Water Research Laboratory

Coastal Adaptation and Protection Options for Port Sorell and Shearwater

WRL Technical Report 2012/20
August 2012

by
M J Blacka and F Flocard

UNSW
THE UNIVERSITY OF NEW SOUTH WALES

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Project Details

Report Title	Coastal Adaptation and Protection Options for Port Sorell and Shearwater
Report Author(s)	M J Blacka and F Flocard
Report No.	2012/20
Report Status	Final
Date of Issue	31 August 2012August 2012
WRL Project No.	2012071.01
Project Manager	Matt Blacka
Client Name	Local Government Association of Tasmania
Client Address	GPO Box 1521, Hobart, Tasmania, 7001
Client Contact	John Harkin (Department of Premier and Cabinet, Climate Change Office)
Client Reference	

Document Status

Version	Reviewed By	Approved By	Date Issued
1.0 Draft	GPS	GPS	10/08/2012
2.0 Final	GPS	GPS	31/08/2012

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1. Introduction

The Water Research Laboratory (WRL) of the University of New South Wales (UNSW) was commissioned by the Local Government Association of Tasmania (LGAT) to provide coastal engineering advice with regards to coastal protection and future climate change for the area of Port Sorell/Shearwater on the north coast of Tasmania. This advice was part of the Tasmanian Coastal Adaptation Decision Pathways (TCAP) project, with the advice being utilised to assist the local council for the area (Latrobe Council) to develop plans to adapt to future climate change. As per the brief for the project, the advice provided in this report consists of the following three components:

1. Brief review of the coastal processes around the beaches of Port Sorell and Shearwater;
2. Review of the possible options to improve the existing erosion protection assets and possible options to protect and augment sand on the beach for future conditions;
3. Feedback on the "Private Proposal for Amelioration of Flood Risk & Beach Erosion in Port Sorell" provided to the Latrobe Council.

Due to the budget and time restrictions on the project, WRL's analysis is based only on observations and previous photos of the site, experience, and simple desktop coastal engineering calculations. No detailed modelling or analysis was undertaken. Further detailed analysis would likely yield refined advice if such modelling were to be completed. Nevertheless, this report provides a summary of WRL's analysis and is considered suitable to assist Latrobe Council to:

- Further understand the basic coastal processes at the site with regards to coastal erosion;
- Develop a long-term strategy for limiting or reversing beach recession in the area;
- Develop a short-term/emergency protection strategy for containing coastal erosion;
- Understand key parameters for various types of coastal structures for the present day, and how they should be adapted for future scenarios.

2. Location and Environmental Conditions

2.1 Site Description

An overview of the Port Sorell and Shearwater area is shown in Figure 1, with the project study area highlighted. The towns of Shearwater and Port Sorell are located on the Tasmanian north coast estuary of the Rubicon River, at a low terminal end of a 3 km long sandy spit complex. The main beach within the study area is Freers Beach, a 2 km long semi-circular beach facing north-east. At the southern end of Freers Beach, the shoreline turns at a groyne/stormwater outlet and trends to the south-east for another 1 km until the mouth of the Panatana Rivulet River joins the estuary.

Following discussions with Council, this report focusses on the sandy embayment of Freers Beach, as this section of the coast has suffered erosion in recent times which will be potentially exacerbated with future climate change.

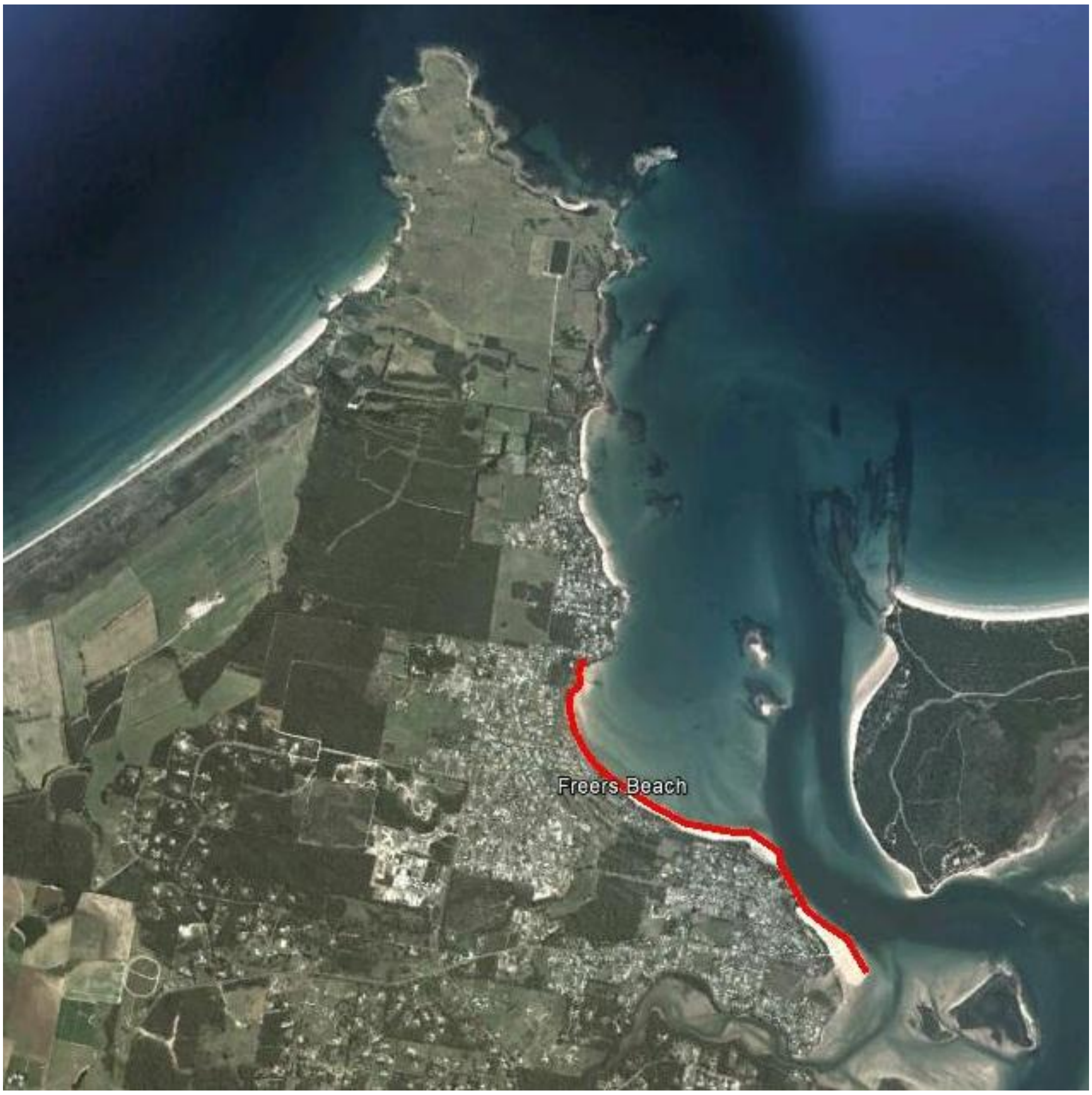


Figure 1: Location and Study Area

2.2 Environmental Conditions

2.2.1 Wave Climate

The northern coast is the most sheltered of Tasmania's four coastlines, but is still prone to moderate waves. Wave conditions are usually described in terms of *significant* wave height (H_s) and peak wave period (T_p).

A review of available wave data was performed for the northern coast of Tasmania in Carley (2008) for a study on climate change adaptation around the town of Stanley. This analysis considered the following sources:

- 2.1 years of buoy data recorded at Burnie;
- Wave hindcasting based on design wind speeds from AS1170.2 (2002); and
- 8 years of visual observations from Low Head.

It was clearly stated in Carley (2008) that all information sources were only suitable for crude estimates of extreme wave heights beyond approximately a 10 year Average Recurrence Interval (ARI), and the following statistics were estimated for H_s during extreme events:

- 1 year ARI: 4.0 m
- 10 year ARI: 5.5 m
- 50 year ARI: 6.5 m
- 100 year ARI: 7.0 m

While it should be highlighted that these values are only estimates, there is a lack of better wave climate predictions for the northern coast of Tasmania, and as such these values have been adopted for the analysis in this study. A peak wave period of 10 s has been adopted for these design conditions from Carley (2008), based on the maximum measured waves and the results of wave hindcast calculations.

2.2.2 Water Levels

Water levels consist of tides which are forced by the sun, moon and planets (astronomical tides), and a tidal anomaly. Tidal anomalies result from factors such as wind setup or setdown, barometric effects, seasonal changes and coastally trapped waves. The largest positive anomalies are associated with major storms and are driven by barometric setup (associated with low barometric pressure) and regional wind setup, which are often combined as "storm surge". Water levels within the surf zone are also subject to wave setup and wave runup. Water levels within the estuary are also likely to be affected by freshwater flood flows, and while the mechanisms causing storm surge and freshwater flooding may be similar, consideration of the joint probability of the events is complex and beyond the scope of this study. Figure 2 shows the various contributions to extreme water levels.

