	NA	0.5 m
Residential south	Water would completely overtop the levee and dunes and inundate residential area at depths 0.5m to 0.6m	Residential sections flooded at depths 0.5 to 0.6m	0.2m over levee. 0.5- 0.6m over-topping of frontal dunes	0.4–0.5 m	0.1 to 0.2 m (southern portion only)
Boat ramp area	The boat ramp area is the highest point in Pine Point. Water would just encroach half way across the carpark (towards Beach Rd).		0 m	0 m	0 m

Summary:

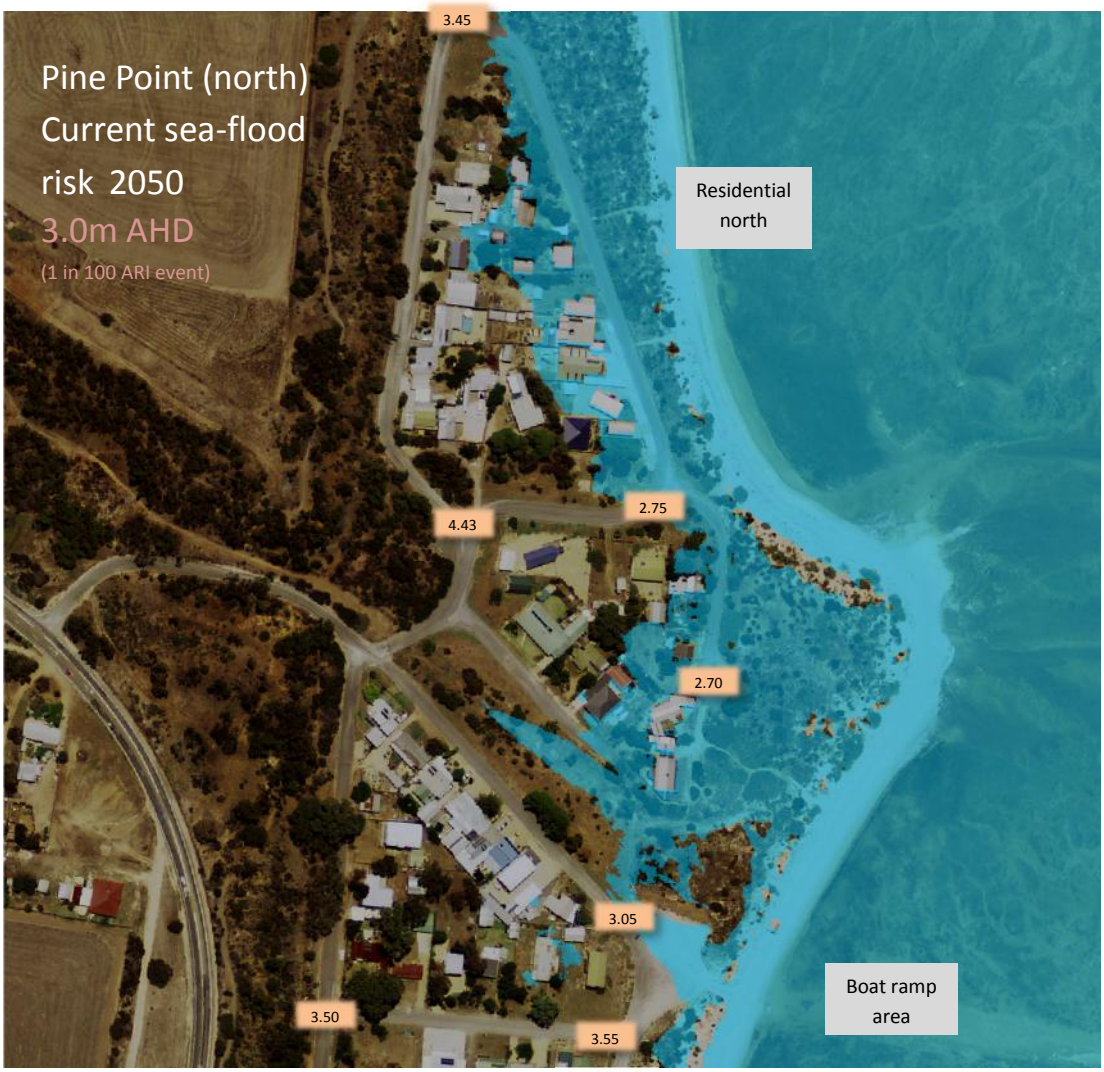
If a 3.0m AHD sea-flood event occurred of significant duration the impact of the flood on the southern area with residential sections flooded to depth of 0.5m–0.6m AHD.

- **Pine Point (north of boat ramp)**

General Possible Impact

The flood mapping generated from data from the DEM gives a broad overview of the impact of a 3.0m AHD flood to Pine Point, if the event was of significant duration and not just a short overtopping of the defences. It is also important to recall that this flood scenario is the 1 in 100 ARI event, and therefore an extremely rare event.

Figure 4:18 Flood mapping for 1 in 100 ARI event of 3.0m AHD (2050 sea-flood scenario)



Rendition of flood map from DEM (M.Western, 2015)

Specific possible impacts

Using the visual representation of the DEM, and the surveying points of the surveyor, the likely impacts of a sea flood of 3.0m AHD are listed in Table 4.6 below.

Table 4:6 Location and nature of breaches (Sea-flood scenario 3.0m AHD, 2050)

Location	Location and nature of breaches	Notes	Depth Of water over defences/ dunes	Depth Esplanade	Depth Main Road
Boat ramp area	Water encroachment through dunes and half way up car park. Dunes over-topped and water filling gullies (and storm water channel).		0.1-0.3 m	0.0m	0.0 m
Residential north	Water would flow over dunes for entire length of Esplanade	Moderate flooding of residential area at depths 0.4m to 0.5m	0.4- 0.5m over-topping of frontal dunes	0.6–0.7 m	0 m
Shack area (north)	Two houses surveyed at 2.60m AHD. Sites would be inundated to 0.5m to 0.6m	Not pictured on Figure 4.18	0.4 m	NA	Unknown – likely 0 m

Summary:

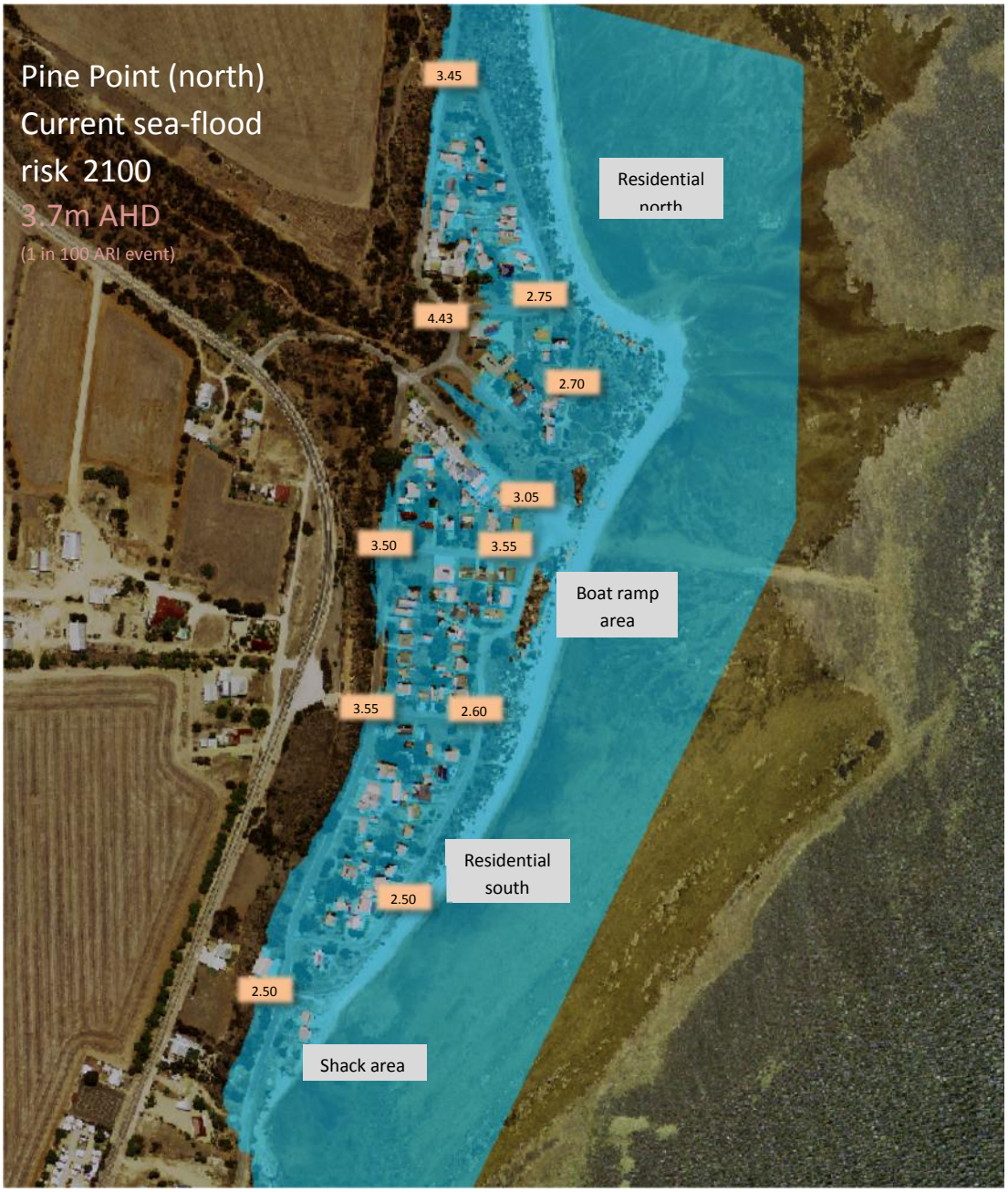
If a 3.0m AHD sea-flood event occurred of significant duration the impact of the flood on the northern area cause moderate flooding to roads and residential areas.

What is the likely impact on Pine Point of a 3.7 m AHD[34] event (2100 sea-flood scenario

General Possible Impact

The flood mapping generated from data from the DEM gives a broad overview of the impact of a 3.7m AHD flood to Pine Point, if the event was of significant duration and not just a short overtopping of the defences.

Figure 4:19 Flood mapping for 1 in 100 ARI event of 3.7m AHD (2100 sea-flood scenario)



[34] Wave run-up of 0.1m has been included in this scenario.

Specific possible impacts

The concept of flood mapping this far into the future is to enable policy makers to consider the long term effect of planning decisions, as infrastructure and housing have long life spans. Note, for this flood scenario to be realised an acceleration in the rate will need to occur in which sea level rises in the second half of the century. It is expected that scientists will monitor the rate of sea level rise over the coming decades and will be able to more accurately forecast anticipated rises by the end of the century.

If a 3.7m AHD event occurred the impact on Pine Point would be very significant. The vast majority of the dune system would be significantly over-topped and residential property flooded at depths ranging from 0.5m to 1.4m AHD. Most roads would suffer inundation, with Main Street adjacent the escarpment suffering more minor flooding in the middle section of the settlement but more significant in the northern and southern reaches.

4.4 Analysis of emergency egress and access

For reasons outlined in the introduction (p. 10) an analysis of emergency egress and access issues for the 3.0m AHD sea-flood scenario for 2050 will be utilised. This assessment takes no account of any protection works that may be implemented subsequent to this study. In conducting this assessment it is also important to recall the nature of sea flooding in the Pine Point area (Table 4.7).

Table 4:7 Sea flood characteristics for Pine Point coastal region.

Flood characteristic	Pine Point region
Depth of water	Shallow
Velocity of water	Low, due to tidal action and ocean terrain
Wave action	Minimal due to depth of water and friction of samphire and mangrove habitats
Direction of water	From the east
Duration of flood	Short 1-2 hours
Warning	Predictable as the flood will relate to tide.

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

The fact that Main Street is virtually free from inundation in this sea-flood scenario (apart from the southern section), and that it acts as a spine to the settlement along the base of the escarpment, means that the vast majority of residents could move less than 100 metres away from the sea front and locate dry land. Vehicular access would always be open in this scenario through the northern access road. Most other roads would suffer inundation at less than 0.3m. The southern section of Main Road would suffer inundation at 0.5m making this impassable with normal sedan vehicles.

In a 3.0m flood event could emergency vehicles access Pine Point?

The fact that Main Street is virtually free from inundation in this sea-flood scenario (apart from the southern section), and that it acts as a spine to the settlement along the base of the escarpment means that emergency service vehicles could move within close proximity to all residential areas apart from the three shacks on the southern end of the settlement. Most other roads within the settlement would suffer inundation at less than 0.3m.

4.5 A profile of assets at risk

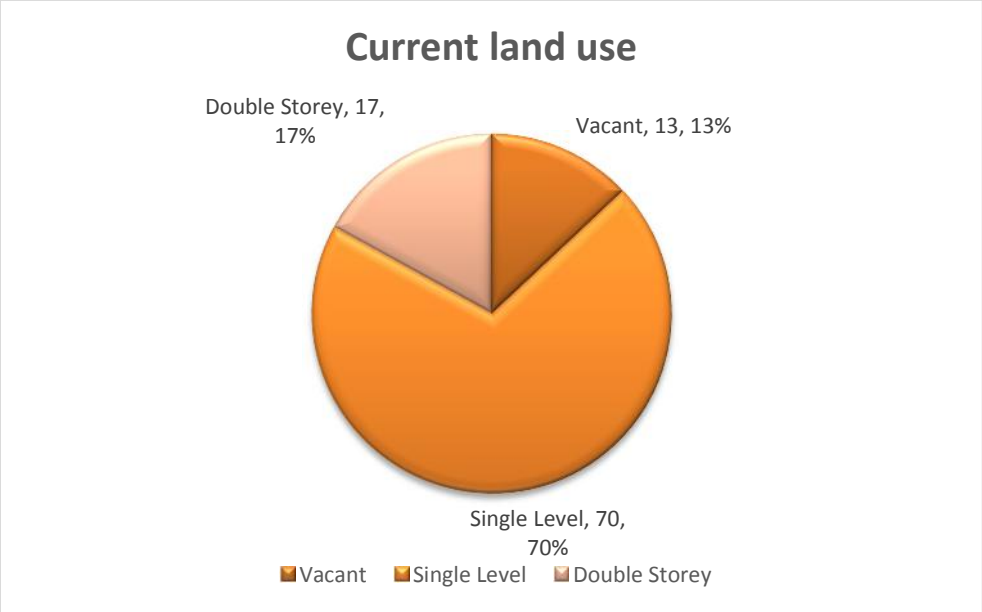
The purpose of this section is to identify the built assets at risk from sea-flood divided into two main categories: privately owned assets, and council owned assets. Identifying the different construction types provides appropriate data from which to offer some solutions for future adaptation. Identifying the value of the assets provides a context for future decision making, and assigning approximate damage costs in each flood scenario assists in prioritising future actions.

4.5.1 Privately owned assets:

Current land use

The current land use of the privately owned allotments in the 'at risk' area in the Pine Point 'at risk' area is depicted in Figure 4:20.

Figure 4:20 Current land use in Pine Point (at risk area).



Yorke Peninsula Council valuation records for 2015 show that the land and buildings for privately owned assets (including commercial assets) in the 'at risk area' are valued at:

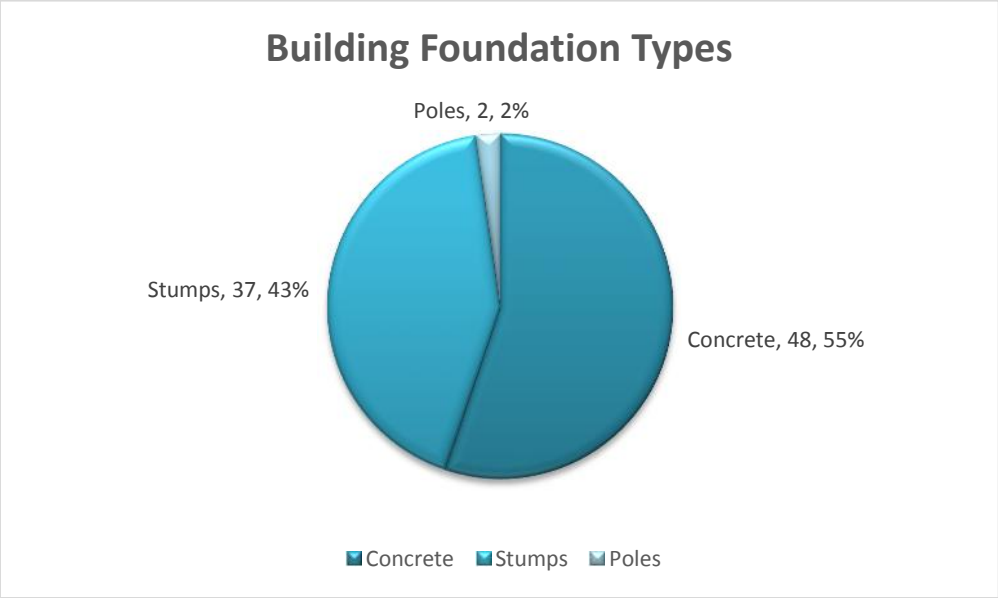
Table 4:8 Value of residential assets – Pine Point (Lower section - Billy Goat Flat).

Location	Site Value	Improvements	Total Capital Value
Pine Point	$17,657,000	$8,008,000	$25,665,000

Building foundation types

The foundation types utilised in 87 buildings in the Pine Point (Billy Goat Flat area) is depicted in Figure 4:21.

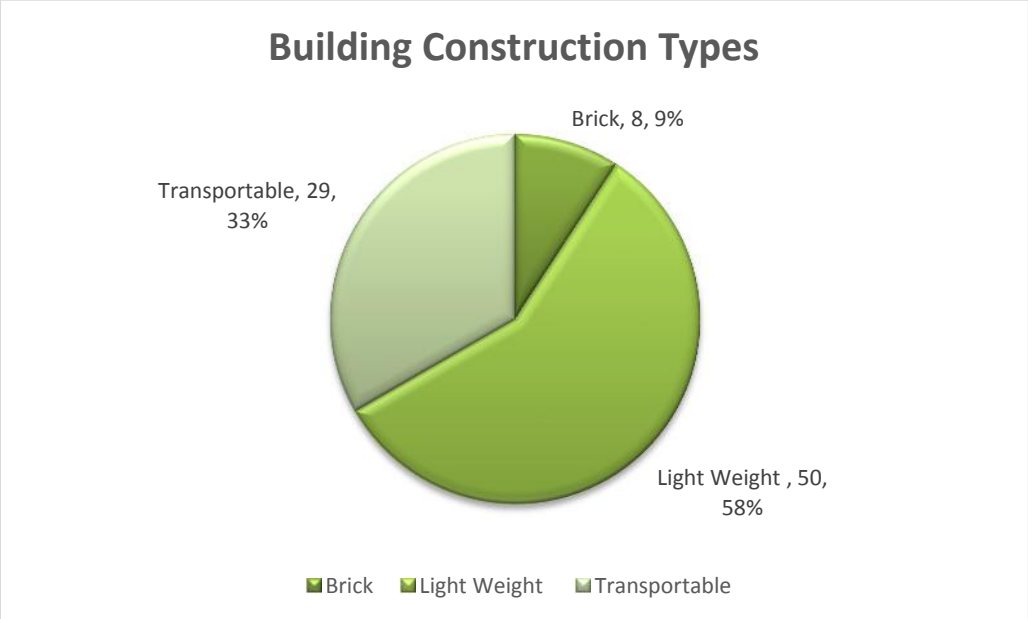
Figure 4:21 Current building foundation types in Pine Point.