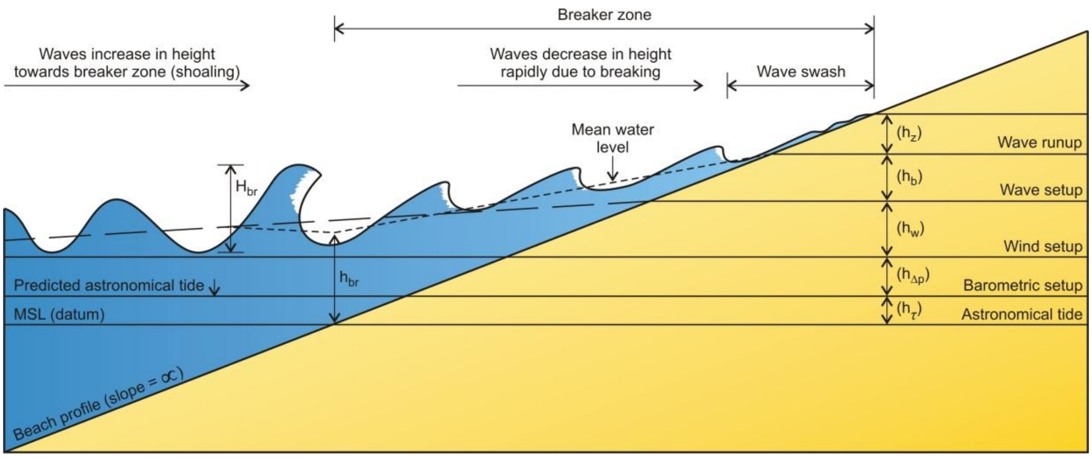


Figure 2: Components of Extreme Coastal Water Levels

The Australian National Tide Tables 2009 (RAN, 2008) values for the Port of Devonport are reproduced in Table 2.1. Australian Height Datum (AHD) is approximately mean sea level. Chart datum has been converted to AHD using the offset of 1.96 m. Due to tidal anomalies (barometric setup, wind setup, trapped waves), extreme water levels will exceed the highest astronomical tide and are further discussed below.

Table 2.1: Published Tidal Planes for Devonport

	Astronomical Tidal Planes						
Datum	HAT	MHWS	MHWN	MSL	MLWN	MLWS	LAT
Chart datum	3.6	3.3	3.0	2.0	0.9	0.7	0.0
AHD	1.7	1.3	1.0	0.0	-1.0	-1.3	-2.0

Hunter (2008) estimated peak water levels for various recurrence intervals for Burnie, based on tides as well as regional scale barometric and wind setup. Burnie is approximately 40 km west of Devonport and 55 km west of Port Sorell, with the Australian National Tide Tables 2009 (RAN, 2008) showing that predicted astronomical tides for Devonport are within 0.05 m of those for Burnie.

On the open coast, local wave setup in excess of the broader scale water levels can typically be approximated as 15% of the offshore significant wave height, based on a coastal engineering "rule-of-thumb". However, as Freers Beach is well within the mouth of the Rubicon Estuary, wave setup will be somewhat less than this, as:

- Most wave breaking during large wave conditions is expected to occur near/outside the estuary entrance;
- There is a long sand flat of less than 5 m depth extending seaward from Freers Beach some 2.5 km to the estuary entrance; and
- The estuary entrance is wide, and is deeper and more protected on the eastern side.

Based on coarse bathymetric survey contours for the entrance of the Rubicon Estuary provided by Tasmanian Aquaculture and Fisheries (TAFI), WRL have undertaken a crude analysis of wave setup for the exposed sections of Freers Beach using the 1D surf zone model of Dally, Dean, and Dalrymple (1984). This analysis is conservative in that it did not allow for effects of wave diffraction and refraction in the estuary which would reduce wave energy and setup, and assumed that there was 100% coincidence of extreme wave and water level conditions (i.e. the 100 year ARI wave event occurs with the 100 year ARI extreme storm surge water level). While crude, this analysis is reasonable for providing practical upper limit estimates of wave setup for Freers Beach.

Extreme water levels for various recurrence intervals including the effects of regional storm surge and local wave setup are shown in Table 2.2 based on the extreme storm surge water levels of Hunter (2008).

Table 2.2: Estimated Present Day Extreme Event Water Levels (Excluding Freshwater Flood Contribution)

ARI (yrs)	Storm Surge Water Level (m AHD)	Wave Setup (m)	Total Nearshore Water Level (m AHD)
1	1.75	0.19	1.94
10	1.87	0.29	2.16
100	1.93	0.40	2.33

2.2.3 Sea Level Rise

Climate change is expected to result in accelerated sea level rise. The National Committee on Coastal and Ocean Engineering "Guidelines for Responding to Climate Change" (NCCOE, 2004) provide "engineering estimates" for sea level rise on the basis of the IPCC (2001) Third Assessment Report (TAR). The values presented by NCCOE (2004) for the "engineering estimates" are based on the TAR SRES scenarios, and are shown in Figure 3.

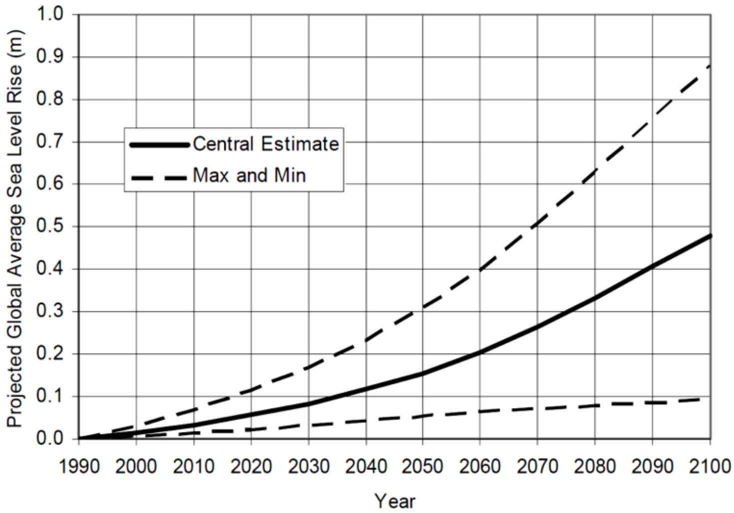


Figure 3: Projected Sea Level Rise Estimates from NCCOE (2004)

Hunter (2008) again used values from the IPCC TAR, and presented sea level rise projections for three separate SRES scenarios, namely B1 (low impact), A1B (medium impact) and A1FI (high impact). Hunter (2008) generally did not use the IPCC (2007) fourth assessment report (AR4), as sea level rise projections were not published for times throughout the 21st century, and the report findings were not published at the time of part of his analysis being completed. The sea level rise projections from Hunter (2008) are shown in Figure 4.

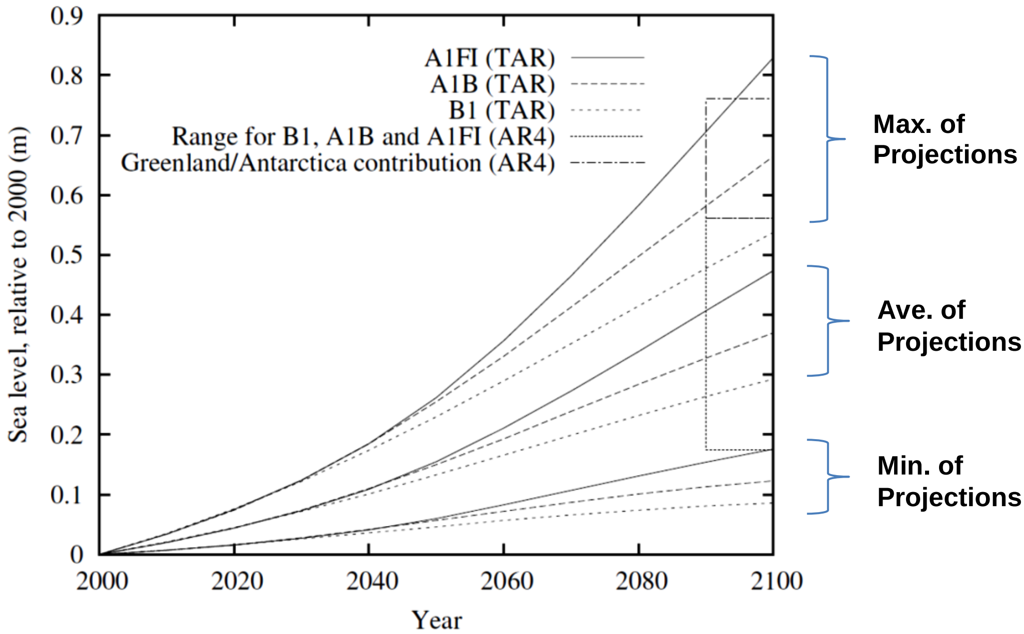


Figure 4: Projections for Sea Level Rise from Hunter (2008)

The dynamic nature of the Freers Beach estuarine section of coast and the large uncertainty in sea level rise projections means that it is unreasonable to attempt to project beyond 2050 in terms of the broad nature of the coastal engineering advice in this study. For the purpose of providing practical coastal engineering guidance to Council the "engineering estimate" for sea level rise adopted for this this study is the high range 2050 value of 0.3 m, consistent with both NCCOE (2004) and Hunter (2008). 2050 extreme water levels for various recurrence intervals including the effects of regional storm surge and local wave setup are shown in Table 2.3.