Building construction types

The building construction types utilised in 87 buildings in the Pine Point (Billy Goat Flat area) is depicted in Figure 4:22.

Figure 4:22 Current building construction types in Pine Point.



*Note: some interchange exists with designation 'light weight' and 'transportable'.

4.5.3 Impact of sea-flood scenarios upon assets

Using the surveyed floor levels the depth of flood is calculated for each dwelling in the 'at risk' area. Damage costs for each of the scenarios are assigned based on depth of flood over floor level and are reported in present day values. Assigning damage costs in this way provides a methodology for comparison between scenarios in one settlement and assists in prioritising actions in comparison with other settlements. The purpose is not to predict what the cost might be in the future for 'doing nothing'.

Scenario 2015

If the 2015 one in one hundred ARI sea-flood scenario occurred in 2015, and it lasted for a significant duration of time (not just a brief overtopping of the defences), 16 dwellings are likely to be inundated with a potential damage cost to buildings of $198,000.

Figure 4:23 Pine Point– impact of 2.7m AHD sea-flood event on buildings.

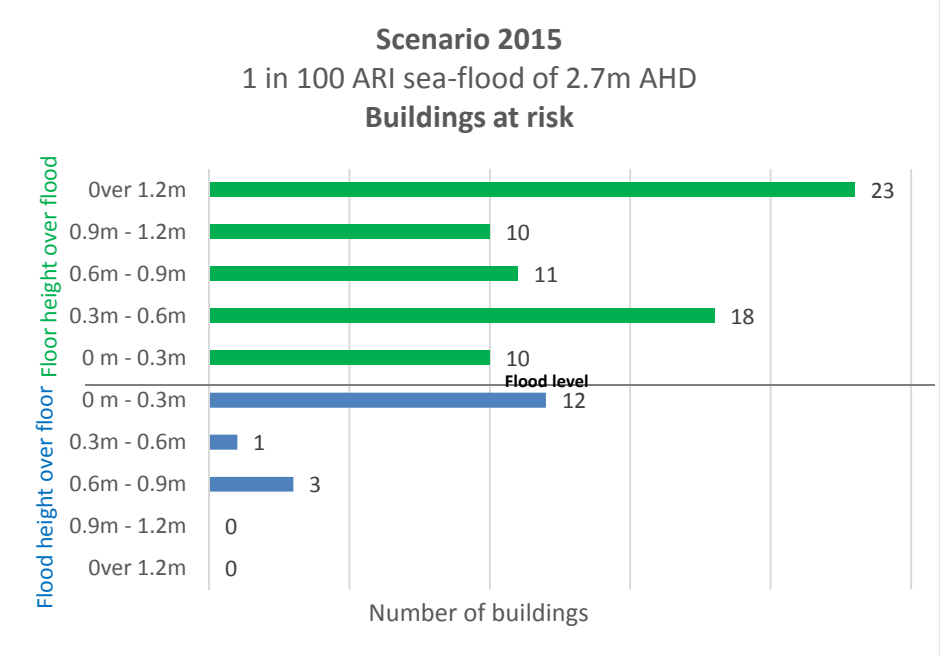


Table 4:9 Pine Point (2.7m AHD event) – potential damage cost to buildings.

Potential damage in 2.7m AHD sea-flood event		
Water over FFL	Buildings	$ damage
>0.00	4	$24,000
>0.10	5	$45,000
>0.20	3	$36,000
>0.30	1	$15,000
>0.50	0	$0
>0.60	1	$24,000
>0.70	2	$54,000
Total	16	$198,000

Scenario 2050

If the 2050 one in one hundred ARI sea-flood scenario occurred in 2015, and it lasted for a significant duration of time (not just a brief overtopping of the defences), 26 dwellings are likely to be inundated with a potential damage cost of $429,000.

Figure 4:24 Pine Point– impact of 3.0m AHD sea-flood event on buildings.

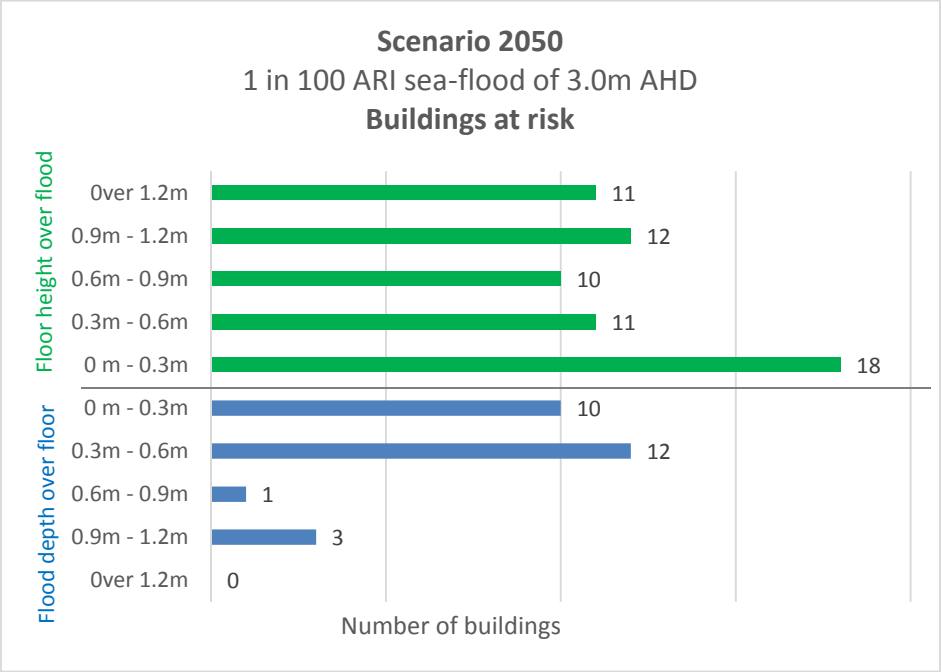


Table 4:10 Pine Point (3.0m AHD event) – potential damage cost to buildings.

Potential damage in 3.0m AHD sea-flood event		
Water over FFL	Buildings	$ damage
>0.00	4	$24,000
>0.10	4	$36,000
>0.20	2	$24,000
>0.30	4	$60,000
>0.40	5	$90,000
>0.50	3	$63,000
>0.60	1	$24,000
>0.70	0	$0
>0.80	0	$0
>0.90	1	$33,600
>1.00	2	$74,400
>1.10	0	0
Total	26	$429,000

Scenario 2100:

If the 2100 one in one hundred ARI sea-flood scenario occurred in 2015, and it lasted for a significant duration of time (not just a brief overtopping of the defences), 60 dwellings Pine Point are likely to be inundated with a potential damage cost of $1,645,800.

Figure 4:25 Pine Point– impact of 3.7m AHD sea-flood event on buildings.

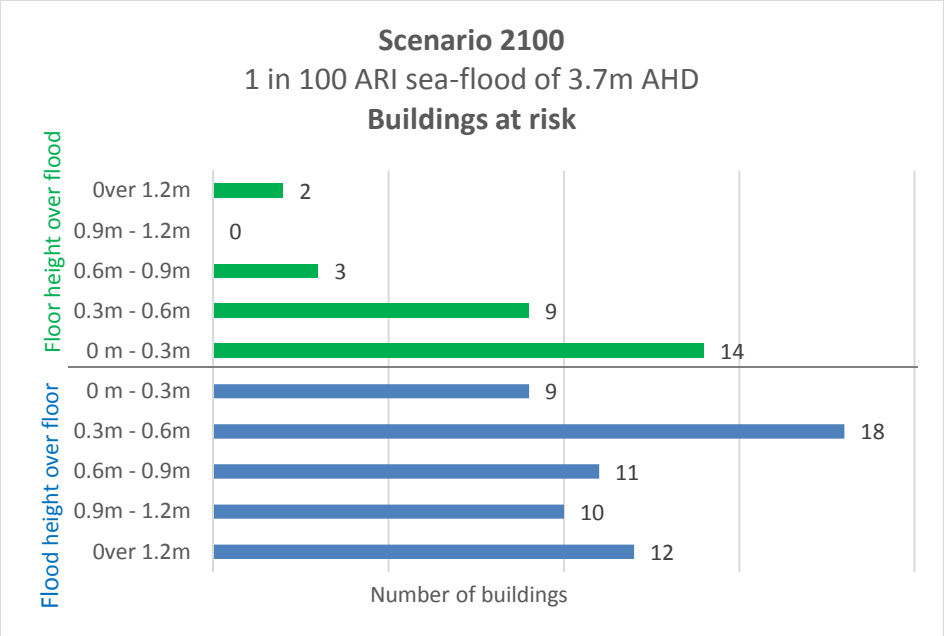


Table 4:11 Pine Point (3.7m AHD event) – potential damage cost to buildings.