Table 2.3: Estimated 2050 Extreme Event Water Levels (Excluding Freshwater Flood Contribution)

ARI (yrs)	Storm Surge Water Level (m AHD)	Wave Setup (m)	Total Nearshore Water Level (m AHD)
1	2.05	0.18	2.23
10	2.17	0.27	2.44
100	2.23	0.38	2.61

3. Site Investigation

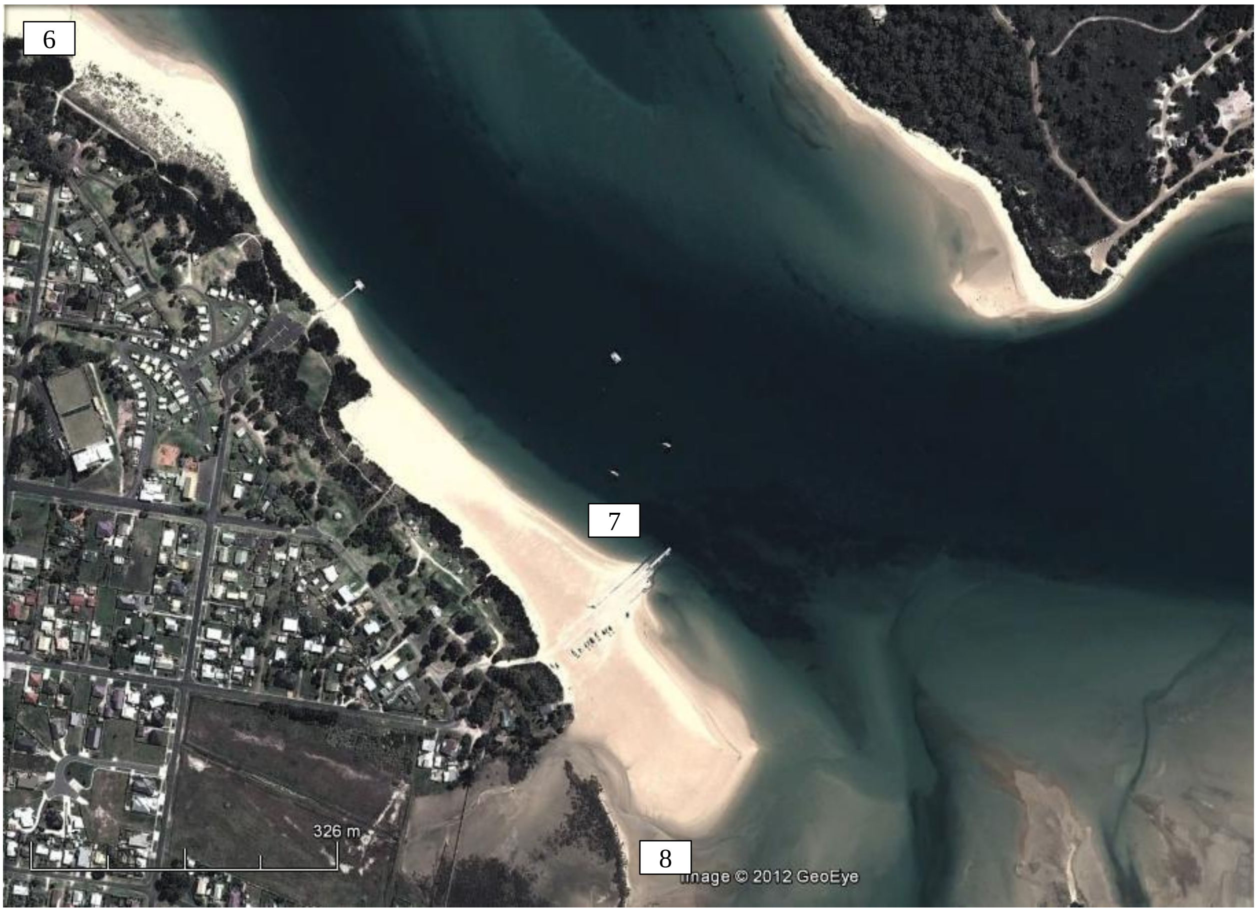
3.1 Overview

WRL Senior Coastal Engineer Matt Blacka visited Freers Beach on 18/07/2012 with Latrobe Council Engineer Jonathan Magor. The investigation was undertaken to observe the recent erosion and to gain a better understanding of the processes and interactions at the site. This inspection also provided opportunity to discuss previous coastal management and community views in the area, which are important in the consideration of future coastal management strategies. The beach was observed over approximately a five hour window (high tide to low tide), with a range of observations, photographs and sand samples taken across the study area.

A range of previous coastal protection measures can be seen along the embayment, and these features have been used as reference points for the field observations. These reference points are shown in Figure 5 and Figure 6 and described in Section 3.2.

1A: Revetment South of Freer Street
1B: Revetment North of Freer Street
2: Northern End of Freers Beach
3: Stone Covered Stormwater Outlet
4: Stone Covered Stormwater Outlet
5: Offshore Rock Breakwater
6: T-Head Rock Groyne/Stormwater Outlet

Figure 5: Location Diagram for Significant Coastal Features (Northern Section)



7: Boat Launching Ramp 8: Area south of Marys Creek Outlet

Figure 6: Location Diagram for Significant Coastal Features (Southern Section)

3.2 Present State of the Beach and Observations

Location (1A) at the end of Freer Street and to the south of the beach access is a rock armoured revetment wall that is believed to have been constructed in July 2010 as an emergency protection measure. The revetment (shown in Figure 7) has the following characteristics:

- Predominantly igneous rock armour ranging approximately from 200 kg to 5000 kg;
- Crest level of approximately 4 m AHD (based on area behind crest being 3.5 m AHD as reported by Council from LiDAR measurements);
- Toe level of approximately 1 m AHD;
- Slope varying from approximately 1V:2H to vertical at the southern end of revetment.

There is no beach seaward of the revetment at high tide, and there is a nearshore gutter extending the length of the seawall and approximately 30 m seaward of the wall toe. A shallow sand bar exists further seaward, indicating that the revetment wall has likely exacerbated erosion of the nearshore beach with the sand from the beach laying in the detached bar. It should, however, be noted that while the revetment may have exacerbated erosion of the beach, it has likely saved the adjacent sewer pumping station from damage that natural erosion would otherwise have caused if protection works were not implemented.

Figure 7: Rock Revetment at Location (1A)

Location (1B) at the end of Freer Street and to the north of the beach access is a rock armoured revetment wall that is believed to have also been constructed in July 2010 as an emergency protection measure. The revetment (shown in Figure 8) has the following characteristics:

- Predominantly lower quality conglomerate rock armour with typical size of approximately 20 kg to 500 kg, though some larger igneous stones up to several tonnes are also present;
- Crest level of approximately 3 m AHD and dropping further to the north;
- Toe level of approximately 1 m AHD;
- Slope of approximately 1V:2H.

Figure 8: Rock Revetment at Location (1B)

Location (2) at the northern end of Freers Beach is a sand flat area with a low vegetated dune backing the beach. This area has suffered less erosion than stretches of the beach further south.

Figure 9: Beach at Location (2)

The beach between Freer Street and the stormwater outlet at (3) is presently in a well eroded state (see Figure 10). There is very little sandy beach remaining above the high tide level, though the erosion is yet to create a scarp within the vegetated dune. The southern end of the revetment at (1A) is at risk of being outflanked and causing additional erosion in this area if a healthy beach is not re-established and erosion is allowed to continue.

Figure 10: Beach Between Revetment (1A) and Stormwater Outlet (3)

Location (3) is a stormwater outlet that terminates on the beach (see Figure 11). To help prevent sand from the beach blocking the concrete outlet pipe, a ring of rock armour has been built around the end of the pipe. The rock armour remaining intact on the structure ranges in size from approximately 150 kg to 3,000 kg, though there is a lot of smaller material that has been washed to the toe of the structure by waves. The rock armouring extends a distance of approximately 20 m seaward across the beach, with the structure effectively acting as a short groyne.

Figure 11: Rock Armoured Stormwater Outlet Structure at (3)

The beach between the stormwater outlet structures at (3) and (4) is in a heavily eroded state, with very little dry beach present at high tide. An erosion scarp of approximately 1 m in height is present along parts of this section of beach (see Figure 12 bottom), and a range of medium sized shrubs have recently collapsed from the dune onto the beach due to erosion of the sand from around their roots (see Figure 12 Top).

Figure 12: Eroded Section of Beach Between Stormwater Outlets at (3) and (4)

Location (4) is a stormwater outlet that terminates on the beach with a concrete headwall (see Figure 13). The outlet pipe has been armoured with rock in the past, though the purpose of the rock at this structure is not entirely clear. The rock armour remaining intact on the structure has a typical size of 200 kg to 3000 kg, though there is smaller material that has been washed to the toe of the structure by waves. The outlet extends a distance of approximately 15 m seaward across the beach, with the structure effectively acting as a very short groyne. Though not undermined at present, further erosion of the beach could see the headwall of this outlet undermined and damaged if works to protect the structure are not implemented in the near future.

Figure 13: Stormwater Outlet at Location (4)

The section of beach between the stormwater outlet (4) and the offshore breakwater (5) is also eroded, though to a lesser degree (see Figure 14). Though very little dry beach is present at high tide, there is no significant erosion scarp at present, and the erosion has not yet impacted the dune vegetation. The offshore breakwater (5, see Figure 15) is having a clear impact on the beach, with a salient of up to 10 m in width present. Based on discussions with a Council staff member who worked on the construction of the offshore breakwater, it was likely built around the late 1980s. It is understood that the armour was placed directly onto the sandy bottom, and that trucks were able to access the site to tip armour material during low tide. It estimated that the offshore breakwater (5) has the following characteristics:

- Crest level ranging from MSL at ends up to 1.5 m AHD in centre;
- Crest length (longshore) of 100 m;
- Distance offshore of 150 m;
- Armour stone size of 5000 kg to 7000 kg;
- Toe level of -1 m AHD.

It is understood that the breakwater had a more substantial crest after construction, but has lost armouring material over time due to wave attack. This structure was also planned to be built as the centre structure in a field of three structures, however, the outer two structures were never completed.

Figure 14: Beach Between Stormwater Outlet (4) and Offshore Breakwater (5)

Figure 15: Offshore Breakwater (5)

South of the offshore breakwater (5) and north of the stormwater outlet (6), the beach has had significant recent accretion (between Anderson Street and Rice Street). The beach in this area has a well-established and vegetated back beach dune and is significantly wider (approximately 50 m) than the sections further north. Just seaward of the dune a significant quantity of loose sand has been freshly deposited during recent storms, with the deposition so deep in places that a previous beach access way and dune vegetation has been partially buried (see Figure 16 Bottom). It is postulated that this is the sand recently eroded from sections of beach north of (5).

Figure 16: Accreted Beach Between Offshore Breakwater (5) and Stormwater Outlet (6)

Location (6) at present appears to be a rock armoured groyne structure that extends some 75 m seaward across the beach, ending with a perpendicular hook at its seaward end (see Figure 17). The beach has filled against the groyne to such a degree that only the upper 0.2-0.5 m of rocks are visible above the sand. Due to the overfull beach at this location, it would appear that almost all littoral drift sand transport would directly bypass this structure.

Upon consultation of older aerial photographs of this site, it is believed that this groyne structure is actually on top of an old stormwater outlet. Regardless of the origin, it is likely that this structure has been trapping littoral drift sand for at least the past 20 years (until it reached its present full state) and has significantly re-shaped this section of the beach.

The coast changes alignment significantly at this location (6) from east-west to north-south.

Figure 17: Groyne Structure Crossing Beach at Location (6)

South of (6) the beach is in a relatively accreted state through to the boat ramp and pontoons at (7, See Figure 18). This stretch of beach is completely sheltered from wave attack (aside from local wind driven seas on the estuary), and appears to have a healthy supply of sand. Despite having completely different alignment to the beach further north, the sediment on the beach is still consistent in appearance, suggesting that it is likely a part of the same sediment compartment. South of (7) Marys Creek crosses the beach, and there is a clear change in the appearance of the sediment at location (8). It is apparent that the sediment at location (8) contains a higher fraction of estuarine silts and is also darker in colour, so typical of estuarine mud flat areas. It appears that the clean marine sand at location (7) differs in nature to the estuarine sand at (8), and therefore likely indicating the closure of the marine sand cell of Freers Beach at location (7).

Figure 18: Healthy Beach Adjacent to Boat Ramp at (7)

3.3 Sand Sampling and Grain Size Distribution

Sand samples were collected from numerous locations along the beach and analysed for particle size distribution. The results of the analysis are shown in Appendix 1. It can be seen that the sand from the mudflat at location (8) has approximately 10% of mass smaller than 125 microns, whereas all other samples from Freers Beach have 0% smaller than 125 microns. In general the particle size for the beach material has a median grain size of approximately 200 microns.

4. Summary of Coastal Processes at the Site

The site is exposed to wave energy from Bass Straight propagating into the estuary during north-easterly wave conditions. Due to the aspect of the entrance as well as the presence of Penguin Island, there is a natural gradient in wave energy entering the estuary entrance as shown in Figure 19. This gradient in wave energy likely results in higher levels of cross-shore sediment transport during storm conditions (storm bite) for the area between locations (2) and (4) on Figure 5, and a general tendency for long-term littoral drift from the north-west end of Freers Beach toward the south-east. It is also probable that sand removed off the active beachface during storms at the northern end of the embayment is pushed south-east along the embayment and deposited in the area between locations (4) and (6) on Figure 5. This process has throughout time likely created an imbalance in available beach sediment at the north-western end of the beach and a surplus of sand at the south-eastern end of the beach through a combination of underlying littoral drift and short term storm erosion.

Figure 19: Wave Exposure and Sediment Transport Processes

The existing coastal structures installed at the site (thought to be in the late 1980s or early 1990s) provide further confirmation of these sediment transport processes. Clearly this stretch of coast has been dynamic and suffered from erosion in the past, as there is evidence of back beach protection in the form of gabion baskets, as well as a groyne (6), stormwater outlets (3 and 4), an offshore breakwater (5), and mostly buried rock revetments extending from (5) to

(6). Appendix 2 shows a range of aerial photographs of Freers Beach through time, where the impacts of these coastal structures and the evolution of the shoreline can clearly be seen.

Images from 1990, 1994, and 2006 all show a clear build-up of sand against the north-western (updrift) side of the stormwater outlets, with erosion on the south-western (downdrift) side. This is a tell-tale signal of north to south longshore sediment transport along the embayment. Images from 2000 onwards all show a clear widening of the beach in the lee of the offshore breakwater, which confirms that the structure is having a positive impact in terms of widening the beach in its lee.

It can also be seen from the historical imagery that throughout the 1990s the north-western end of the embayment was sediment rich with a relatively healthy beach, while the south-eastern end of the embayment was sediment poor with a narrow eroded beach. In the early 2000s the beach was relatively uniform in width. In recent years this has reversed, with a wide healthy beach developing at the south-eastern end of the embayment and an eroded narrow beach at the north-western end. This is likely evident of a longer term cycle in sediment supply to different sections of the embayment with sediment possibly moving onto the beach in inter-decadal slugs, or a long term deficiency in sediment supply which is visible at the north-western end at present and will propagate to the south-eastern end in coming years.

While providing a final line of defence against erosion, the emergency protection revetment at the end of Freer street is also likely to exacerbate erosion of the beach in this area, particularly during storm conditions. This process occurs due to increased wave reflection and turbulence caused by the wall when waves are able to runup and impact the structure. Revetment structures such as this are also known to generate additional erosion of the beach adjacent to the downdrift (southern) end of the structure. Specific precautions are normally implemented during the construction of back beach revetments to ensure that any additional erosion does not result in outflanking and damage to the structure.

5. Recommended Erosion Protection Strategy

Given the recent erosion experienced on Freers Beach, WRL recommend that two conceptual strategies be considered for managing the beach:

- Short term strategy to recover the beach over the northern part of the embayment from recent erosion and alleviate immediate risk from further erosion;
- Long term strategy to build a stable beach along the entire length of the embayment which will assist in reducing any long term recession that may occur as a result of sea level rise or other underlying negative sediment budget.

Furthermore, advice is provided for a conceptual emergency protection strategy, should erosion continue and present a significant risk in the near future.

5.1 Short-Term Strategy

While no detailed volumetric analysis has been undertaken, observations of the site indicate that there is an imbalance in the beach width around the embayment, with considerable short-term erosion over the north-western half of the embayment and accretion over the south-eastern half. It may be feasible to redistribute the sand reserves on the beach to create a more uniform beach width around the entire length of the embayment. In summary, this would involve:

- Shifting sand to the area between (2) and (4) from areas (6) and (7);
- Slightly extending the stormwater outlet groynes at locations (3) and (4); and
- Monitoring the beach through profile surveys.

Figure 20 shows the conceptual layout for the short-term strategy. It is expected that this strategy could be implemented for a cost of the order of $100,000.

In a process known as "beach scraping" or "beach reshaping", sand can be taken from one section of the beach and utilised to nourish other sections of the beach. This process has been undertaken at numerous locations, with WRL having recent experience with projects at New Brighton Beach (near Byron Bay, NSW) and Roches Beach (Lauderdale, Tasmania). Survey profiles of the entire beach and detailed volumetric analysis of available sand reserves would be required to plan such a project, as well as consideration of environmental aspects of the process. Typically only a very shallow portion of sand is taken off the surface of the beach in the borrow area, though this may be able to be more substantial for some areas of Freers Beach. This sand is then used to build beach width over the intertidal zone of the nourishment area, and volume permitting, also rebuild a back beach dune.