Potential damage in 3.7m AHD sea-flood event		
Water over FFL	Buildings	$ damage
>0.00m	5	$30,000
>0.10m	4	$36,000
>0.20m	4	$48,000
>0.30m	3	$45,000
>0.40m	11	$198,000
>0.50m	2	$42,000
>0.60m	5	$120,000
>0.70m	4	$108,000
>0.80m	4	$120,000
>0.90m	2	$67,200
>1.00m	4	$148,800
>1.10m	5	$204,000
>1.20m	7	$310,800
Total	60	$1,477,800

4.5.3 Council owned assets:

Yorke Peninsula Council's assets in Pine Point are *buildings*, *structures* such as public toilets, shelters, picnic facilities, and *public roads and footpaths*. Assets likely to be subject to inundation are identified and the full value of the assets at risk calculated. However, taking into account the nature of the flood waters in the Pine Point region (see p. 45) and that these flood events are tidal and therefore short lived, qualifications are added to contextualise the damage risk appropriately.

It is recognised that most of the assets listed below will be obsolete by 2100. The impact of the 2100 sea-flood scenario has been applied so as to provide appropriate data from which to make future decisions.

Buildings and Structures (Council owned)

Table 4:12 Council owned buildings and structures

Council Assets – Buildings and Structures				**Subject to inundation**		
Specific Item	**Location**	**Street**	**Total Value**	**2015 2.7m**	**2050 3.0m**	**2100 3.7m**
Shelter	Boat ramp	Esplanade	$16,215	Minor 0.4	Minor 0.7	Minor 1.4
Flood protection levee	Southern end	NA	Not listed	NA	NA	NA

Contextualisation notes:

The outlook for Council owned assets to 2050 is positive with no buildings under threat. The shelter listed above would only suffer inundation at its base. However, increasing erosion may leave the shelter increasingly stranded forward of the dune line and destabilise the base.

The nature and condition of the flood protection levee situated in the southern section of the settlement is reviewed on p. 26 above. The exact final cost of the installation of the levee is unknown, but records exist to suggest it was approximately $13,000[35].

Roads and associated infrastructure (Council owned)

Analysis of flood scenarios using the DEM indicates that there is minimal current flooding risk to roads and associated infrastructure but should the sea level continue to rise as predicted, by 2050 roads will come under increasing inundation threat[36] at depths ranging from 0.4m to 0.7m.

Ways to calculate possible cost of damage to roads are 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

[35] See also p. 20 in regard to ownership issues raised by CPB.
[36] Assumes that no protection measures are installed.

apply $8350.00 per km of length affected (Victorian Government 2000) but both of these methods appear arbitrary.

The works manager (Keith Earl) from DC Mallala who has had experience with localised flooding in that region was of the opinion that due to the rarity of the event, the short lived nature of the event, and the more benign nature of the movement of water that damage and associated costs were likely to be minimal to roads. However, this assumes that the water is capable of draining away within a short time period after the event. If the 2050 sea-flood scenario occurred, water would over top the dunes and flow into low lying areas with no means of draining away. Damage to infrastructure and vegetation would be anticipated to be higher unless ways can be round to remove the water.

The total value of roads as at 2015 in the Billy Goat Flat area is $447,500[37] (see Appendix D).

4.5.4 Summary:

This section has provided an overall picture of the assets that are situated in the 'Billy Goat Flat' area of Pine Point that are likely to be under threat in the various sea-flood scenarios.

Current potential damage cost to residential assets is estimated at $198,000, and potential damage costs should the 2050 sea-flood scenario occur at $429,000 (at today's values). But such events may not just occur once, but could occur multiple times and therefore damage bills would also be multiple and become more prohibitive.

In the shorter term, roads would be unlikely to be inundated at any significant depth, but as the sea level continued to rise, inundation would become more frequent, and at greater depths. On the positive side the flood events are expected to be short-lived and at low velocity suggesting that damage would be minimal. One problem will be that flood water will lay in lower sections of the settlement which will increase the damage costs and disruption subsequent to the flood event.

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. This factor should be utilised in the longer term planning for the settlement and will be incorporated into the second stage of this study.

[37] Note: The Parade road does not seem to be on the register.

4.6 The current policy framework

Yorke Peninsula Council makes planning decisions regarding Pine Point in the context of broader strategic policies and within the statutory requirements of the Development Act 1993.

Assessment questions:

1. What is the strategic planning policy environment in which Council makes coastal decisions?
2. What are the key development assessment policies for coastal development applications?
3. How has Yorke Peninsula Council been operating within the statutory planning environment?

4.6.1 What is the strategic planning policy environment in which Council makes coastal decisions?

South Australian State strategic policy framework

The report *Prospering in a Changing Climate: Climate Change Adaptation Framework for South Australia* relates to the entire state but recognising the importance of regional variation, provides for the development of locally relevant responses for each of the twelve state regions. The report notes that adaptation response should be prioritised by assessment of risk, cost and equity using the best available science. The vulnerability of the coast to sea level rise is noted with particular note taken of the Yorke Peninsula.

"*Regional areas such as Yorke Peninsula are particularly vulnerable. Increasing development in the region, which is popular for retirees and people seeking a sea change, increases the risks.*" *(p35).*

Coastal landowners and lenders are highlighted as vulnerable to losses from inundation and erosion caused by rising sea levels. The policy recognises the importance of securing new settlements from foreseeable sea level rise and other coastal impacts of climate change and also guiding the adaptation of existing communities to cater for the impacts of climate change.

Regional strategic policy framework

There are a number of strategic level plans and policy documents which have some bearing on the issue of sea level rise.

- *Central Local Government Region Integrated Climate Change Vulnerability Assessment - 2030.*

This report notes the importance of decision making on infrastructure such as roads during this period as having implications as far forward as 2100 and beyond when sea level rise of a metre or more is possible (p16). In other words, decisions in the near future need to take into account longer range predictions and the threats they imply. A vulnerability assessment score is generated by assigning scores individually for exposure, sensitivity, potential impact and adaptive capacity for each of the three factors above. For the region as a whole the vulnerability index is medium with a high score for environmental factors.

- *Yorke and Mid North Climate Change Action Plan*

This policy document sets out the priorities for addressing climate change in the region. It notes this as a process of reducing risk, improving resilience and maximising opportunities. It notes the importance of planning decisions in respect of risk and sustainable limits. Resilience within local communities, especially in respect of emergency management, is stressed as important. One of three priority projects noted is the need for digital elevation modelling of the 800km of coast in the region to improve understanding of the threats from sea level rise and storm surge impacts on communities, industries and the environment.

- *Yorke Peninsula Regional Land Use Framework 2007*

This document forms part of the Planning Strategy for South Australia which guides strategic land use policy across the state. It notes that in recent years coastal settlements on the Yorke Peninsula have experienced a surge in demand for both residential and holiday accommodation and industry and tourism have expanded. In some areas on the Yorke Peninsula 40% of residential properties are holiday homes and whilst in the past these may have been shacks many are now being upgraded to more substantial properties (p11). Also the permanently resident population is amongst the oldest in South Australia with a third of the population in 2006 aged over 60.

Policy statements relevant to sea level rise include:

- Plan for the impacts of climate change, including sea level rise and storm surges,
- Ensure planning minimises risk to property and people, especially in low lying coastal areas subject to erosion and flooding,
- Manage coastal development and tourism activities,
- Manage coastal township growth to avoid inefficient linear development and exposure of people and property to hazards (eg flooding, coastal erosion) (p15).

Pine Point (Billy Goat Flat area) is not designated for significant expansion in the plan and the township is not expected to experience significant population growth.

- *Yorke Peninsula Council Strategic Plan 2012-2015*

The Plan sits within the broader context set out in the South Australia State Strategic Plan which *inter alia,* notes that citizens should actively participate in shaping the future of the state and that the state should be prepared for natural disasters.

The plan commits Council to work with state government and other agencies to ensure adequate coastal protection work, required to maintain the significant coastline, is undertaken (Sustainable Communities 2.2).

4.6.2 What are the key development assessment policies for coastal development applications in Pine Point?

Current statutory framework

Yorke Peninsula Council assesses proposals for new development under the Development Act 1993 using policy set out in the Council's Local Development Plan.

The South Australian Coast Protection Board provides the state-wide policy for dealing with coastal matters and this policy finds its expression and application through local Development Plans. The Development Act 1993 and Development Regulations 2008 require Councils to refer new development in coastal zones to Coast Protection Board for 'regard' or 'direction'. A typical matter for 'regard' relates to the height above 0 AHD 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.

Local Development Plan

The Yorke Peninsula Council Development Plan (consolidated 6th November, 2014) is the statutory policy document to manage new development in the region. The Development Plan has been revised using the *Better Development Plan* process and therefore does contain the current Coast Protection Board policy.