While calculation of the exact littoral drift sediment transport rate along Freers Beach is beyond the scope of this project, it is expected to be substantial enough to reduce the effectiveness of any nourishment sand placed over the north-western end of the beach, unless additional structures are built to retain the sand. This is typically facilitated through the construction of groynes across the beach, which to a certain degree have already been established through the armouring of the stormwater outlets at (3), (4), and (6). The rock armouring of the groynes at locations (3) and (4) could be extended by a suitable distance to retain the nourished sand. As a guide, the groyne at location (6) is approximately 75 m long and has created a beach that is more than adequate in width. As a trial option the groynes at (3) and (4) could be extended from 15 – 20 m length to being 30 – 40 m length.

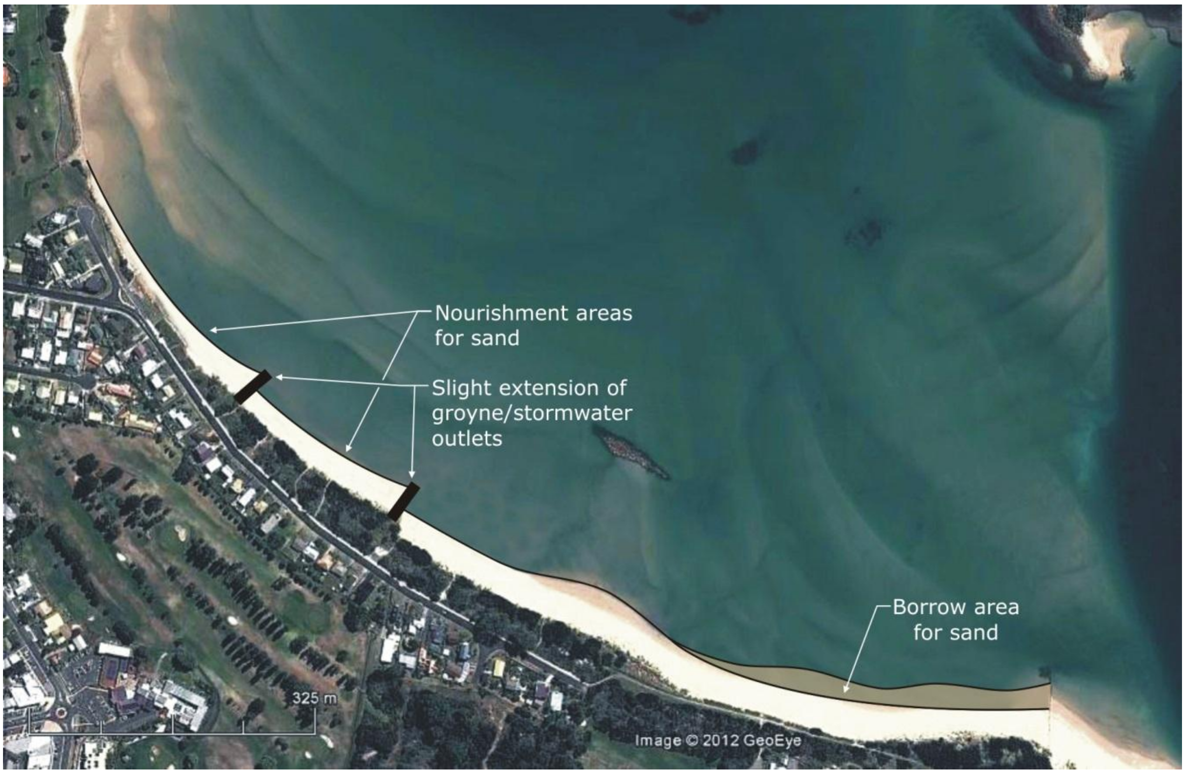


Figure 20: Schematic of Conceptual Short-Term Strategy

Caution should be taken when establishing the exact length of the groyne extension, as extending the structures too far seaward will begin to trap additional littoral drift sand on the beach (beyond that placed through beach scraping nourishment), and in the longer term may starve the downdrift sections of beach from a sand supply. This would eventually result in erosion of the beach at the south-eastern end of the embayment. It is recommended that the groynes only be extended to the distance required to retain the nourishment sand, so that the compartments between the groynes are "pre-filled" and additional littoral drift sand is not captured.

5.2 Long-Term Strategy

The exact details of a long-term strategy should take into consideration the response of the beach to the short-term strategy discussed in Section 5.1. Nevertheless there are several combinations of conceptual management works that could be undertaken to reduce the impacts of beach erosion over the long-term.

If the short-term strategy is able to produce a suitable and stable beach around the embayment, then the recommended long-term management strategy would be to:

- Scrape small quantities of sand from the intertidal zone and build a dune over the back beach revetment, likely through multiple scraping campaigns over several years to a decade;
- Revegetate the established dune;
- Continue to monitor the long term behaviour of the beach through aerial photography and profile surveys;

Cost for this long-term strategy would be relatively low, likely of the order of $20,000 if community groups are involved for the dune management aspects.

If the short-term strategy is unable to produce a suitable and stable beach around the embayment, then depending on the results of the beach monitoring the second recommended long-term strategy would be to:

- Further extend existing groynes at locations (3) and (4) to be similar in length to that at (6);
- Add another groyne if required at (1);
- Continue to monitor the long term behaviour of the beach through aerial photography and profile surveys;

Or the third option to:

- Construct offshore breakwaters like (5) along the north-western section of the embayment, for example at locations (1A) and (3);
- Shift sand from salients that develop in the lee of the breakwaters to build a dune over the back beach revetment and to create a uniform width beach;
- Revegetate the established dune;
- Continue to monitor the long term behaviour of the beach through aerial photography and profile surveys.

The second and third long-term management options are shown schematically in Figure 21 and Figure 22 on the following page. It is expected that the second option could be implemented for a cost of the order of $220,000, while the cost of the third option would be of the order of $420,000.

Typically beach management strategies that involve augmentation of the beach and protection structures are facilitated through the construction of trial structures and monitoring of their performance, as exact prediction of beach response is complex and can be unreliable. In this case existing structures on the beach such as the groynes/stormwater outlets at (3), (4), and (6) as well as the offshore breakwater at (5) are all considered as trial structures. It is clearly evident from aerial photography in Appendix 2 that some of these structures are successful at retaining sand on the beach.

Design of offshore breakwaters for widening a beach has been reasonably well studied, with several methods available for predicting beach response. In this case, the existing breakwater at (5) could be used to verify these methods for specific application of designing additional structures at the site. Caution should be taken if multiple structures are to be installed along the north-western section of the embayment, as while the structures will block wave energy from the beach they may also block the onshore migration of sediment from sand shoals in the estuary, and may therefore create further sediment supply and erosion problems. This would require more detailed consideration of the sediment transport processes at the site, but is still considered a viable conceptual long-term solution that could be investigated.

Figure 21: Schematic of Second Conceptual Long-Term Strategy

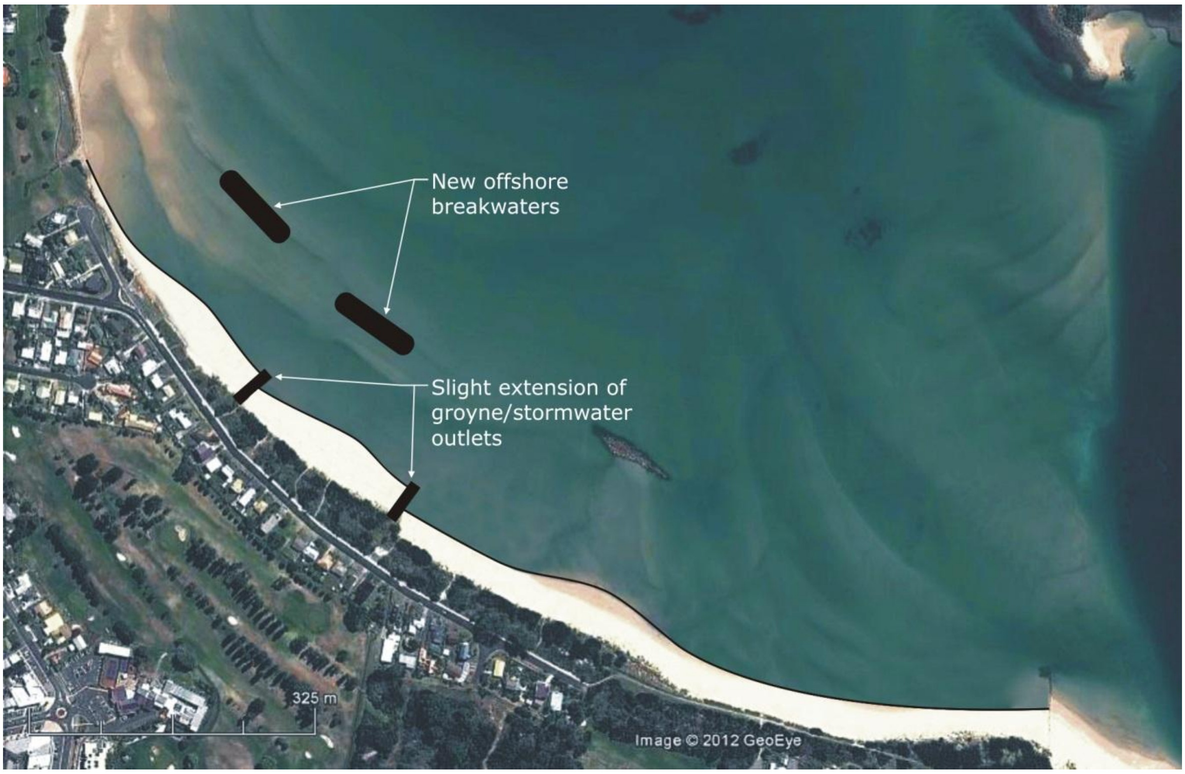


Figure 22: Schematic of Third Conceptual Long-Term Strategy

5.3 Emergency Protection Strategy – The Last Resort

While the beach is in an eroded state at present, few significant public or private assets appear to be in immediate danger of coastal erosion, with the emergency protection works previously constructed at the end of Freer Street providing protection to the sewer pump station that would otherwise be vulnerable. It is expected that with time the beach will naturally recover at least partially, though this may take several years and erosion may worsen prior to recovery. Ideally the beach would be left to recover naturally, or recover through the combination of short and long-term strategies discussed in Sections 5.1 and 5.2. Nevertheless Council is advised to prepare designs and plans for installation of emergency protection works should they be required. Non-planned emergency coastal protection has been widely seen to have long-term negative impacts on beaches around Australia. If emergency protection works are well thought out and appropriate materials are stockpiled, there is no reason why the works cannot become a permanent well engineered final line of defence against coastal erosion.

As revetments have already been constructed at the back of much of Freers Beach, establishing a design for a continuous emergency protection revetment is advised. This is expected to involve further assessment of the location, alignment, and details of existing sections of structure in order to plan for additional sections of structure to be integrated. When planning the new sections of revetment, aspects that should be taken into consideration include (but are not limited to):

- Community consultation and beach/foreshore uses;
- Achieving a uniform and smooth plan alignment;
- Minimising abrupt changes in alignment or structure details (crest level, toe level, slope);
- Cross section design for different stretches of the beach;
- Beach access ways through the revetment;
- Alignment that maximises future opportunity for the beach to recover seaward of structure, and that will allow the terminal revetment to be buried within a vegetated dune if possible;
- Location of key infrastructure or property to be protected;
- Long-term beach regeneration plan, which may offer protection from wave attack through additional offshore breakwaters and/or a sandy beach buffer.

Preliminary guidance on structure design aspects for the emergency protection revetment are included in Section 5.4. A well thought out coastal management strategy would see armour materials stockpiled for implementing the short and long-term strategies (Sections 5.1 and 5.2), with the opportunity to use the material at short notice for constructing sections of emergency protection revetment in the interim if required. The goal should, however, remain to re-establish the beach as an erosion buffer through implementation of appropriate management strategies, with the installation of permanent terminal protection structures only used as a last resort and as minimal as possible.

5.4 Design Aspects for Coastal Structures at Freers Beach

Using the wave climate information presented in Section 2.2.1 and the design water levels in Section 2.2.3, WRL have made preliminary estimates of the nearshore wave climate along the exposed sections of Freers Beach using the method of Goda (2007). Based on these calculations, coastal engineering rules of thumb, and experience, a range of recommendations have been made for key coastal structure design parameters. These estimates are based on a simplistic approach (restricted to available budget and time), nevertheless are expected to be conservative and provide a guide to Council for planning and costing various types of structures and management approaches. It is expected that more detailed design analysis would be required to produce more efficient structure designs, and to take into consideration a wider range of design criteria.

Calculations undertaken by WRL to establish design criteria include the best practice desktop assessment methods of:

- Nearshore wave height estimates using Goda (2007);
- Armour size estimates using the Hudson equation (SPM, 1984);
- Armour grading ranges using CIRIA (2007);
- Overtopping calculations and crest levels using Eurotop Overtopping Manual (2007);
- Offshore breakwater calculations using Burcharth et al. (2007).

Calculations for approximate cost estimates undertaken by WRL were based on:

- Recent experience with coastal structure conceptual designs in NSW;
- Costs advised by Latrobe Council for construction of emergency protection works at end of Freer Street;
- Quote estimates provided by a local quarry operator.

The unit rates used for WRL's cost estimates and sources for the information are summarised in Table 5.1. It should be noted that the adopted cost rates and cost estimates made for the various management options are not highly accurate, and are only intended to provide a guide to Council for the expected order-of-magnitude of costs.

Table 5.1: Cost Rates Used for WRL's Cost Estimates

Item	Rate	Source
Estimated Cost Rates		
Delivered and Placed Armour	$55/Tonne	Latrobe Council for Emergency Protection at Freer St
Delivered Armour	$20/Tonne	Estimate from Local Quarry Operator
Delivered Armour	$45/Tonne	Estimate from NSW Quarry for Similar Haulage Distance
Delivered Armour	$40/Tonne	Estimate from NSW Quarry for Similar Haulage Distance
Armour Placement	$15/Tonne	Previous Experience
Geotextile Supply	$7/m^2	Previous Quote from Supplier
Geotextile Placement	$10/m^2	Previous Quote from Supplier
Sand Earthworks	$2/m^3	Estimate from Construction Guide
Adopted Cost Rates		
Delivered Armour	$40/Tonne	
Armour Placement	$15/Tonne	
Geotextile Supply	$7/m^2	
Geotextile Placement	$10/m^2	
Sand Earthworks	$2/m^3	

For cross shore groyne structures implemented as extensions on the existing stormwater outlet armouring, the following approximate design values can be used as an initial guide:

- Rock armour size: 1500 to 4500 kg, with median 3000 kg;
- Crest level: Approximately 1.8 m AHD, or similar to existing structures;
- Cost: Approximately $2,000 per linear metre (not including stormwater drainage).

Figure 23 shows a cross-section drawing of a conceptual groyne structure.

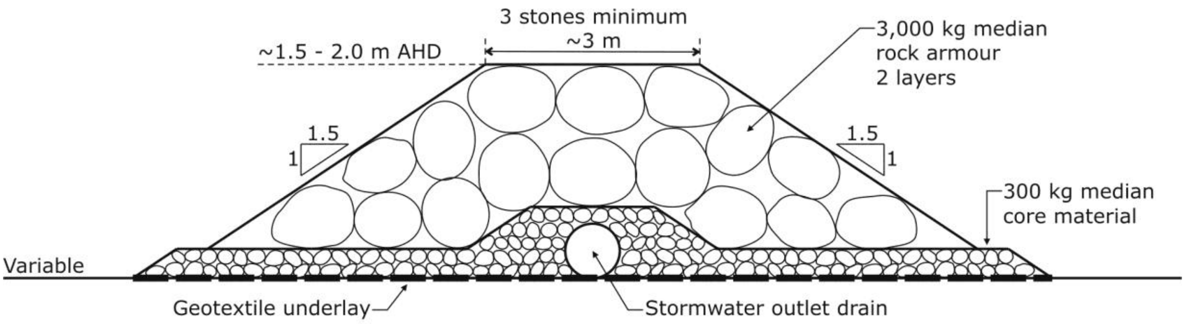


Figure 23: Conceptual Rock Groyne Cross-Section

For offshore breakwater structures the following approximate design values can be used as an initial guide:

- Rock armour size: 1700 kg to 5300 kg, with median 3500 kg;
- Ratio of breakwater length to distance from beach: 0.5 to 0.67 (similar to existing structure);
- Spacing between breakwaters: 65 m minimum, 80% of breakwater length maximum;
- Crest level: Approximately 1.8 m AHD;
- Crest width: Approximately three armour stones minimum;
- Side slopes: 1V:1.5H;
- Cost: Approximately $2,000 per linear metre.

Figure 24 shows a cross-section drawing for a conceptual offshore breakwater structure.

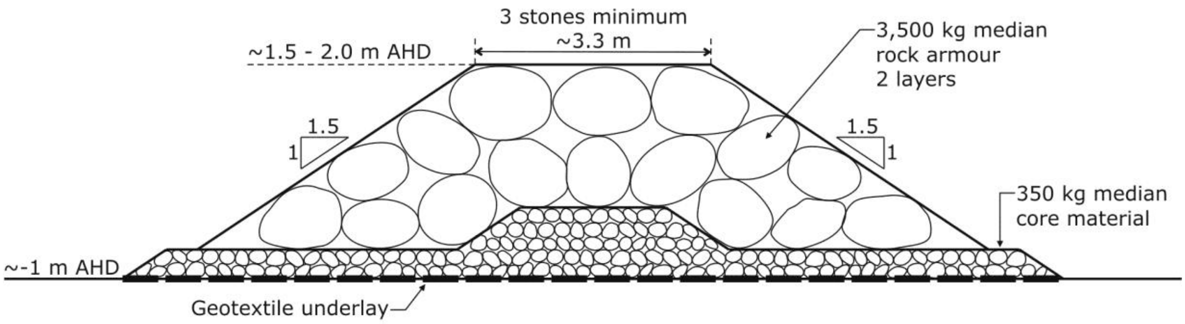


Figure 24: Conceptual Offshore Breakwater Cross-Section

For a terminal revetment structure at the back of the beach the following approximate design values can be used as an initial guide:

- Rock armour size: 1500 kg to 4500 kg, with median 3000 kg;
- Crest level: 5 m AHD to 5.5 m AHD if possible, no less than 4.5 m AHD;
- Toe level: -0.5 m AHD to -1.0 m AHD;
- Slope: No steeper than 1V:1.5H;
- Two layer thickness of rock armour minimum;
- Cost: Approximately $2,200 per linear metre.