The four main land use zones applied within Pine Point are (Figure 4:26):

- Settlement Zone
- Coastal Conservation Zone (in oval and golf course region)

With this current zoning arrangement, there is no requirement for development applications to be referred to Coast Protection Board for advice[38] (Schedule 8, Development Regulations). However, the Development Plan does contain Principle of Development Control 20 (p. 26) that states that 'development…should be protected from sea level rise by ensuring all of the following apply:

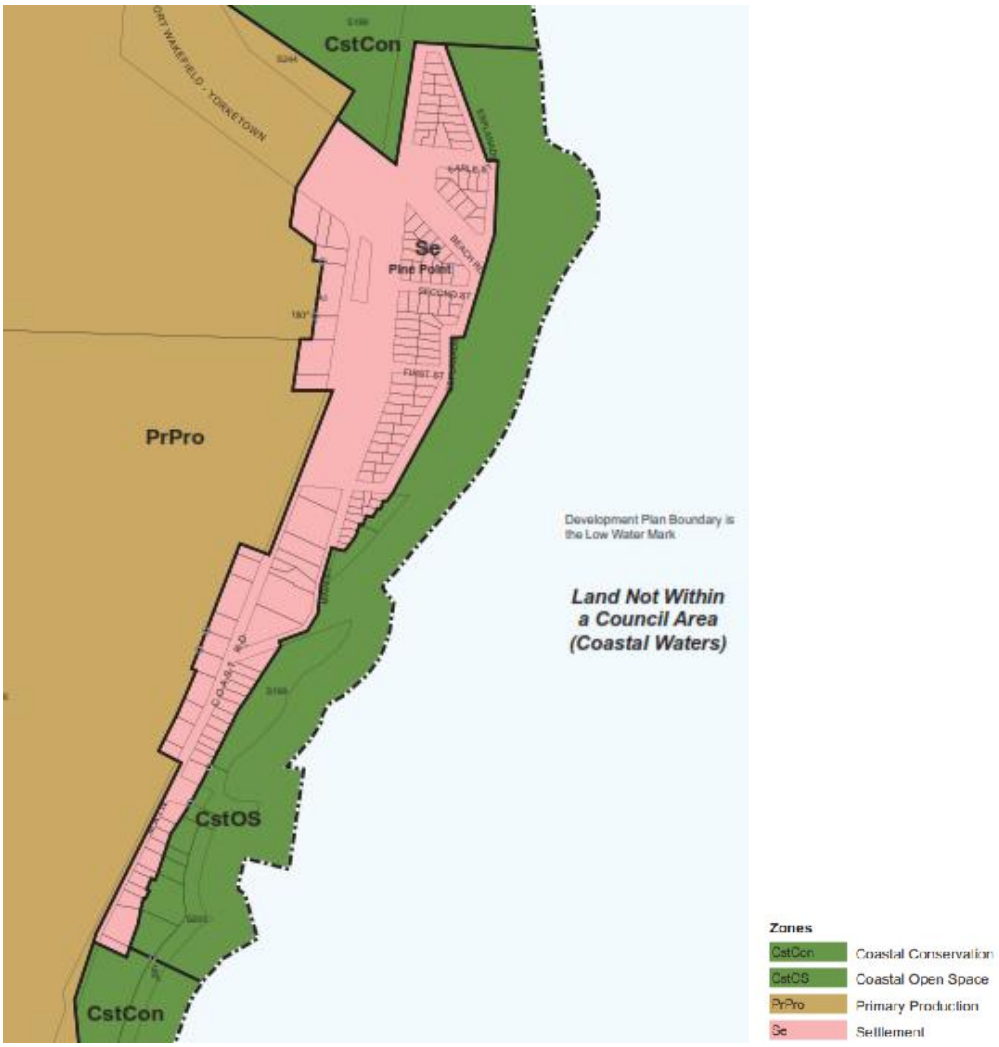
(a) Site and building floor levels are in accordance with those outlined in *Table YoP/1 – Coastal Areas: Site/Building Floor Levels*

(b) There are practical measures available to protect the development against an additional sea level rise of 0.7 metres…'

The policy heights recorded in the Development Plan for Pine Point are 3.35m AHD for sites, and 3.60m AHD for floor levels. Note: as part of this study, these policy levels have been reviewed and new policy levels adopted that will be incorporated into the Development Plan in due course (see p.7).

[38] The exception is the three shack sites at the far north end of the settlement.

Figure 4:26 Yorke Peninsula Council Zone Map YoP/63 for Pine Point



The Yorke Peninsula Council Development Plan also contains *Table YoP/4 – Design Guidelines for Coastal Dwellings* which is a six page policy document to which applicants must have regard, including those applications which are proposed for the Settlement Zone.

4.6.3 How has Yorke Peninsula Council been operating within the statutory planning environment?

Department of Environment Water and Natural Resources (CPB) reported that Yorke Peninsula Council referred two development application for review from period of 2003 to 2015, both of these on Main Street and within the Coastal Conservation Zone. Due to the fact that Council has incorporated site and building levels into its Development Plan, no referrals are required from within the Settlement Zone to CPB and the Council ensures that the levels are adhered to in the planning approval processes. A review of seven houses constructed in the last ten years reveals that all but one had floor levels in excess of 3.60m AHD[39].

[39] 153 The Esplanade was surveyed at 3.41m AHD. However due to the downward revision of sea-flood risk levels for Pine Point, this height will be adequate.

The levee in the southern portion did receive Council approval in 2002 and was appropriately referred to Coast Protection Board for direction. However, the conditions of approval stated that the levee should have finished height of 3.25m AHD but currently has height of 2.80m AHD and at height 2.40m AHD where it meets Main Road[40].

4.6.4 Conclusions

The broader strategic policy outlook for Pine Point (Billy Goat Flat section) is that it is not designated for future expansion and not expected to come under any significant population pressure. Thirteen vacant allotments and approximately twenty dwelling approaching obsolescence will provide some room for future development.

The Yorke Peninsula Council Development Plan does contain current Coast Protection Board policy and utilises the current site and building floor levels for the Pine Point region. As part of this study, it is important to recall that these levels have now been amended in July, 2015.

In the period 2003-2015, two Development Applications were referred to Coast Protection Board for advice (both of these were applications in the Coastal Conservation Zone), and one application to install a levee in the southern area was referred for 'direction'.

[40] Note: The downward revision of the sea-flood risk for Pine Point suggests that the majority of this levee is adequate to cater for the current risk (revised 2015).

4.7 Exploration of liability issues

- **What obligation did the Council have to take into account impacts from the sea at the establishment of Pine Point?**

Pine Point was established in 1874 over 100 years before there was any formal planning legislation. There was no overarching statutory requirement for those who established Pine Point to take into account actions of the sea. Furthermore, there has been no expansion within the last twenty years of the residential section of Billy Goat Flat area.

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

Table 4:13 Implementation of protection works

Works	Implemented by:	Installation Date	Planning Approvals	Responsibility
Levee at southern end of settlement	Council	2003	Referred to CPB for direction.	Council to maintain

The current height of the levee is generally 2.80m AHD but is lower at 2.40m AHD where it meets Main Road on the western end. Conditions of approval suggest that the levee should have been installed at 3.25m AHD[41].

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

Council has no records of any breaches of the levee. Residents in community consultation informed that in high water events water traverses from the south behind the three shacks and flows north along Main Road. The water has threatened to bypass the levee on the low end where it meets Main Street.

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

There is no requirement to refer residential developments from Pine Point to Coast Protection Board apart from applications for development in the Coastal Conservation Zone[42]. A random check of dwellings constructed in the last ten years suggests that Council has ensured that dwellings have been installed with appropriate floor levels.

[41] Note: The downward revision of the sea-flood risk for Pine Point suggests that the majority of this levee is adequate to cater for the current risk (revised 2015).
[42] See Schedule 8, Development Regulations, 2008

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

No, but the community consultation and publishing of the State of Play report 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, but taking into account the elevated nature of Pine Point, these may not be necessary.

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:

- Pine Point was founded in the 1800s 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 required 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 respect of protection works, the Council is likely to have a responsibility to ensure that its own protection works are adequately maintained in integrity and height.
- While there is no legal responsibility to implement protection works, Councils do have a responsibility to warn their constituents of any danger of which Council is aware. Therefore, the Council should make the findings and mapping from studies such as this one available to the public. The Council is hosting two rounds of public consultation meetings with residents as a first step in achieving this outcome.
- 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. This matter will be reviewed in Stage 2 of the study.

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, the recent trend in Court decisions indicates that the Court will take into account climate change related factors.

5. Public consultation process – Pine Point (Part 2)

The methodology of reporting contributions from the community in formal and informal settings has been to report within the narrative of the document in green font so as to provide a holistic account.

The following represents matters not specifically addressed within the report, or where major attention was placed upon a particular issue:

Group 5 noted:

- Hard sand moving north (at boat ramp area).
- Former rock protection (rocks on beach) in between rock revetment and levee was removed by Council.

Group 6 noted:

- Southern area 'needs protection – council owned land'.
- Robert James wrote:
    - Most vulnerable area is at base of Bourne Hill – water comes in onto the road and flows back through the properties south of the levee bank
    - The area between the three shacks and the southern levee bank is vulnerable.
    - Council cleaned up rock off the beach.
    - About 10 – 15 metres of beach has eaten away in the area
    - Need to join the sea wall in front of the three shack sites and the levee bank otherwise the seawall and levee will be eaten away.
      (summarised and abridged)

Group 7 noted:

- South easterlies occur in the winter.
- With houses required to be built up is an issue for lower houses (context not provided)
- There is a 'question around old creek being blocked to prevent coastal surge'[43].

[43] Preliminary investigation at Council reveal that Council did not block up the storm water outlet.