While it is understood that the existing emergency protection revetment constructed at the end of Freer Street cost only approximately $1,000 per metre, it had an approximate height of only 3 m, in comparison to the conceptual design specified above which has a height of 6 m. Figure 25 shows a cross-section for a conceptual emergency protection terminal revetment structure.

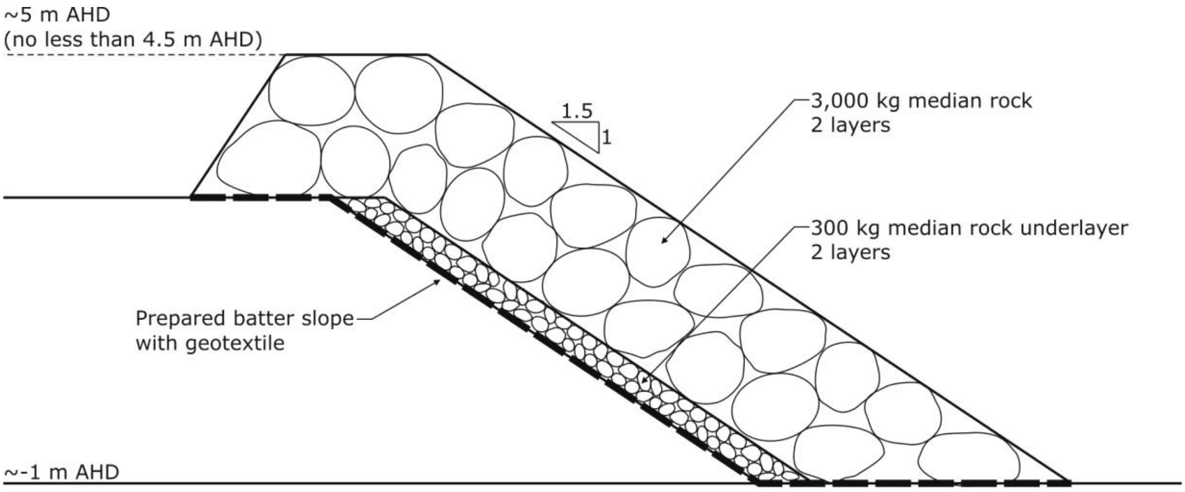


Figure 25: Conceptual Emergency Protection Terminal Revetment Cross-Section

All rock armouring should be of igneous rock type with density of at least 2,600 kg/m^3. It is understood that the Hazell Bros Long Hill quarry produces dolerite of suitable size and with density of 2,900 kg/m^3, which would likely be very good for coastal structure armour material. If the existing stormwater outlet armour protection is to be extended to act more like groynes (as recommended in the short-term management strategy), then consideration should be given to also extending the stormwater drainage pipes within the groynes. While there is no need to extend the drainage pipes from a coastal structure perspective (stormwater flows would be too low to dislodge armour stones and could simply discharge through gaps amongst the rock armour), eventual build-up of the beach against/within the groyne may block the drains and create future stormwater drainage issues.

6. Advice Regarding Community Submission

As well as providing advice for coastal protection and climate change adaptation, WRL were also asked to provide brief feedback regarding the submission to Council titled "Private Proposal for Amelioration of Flood Risk and Beach Erosion in Port Sorell". This submission is included as Appendix 3 of this report, and addresses the proposal to close off the 1.9 km wide entrance to the Rubicon Estuary with a rock armoured seawall constructed in numerous stages.

WRL have considered the various aspects of the proposal in this submission, and make the following key observations with regards to coastal and estuarine engineering aspects:

- The seafloor at the proposed seawall location is approximately -5 m AHD, and to resist wave overtopping the structure would have to have a crest level of at least +6 m AHD, giving a total overall structure height of at least 11 m.

- The structure would be exposed to open Bass Straight waves, and would therefore have to be armoured against waves with height in excess of 4 m (significant wave height). This would require rock armouring with individual pieces weighing of the order of 10 to 20 tonnes which could not be quarried in sufficient quantity to armour 1.9 km of structure. Precast concrete armour units could be utilised but would be excessively expensive.

- Constricting the entrance of the estuary during the process of construction (proposed to be over decades), will likely significantly alter the tidal dynamics of the entire estuary, which would in turn have significant impacts on tidal water level fluctuations, currents, sediment transport, and most importantly estuarine ecology. Rubicon Estuary has been listed as an Important Bird Area (IBA), in particular for wader species, and the proposal would destroy all intertidal habitat for such species. The proposal would also potentially significantly alter or destroy habitat for an entire estuarine ecosystem.

- Designing a lock system which could cope with freshwater flood flows would be a significant engineering project in its own right.

- Designing protection works of this scope would require numerous engineering, environmental, and social studies to be undertaken, which would all require a significant amount of environmental data collection to be completed. Such studies and data collection would take of the order of five years to be completed, and would be expected to cost in the order of one to two million dollars. Even with the completion of such studies, it is likely that the proposal would be rejected on environmental grounds alone.

While examples of "similar" structures are presented in the proposal, it is worth noting that there are important aspects differentiating each case from the entrance to the Rubicon Estuary. Such differences include:

- Structures located in enclosed water bodies, so smaller wave climate (Sorell Causeway);
- Structures are not across or blocking major tidal estuaries (Dunkirk, Herklion, Nice).

7. Conclusions

WRL have undertaken a field and desktop assessment of the Shearwater and Port Sorell area with regards to the following tasks:

1. Brief review of the coastal processes;
2. Review of the possible options to improve the existing erosion protection assets and possible options to protect and augment sand on the beach for future conditions;
3. Feedback on the "Private Proposal for Amelioration of Flood Risk & Beach Erosion in Port Sorell" provided to the Latrobe Council.

WRL's analysis was based only on observations and previous photos of the site, experience, and simple desktop coastal engineering calculations, with the aim of providing information to assist Latrobe Council to:

- Further understand the basic coastal processes at the site with regards to coastal erosion;
- Develop a long-term strategy for limiting or reversing beach recession in the area;
- Develop a short-term/emergency protection strategy for containing coastal erosion;
- Understand key parameters for various types of coastal structures for present day, and how they should be adapted for future scenarios.

In summary, WRL have recommended a range of strategies to recover the north-western section of Freers Beach from recent erosion, which can be implemented in both the short and long term. An emergency protection strategy was also recommended as a last line of defence, should the risk to significant assets or property increase. Key structural parameters of each type of structure have also been estimated to assist Council with further planning and costing of coastal management strategies.

8. References

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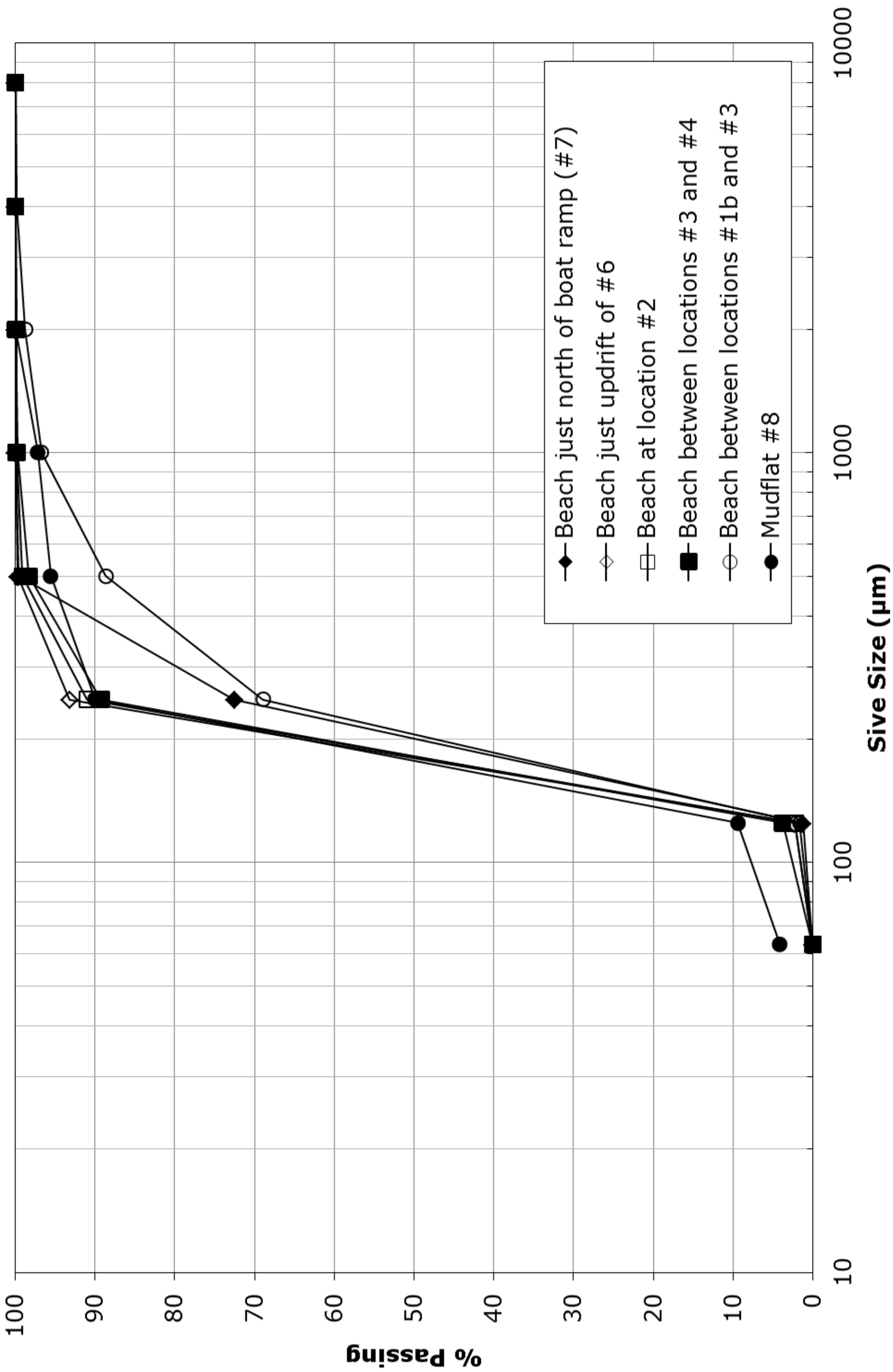
Appendix 1: Sediment Size Analysis