6. Summary and Conclusion

6.1 Summary Table – Pine Point

Stage	Question	Summary comment
1. Site history	When was the settlement founded?	1874, and no expansion of residential sectors since.
	Were climate change and sea level rise issues relevant?	No
2. Existing protection	What existing natural protection exists?	Dunes to the height of 2.40 to 2.50m AHD.
	What breaches have occurred?	No major breaches have been recorded apart from flooding in the southern part of the settlement (south of the levee)
	What man-made protection works have been installed into the settlement?	A levee was installed in 2003 at height 2.80m AHD (with a lower section near Main Street at 2.40m AHD).
3. Impact of storm events	What is the likely impact for a 2.7 m AHD event?	The dunes would be overtopped in places with minor flooding of roads and properties (up to 0.3m).
	What is the likely impact for a 3.0 m AHD event?	The dunes would be overtopped in most places. The existing levee would be overtopped. More major flooding of roads and properties up to 0.6m.
	What is the likely impact of a 3.7m AHD event?	Most of the settlement would be inundated with water at heights varying up to 1.4m.
4. Emergency access and egress	Egress issues in a 3.0 AHD event	Egress would be satisfactory, apart from the southern three shacks.
	Emergency vehicle access in a 3.4m AHD event.	Emergency access satisfactory to within 100m of all dwellings (apart from the southern three shacks).
5. Profile of assets at risk	How many buildings are likely to be affected in 2.7m event?	12, but 8 of these at depths lower than 0.3m. Estimated damage cost: $198k.
	How many buildings are likely to be affected in 3.0m event?	26 at estimated cost of $429k.
	How many buildings are likely to be affected in 3.7m event?	60, at estimated damage cost: $1,477,820.
6. Statutory policy framework	What are key development polices?	Development Plan incorporates current Coast Protection Board polices. Site and building heights for Pine Point will require amendment.
	How has Council operated within the statutory planning environment?	Council refers applications to CPB, applies advice received, and applies building and site levels.
7. Liability issues	Does liability exist if Council fails to implement protection?	No
	Have residents been informed of sea-flood risk?	A newspaper article and mail out to all residents have begun this process. Pending public consultation meetings will also be occasions where residents will be informed of the sea-flood risks.

	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?	Council staff review protection works as part of general duties as required but there is no formal maintenance regime of protection works.

6.2 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 Pine Point was assessed utilising the first seven steps of the investigative framework:

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

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 2 of the project, and Step 8 in the investigative framework.

7. References

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Yorke Peninsula Council Development Plan

Yorke Peninsula Council Strategic Plan 2012-2015

8. Appendices:

Appendix A – Community Sea Level Rise Fact Sheet.

Appendix B – Community Consultation Maps – with participant's contributions

Appendix C - Erosion study: Australian Water Environments

Appendix D - Council infrastructure - roads

Appendix A: Community Fact Sheet

Fact Sheet

Yorke Peninsula Council - **Seawater Flooding Study**

Introduction - Coastal Change

Many Australians choose to live near the sea.
Our coastline is constantly changing in ways that affect people who live near it. In some coastal areas we need to find ways of managing the risk of coastal flooding that may affect homes and properties.

Facts about rising sea levels

Evidence suggests that sea levels have been gradually rising and are predicted to rise further. Tide gauges on our coast have provided more than 100 years of information about tides and storms.

In South Australia, sea levels are estimated to have risen an average of 1.5mm per year during the 20th Century. Since 1990, sophisticated measurement stations have recorded an average rise of 4.3mm per year.

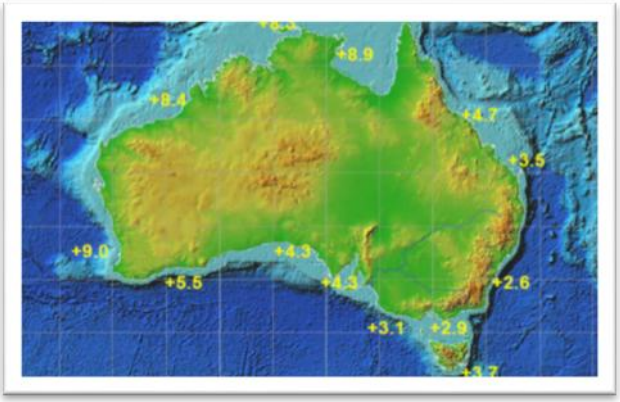
In 1991, the Coast Protection Board predicted that the sea may rise 300mm by 2050.

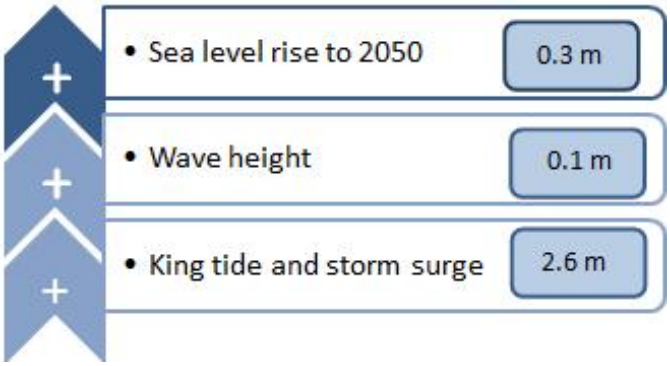
Actual sea level records suggest this prediction is likely to be realised.

Identifying the Risks

Council is leading a study jointly funded by the Commonwealth Government, Coast Protection Board and Council under the Natural Disaster Resilience Program to identify and map coastal flooding risks to local communities.

The study will identify which properties may be at risk of future flood events and will help Council and the community to plan for and manage these future risks.





There have been incidents in recent years where water threatened to overtop the levees and dunes around the gulf. One of the highest flooding events of the last thirty years occurred on Anzac Day, 2009.

Do you recall what happened in your town on that day?

Do you recall other flooding events prior to this?

But what if these flooding events had been higher as predicted may be the case by 2050? The flood map (right) shows how Coobowie may be affected in such an event. In these worst case scenarios properties are likely to be flooded. Roads into some parts of the settlements may also be flooded and emergency vehicles may not be able to access all areas.

Adapting to rising sea levels

In the Yorke Peninsula coastal region, flood defences have been designed for past conditions. In the future we may need to plan for flood levels that may be higher than they are now. Some settlements have more natural protection from flood, while others have less. Some newer coastal houses have floor levels above predicted flood levels. Some older houses may be lower than the predicted level.

Council is developing an Adaptation Plan, in consultation with the community, to respond to the risks from rising sea levels.

Find out more. Have your say. Come to a Workshop.

You are invited to participate in Council's planning for sea level rise. To help us plan, you can attend any workshop to share your knowledge of living in the area, discuss the current risks of coastal flooding, and find out about future flood risks.

Please bring your flood photos and videos!

Workshop 1 Date: 13 April 2015 Time: 1:30 PM
Venue: Port Clinton Community Hall

Workshop 2 Date: 14 April 2015 Time: 2:30 PM
Venue: Pine Point Town Hall

Workshop 3 Date: 14 April 2015 Time: 7:00 PM
Venue: Coobowie Community Hall

For more information, enquiries or feedback please contact Yorke Peninsula Council:

Telephone: 08 8832 0000
Fax: 08 8853 2494 e-mail: admin@yorke.sa.gov.au
Postal Address: PO Box 88, Minlaton SA 5575

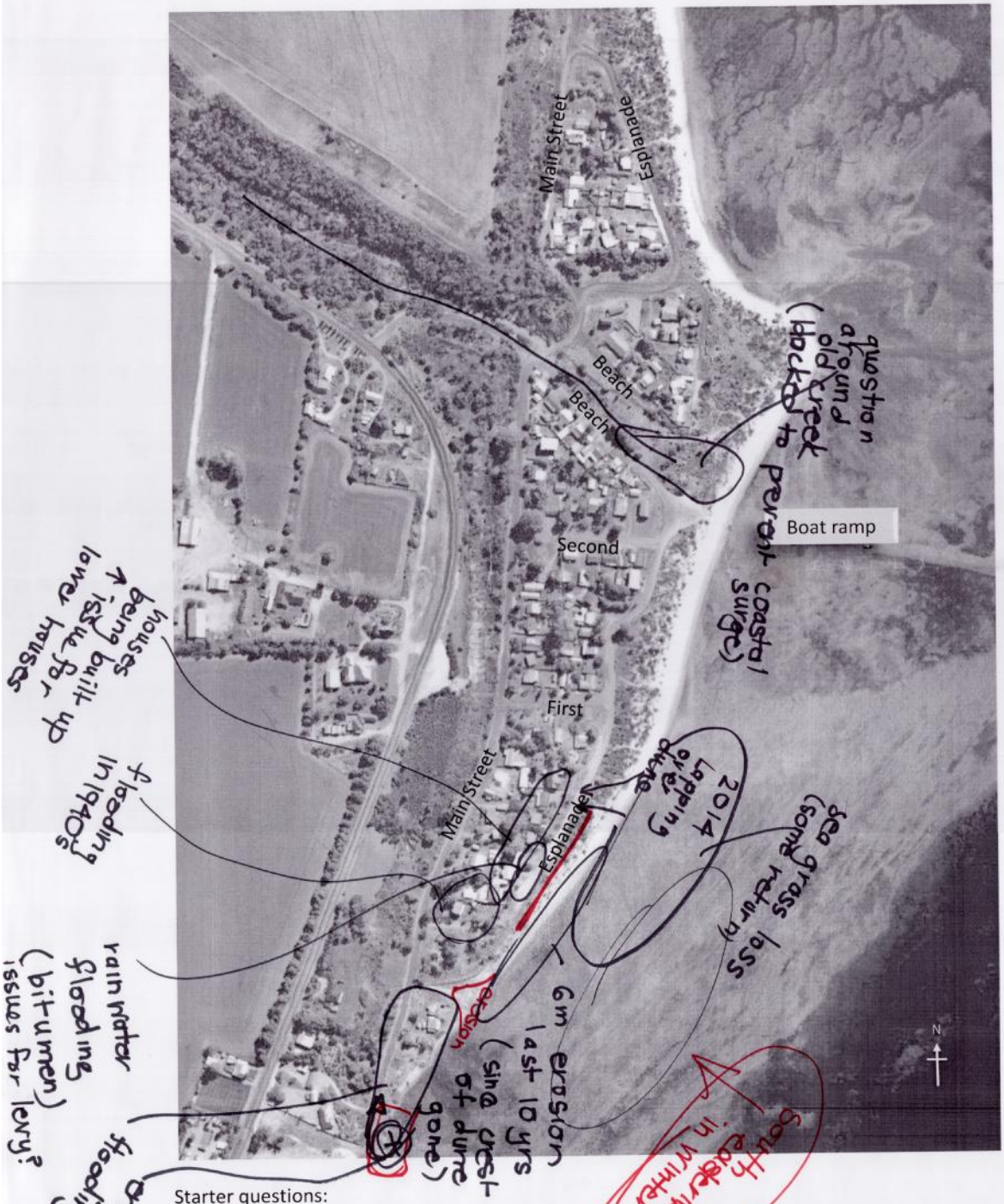
Government of South Australia
Coast Protection Board

DISASTER RESILIENT AUSTRALIA

Appendix B: Pine Point community consultation feedback- maps with mark up from residents 14th May, 2015.

Pine Point: 'Flood Feedback'

13th May 2015, Pine Point Town Hall



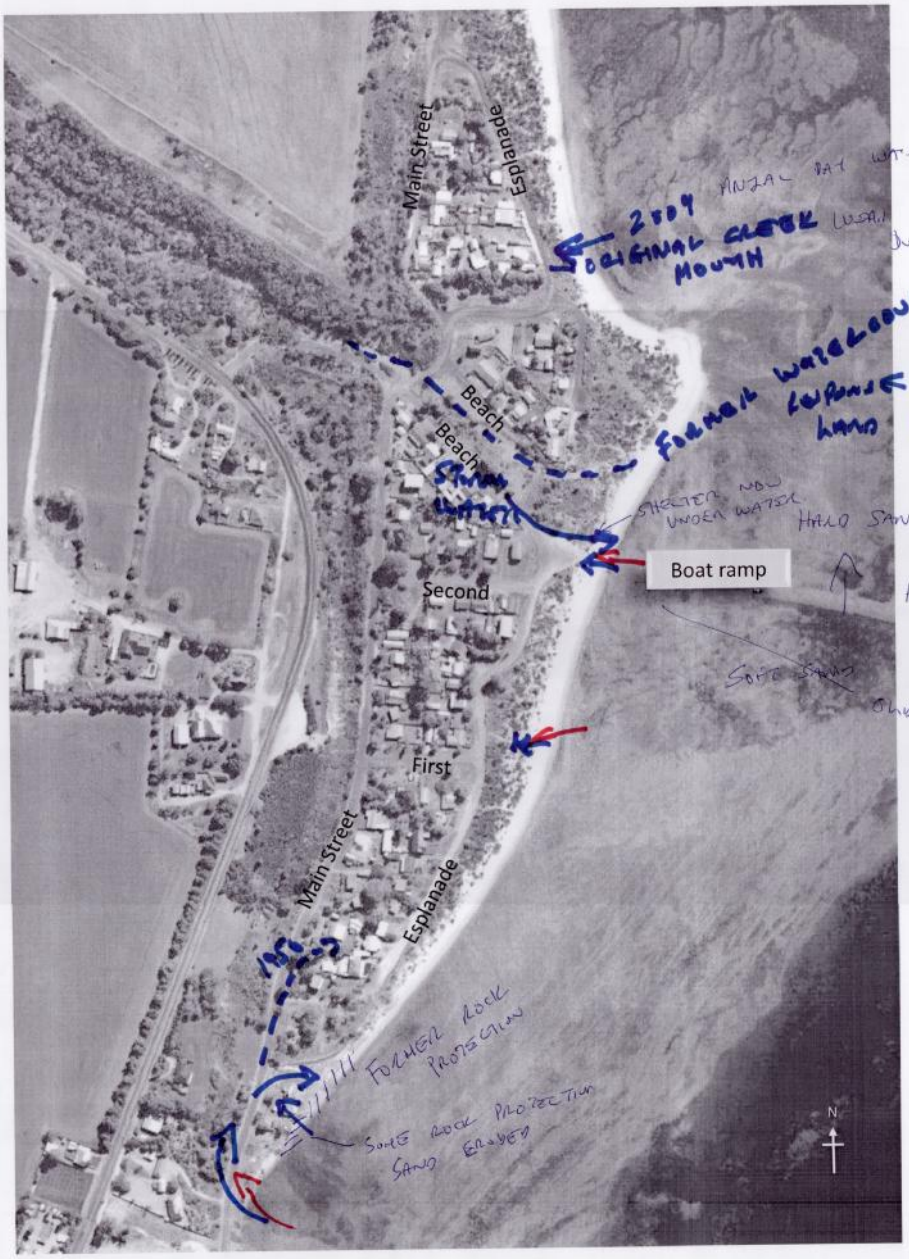
Starter questions:

1. Where have flooding or erosion incidents occurred in the past? (Use blue pen)
2. Where do you feel your settlement is going to be most vulnerable in the future? (Use red pen)
   Write any other comments on the map or use the reverse side for more room

JON

Pine Point: 'Flood Feedback'

13th May 2015, Pine Point Town Hall



Starter questions:

1. Where have flooding or erosion incidents occurred in the past? (Use blue pen)
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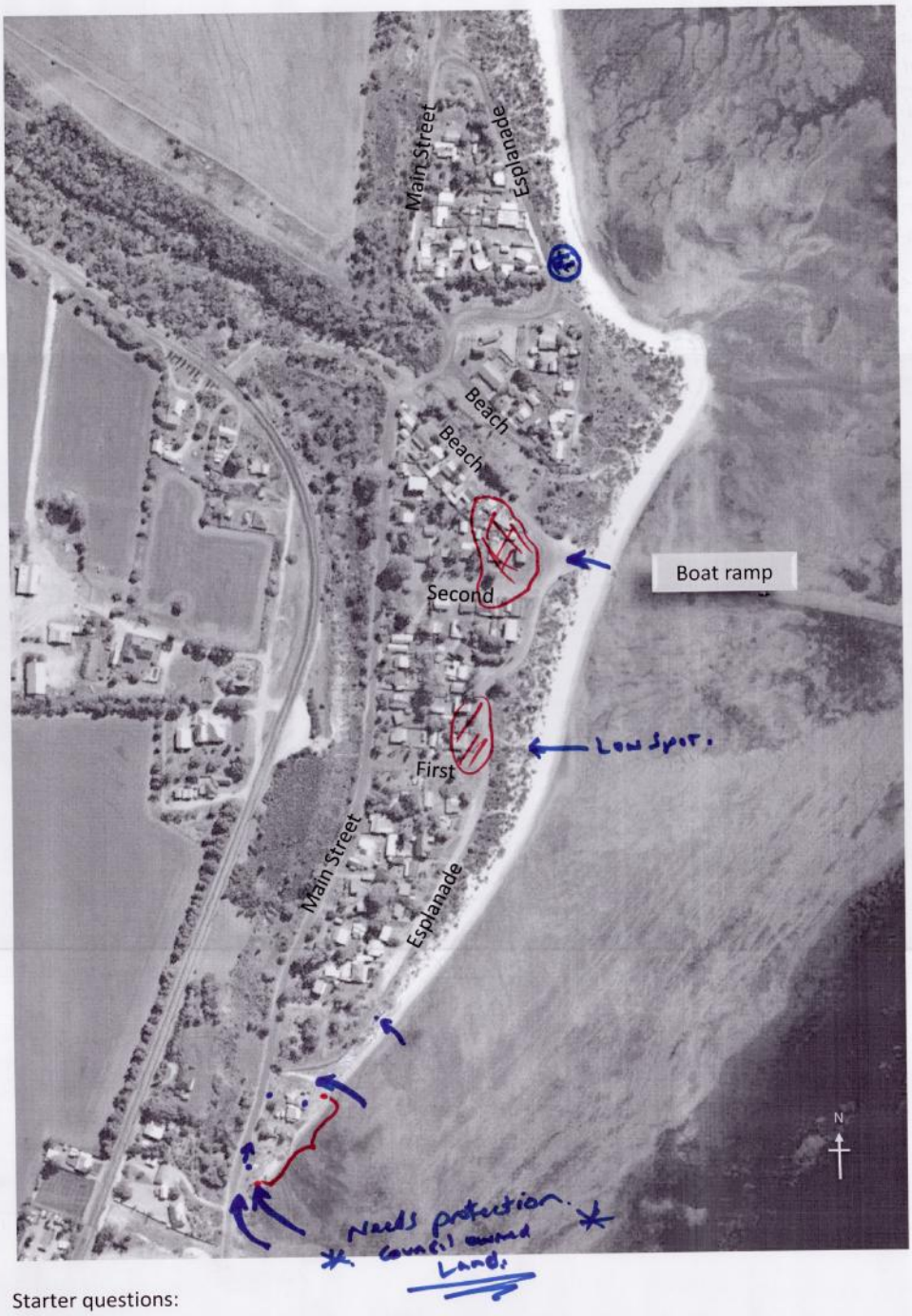
   Write any other comments on the map or use the reverse side for more room

Pine Point: 'Flood Feedback'

13th May 2015, Pine Point Town Hall



Starter questions:

1. Where have flooding or erosion incidents occurred in the past? (Use blue pen)
2. Where do you feel your settlement is going to be most vulnerable in the future? (Use red pen)
   Write any other comments on the map or use the reverse side for more room

Appendix C: Erosion study: Australian Water Environments

Australian WATER Environments

ABN 17 485 960 719

1 / 198 Greenhill Road
EASTWOOD SA 5063

Phone: 08 8378 8000
Fax: 08 8357 8988

Our Ref: 15061

Monday, 13 July 2015

Mr Mark Western
Managing Director
Mutual Projects

Dear Mark

Re: ***Seawater Flooding Adaptation Pathways for Yorke Peninsula Council Settlements – Pine Point Erosion Assessment***

Australian Water Environments has undertaken an assessment of the historical and current coastal erosion issues at Pine Point, Yorke Peninsula. Aerial photography for the Pine Point shoreline from 1976, 2004, 2012 and 2014 was reviewed.

The quality of the photography was generally poor (pixel size > 1 m^2) and variable between the available years. The shoreline extent was considered to be represented by the seaward extent of vegetation on the dune system. It was assumed anything on the coastal side of this line was an area of active erosion and deposition processes. The photography for each of the four years was geo-referenced using several features that were found to be constant. A plan showing the estimated shoreline extent around the southern levee (south) for the years reviewed is included as Figure 1. The estimated shoreline recession around the boat ramp (north) is shown in Figure 2.

The outcome from the comparison of the shoreline through the time series of photos is summarised below.

Time Span (year)	Recession Range (m)*		Recession Rate (m/year)	
	Around Southern Levee	Near Boat Ramp	Around Southern Levee	Near Boat Ramp
1976 – 2004	2 – 5	2 – 4	0.07 – 0.18	0.07 – 0.14
2004 – 2012	2 – 8	-2 – 0	0.25 – 1	-0.25 – 0
2012 – 2014	0 - 5	2 – 5	0 – 2.5	1 – 2.5

- *The recession ranges provided are a typical range only. For each comparison timeframe the actual shoreline positional change at a specific location may be outside the range. The shoreline has been best traced from aerial photography that is low quality so accuracy may be limited to ±3m.*

The outcome was that there appears to be a consistent recession for the time period from 1976 – 2004 between the southern area and the boat ramp. Between 2004 and 2012 recession in the southern area increased significantly but there was no evidence of recession near the boat ramp. This may be as a result of greater sand

movement from the southern area towards the north temporarily increasing the dune extent. An increase in the rate of recession in the southern area appears to be supported by anecdotal evidence provided from locals through earlier community consultation. From 2012 – 2014 the rate of recession in the southern area continued at an increased rate. The rate of recession near the boat ramp also accelerated, perhaps due to a decline in sand supply from the south.

The digital terrain model for Pine Point was also reviewed and this indicated that the levee width was in the order of 4-5 m. As the shoreline is already at the base of the southern extent of the levee, and with the rate of recession appearing to be increasing, it is likely that the levee could potentially be in danger of failing within a 10 year timeframe without further intervention.

The trigger for the increase in shoreline recession rates may be attributable to a number of factors either individually or in combination. Such factors may include:

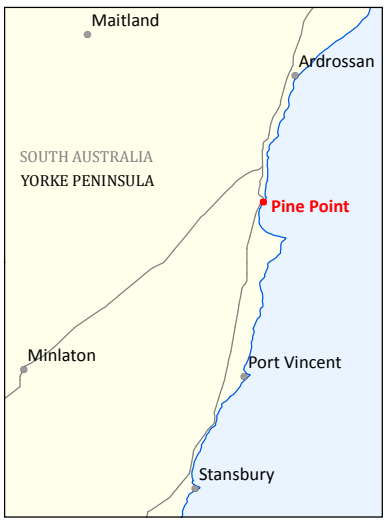
- Lack of fresh sand supply from the south;
- Increase in sea level;
- Drought conditions impacting on dune vegetation health;
- Increase grazing pressure on dune vegetation (i.e. rabbits); and
- Possible increase in strength and persistence of dominant south-easterly winds.

The extent to which each of these factors may be contributing to the increase in shoreline recession has not been verified.

Yours sincerely,

Ben Taylor
Senior Environmental Engineer

Australian Water Environments Pty Ltd



LEGEND

- March 1976
- July 2004
- November 2012
- September 2014

Data Source:
1976 aerial image supplied by Coast Protection Board.

0 20 40 60 80 100
Metres (Scale 1:2,000 A4 Sheet)

Australian WATER Environments

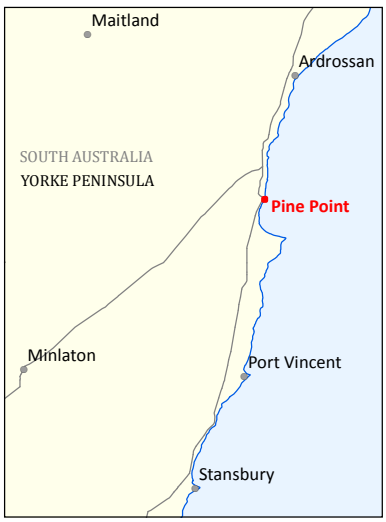
Seawater Flooding Adaptation Pathways for Yorke Peninsula Council Settlements

Pine Point Shoreline Mapping (South)

1976, 2004, 2012, 2014

15061 D003 v3 SouthShorelineAerial 150708
Last Updated: 13/07/2015

Figure 1



LEGEND

- March 1976
- July 2004
- November 2012
- September 2014

Data Source:
1976 aerial image supplied by Coast Protection Board.

0 20 40 60 80 100
Metres (Scale 1:2,000 A4 Sheet)

Australian WATER Environments

Seawater Flooding Adaptation Pathways for Yorke Peninsula Council Settlements

Pine Point Shoreline Mapping (North)

1976, 2004, 2012, 2014

15061 D004 v1 NorthShorelineAerial 150713mxd
Last Updated: 13/07/2015

Figure 2

Appendix D: Council asset infrastructure - roads

Aset ID	Road Name	From	Town limit	Asset Type	Length	Area (M)	CRC $
5449	Esplanade (Pine Point)	Main St	Cul de sac	Concrete Footpath	20		$ 1,930.40
7400	Main St (Pine Point)	Second St	Beach Rd	Township Spray Seal Surface	166	990.4	$ 7,626.08
7401	Main St (Pine Point)	0.45km N of St Vincent Hwy	Second St	Township Spray Seal Surface	402.3	2613.8	$ 20,126.26
8430	Esplanade (Pine Point)	Beach Rd	South Terrace	Township (Northern Zone) Pavement	456.1	2896.1	$ 57,342.78
6502	Main St (Pine Point)	Earle St	Cul de sac	Rollover Concrete Kerb & Channel	110		$ 13,801.70
8837	South Tce (Pine Point)	Main St	Esplanade	Township (Northern Zone) Pavement	80.6	454.7	$ 9,003.06
8862	Second St (Pine Point)	Main St	Esplanade	Township (Northern Zone) Pavement	139	843.7	$ 16,705.26
9322	Beach Rd (Pine Point)	Main St	End	Township Spray Seal Surface	97.5	1092.3	$ 8,410.71
9323	Beach Rd (Pine Point)	Main St	End	Township (Northern Zone) Pavement	97.5	1092.3	$ 21,627.54
7314	South Tce (Pine Point)	Main St	Esplanade	Township Spray Seal Surface	80.6	454.7	$ 3,501.19
7338	Second St (Pine Point)	Main St	Esplanade	Township Spray Seal Surface	139	843.7	$ 6,496.49
7398	Main St (Pine Point)	Earle St	Cul de sac	Township Spray Seal Surface	263.1	1657.4	$ 12,761.98
7399	Main St (Pine Point)	Beach Rd	Earle St	Township Spray Seal Surface	90.4	539.3	$ 4,152.61
7429	Beach Rd (Pine Point)	Main St	Esplanade	Township Spray Seal Surface	196.6	1092.3	$ 8,410.71
7505	Earle St	Main St	Esplanade	Township Spray Seal Surface	105.3	762.5	$ 5,871.25
7529	Esplanade (Pine Point)	Main St	Cul de sac	Township Spray Seal Surface	359.3	2080.7	$ 16,021.39
7530	Esplanade (Pine Point)	Beach Rd	South Terrace	Township Spray Seal Surface	456.1	2896.1	$ 22,299.97
7666	First St (Pine Point)	Main St	Esplanade	Township Spray Seal Surface	100.4	677.4	$ 5,215.98
8485	Beach Rd (Pine Point)	Main St	Esplanade	Township (Northern Zone) Pavement	196.6	1092.3	$ 21,627.54
8594	Earle St	Main St	Esplanade	Township (Northern Zone) Pavement	105.3	762.5	$ 15,097.50
8642	Esplanade (Pine Point)	Main St	Cul de sac	Township (Northern Zone) Pavement	359.3	2080.7	$ 41,197.86
8651	First St (Pine Point)	Main St	Esplanade	Township (Northern Zone) Pavement	100.4	677.4	$ 13,412.52
8917	Main St (Pine Point)	Earle St	Cul de sac	Township (Northern Zone) Pavement	263.1	1657.4	$ 32,816.52
8918	Main St (Pine Point)	Beach Rd	Earle St	Township (Northern Zone) Pavement	90.4	539.3	$ 10,678.14
8919	Main St (Pine Point)	Second St	Beach Rd	Township (Northern Zone) Pavement	166	990.4	$ 19,609.92
8920	Main St (Pine Point)	0.45km N of St Vincent Hwy	Second St	Township (Northern Zone) Pavement	402.3	2613.8	$ 51,753.24
							$ 447,498.60