Appendix 2: Historical Aerial Images

Circa 1990?

1994

2000

2006

2010

2011

Appendix 3: Private Proposal for Review

Tasmanian Coastal Adaptation Pathways

PRIVATE PROPOSAL FOR AMELIORATION OF FLOOD RISK & BEACH EROSION IN PORT SORELL

SUMMARY

The authors of this proposal participated in level 3 discussions (19 May) following the presentation of TCAP for Port Sorell on 10 May 2012 where they advocated works at the mouth of the Rubicon Bay, in the form of a Sea Wall (S.W.) to control the impact of Sea Level Rise (SLR).
This proposal details a series of works in gradual increments over many years which will enhance the amenity of Port Sorell at every stage and provide an option to fully counter SLR in Rubicon Bay and adjacent habitation for the long term, whist enhancing the amenity of the estuary as follows:

1. Re-instating the stone wall fish traps which are of aboriginal origin and enhanced in the 1870's by Major Dumbleton providing a unique and popular tidal attraction until the Latrobe Council, in order to offset shoreline erosion, removed significant quantities of rocks from the Fish Trap outcrop in the 1960s. Having recognised the damage done subsequently loads of conglomerate boulders from Dooley's Hill were roughly and ineffectively placed along the walls in a gesture to redress the loss.
2. Creating a recreational safe harbour for private craft much needed along the N.W Coast and the possibility of a secure marina.
3. The Sea Wall would provide an excellent promenade and rock fishing opportunity.
4. Eventually the full S.W. could provide direct walking and bicycle access to the National Park much called for by the Shearwater Community.
5. Infrastructure for the installation of a tidal power generation plant.
6. Incorporation of boat ramps

Detailed engineering is not provided.

GENERAL CONSIDERATIONS

The Problem

Major damage and inundations occur as a result of the furious N.E. Storms, coinciding with high tides and rivers in spate. The coastal morphology sweeps driving seas along Bakers Beach until they encounter the obstruction of Wilson's Point, a typical water funnel with the opening stretching across Bakers Beach from West Head to Point Sorell with Rubicon Bay as the stem, forcing water up the Rubicon Estuary where it encounters the fresh water coming down the flooded Rubicon and Franklin rivers, Green's Creek and Panatana Rivulet.
(It is not as pronounced a funnel as eg the mouth of the Severn near Bristol. See also Footnote 1, p2)
This is causing coastal erosion in Shearwater and Port Sorell and flooding in some residential areas.

Due to SLR these events are expected to exacerbate with time.

The Proposal

Stage One seeks to cut off this funnel by building a rock sea-wall working from Griffith's Point and Hawley concurrently or alternatingly.

Griffiths Point, Strengthen existing rock breakwater by extending it above storm high water mark using rock available on site (refer Figs 1a,b and 2a,b).
This would also provide a location for fishing and assist boat traffic in and out of the Bay.

Hawley Beach From Larooma Park Point, reinstate the rock sea wall of Fish Trap Rocks, and the Fish Trap proper. Then continue along the spine of the Fish Trap rocks to the rock outcrop midway to the Major's Rocks (Figs 1a,b and 3). Ample rock reserves remain along the coastal strip North of this proposed wall to Shell Grit Beach, the removal of which would enhance the inter-littoral zone, now largely unsuitable for recreational purposes. Much of this work can be done by excavator by gradually extending the Sea Wall construction above high tide following the tidal rhythm.

Completion of Stage One with these two sea-wall sections would reduce the opening of Rubicon Bay to less than 1km (0.9km shown in Fig 1a,b).

Stage Two

Involves step-wise Sea-Wall construction across the mouth of Rubicon Bay, as required, building on the initial two sections and responding to the rate of Sea Level Rise experienced and the availability of funds.

Stage Three

Closure of the mouth of Rubicon Bay perhaps by the end of this century or later by fully joining the two sea wall sections (Stage 1). A lock in this section would allow vessels in and out at all tidal conditions. A tidal power generation plant could be considered at this stage, drawing power from over 10 square kilometres of tidal estuary .

The completed Sea-Wall would serve for hundreds of years but completion is not relevant for the present. Awareness of the 3 stages offered by this proposal is necessary from the start.

The gradual 3-Stage approach provides a long term efficient solution to counter SLR and enables costs to be born incrementally by successive ratepayers as the need arises. Not only could the expense be amortised over an extended period, but by having a defined project, this will facilitate application for State and Federal government assistance which will inevitably become available as the crisis evolves.

1) In the North Sea, funnel action between the UK and the Continent was the cause for the massive inundations in early 1953 that caused major damage along all lower North Sea Coasts and high loss of life in Holland.

The emergency resulted from a powerful NW storm coinciding with a pronounced spring tide.

BACKGROUND- examples from elsewhere

There seems to be a prejudice that the construction of works into the sea has to be massively expensive and difficult. In practice such works have been undertaking in many places such as the Sorell Causeway in Pitt Water around Midway Point Sth Tasmania. In Europe building sea-walls/dikes goes back a long time in history (Footnote 2). Indeed many if not most ports incorporate a sea wall of some dimension.

Six examples of sea-walls are briefly illustrated below.

1) South Tasmania, Sorell Causeway across Pitt Water. Judging by the colours provided by Google, depths there are similar to depths at the mouth of Rubicon Bay. (Fig 5)
2) Humber mouth dam. (Fig 6) This dam is about 5km long and reduces the opening of the Humber mouth by about half. The lands adjacent to the Humber Bay were badly hit in 1953. Note the funnel formed by the Humber mouth, without this dam.
   One of the authors believes this dam was constructed to mitigate 1953 type circumstances.
3) Causeway to a small island in Denmark. About 0.9km long and close to what would be required here later this century. Two images show the view from above and on the ground. (Figs 7a & 7b). Construction would seem harder to justify economically than the proposed protection at the mouth of Rubicon Bay. Note camping along this causeway. It is fully part of the local landscape.
4) Dunkirk Harbour. Harbour protection walls. (Fig 8.)
5) Heraklion Harbour. Harbour protection walls; in part very old. (Fig 9)
6) Nice Harbour (France, Provence). Harbour protection walls. The long white lines show ferry routes. (Fig 10)

(No Dutch examples. The softness of the often peaty ground adds considerable complications and the absence of local rock adds cost. Furthermore the crucial importance of sea defences in Holland dictates high dependability, a condition that would only begin to apply here once SLR reaches beyond 0.9m.)

FURTHER CONSIDERATIONS FOR GRIFFITH POINT CONSTRUCT.

Additional rock for this 0.8-1km sea-wall could come from the quartzite quarry south of the Narawntapu Park. The existing rock shelf provides a very sound foundation. Photographs are attached that show the rock shelf North of Griffith Point is exposed at Low Tide. (Figs 2a&b). Actual construction can be done intermittently over a period of 10-20 years.

This part of the sea-wall would need to be wide and strong enough to carry a truck.

For the exterior finish the wall probably needs to be armoured with large rock or concrete on the Eastern side to withstand wave action. On the Western side this section is protected by the Point Sorell peninsula. The authors consider it likely that sand would rapidly accumulate on the Eastern (Bakers Beach) side of this sea-wall and provide a new section to Bakers Beach. If this build-up would be really quick it could be possible to reduce the hardening of this sea-wall with large rocks, since the sand would take over that function. This can be experimentally established by initially building say 100-200m of this sea-wall, continuing in later years with further say 200m sections.

The authors of this proposal believe this sea-wall would not interfere with the vegetation or animals of the Narawntapu National Park. On the contrary it will start to protect the low lying paddocks on the South side of the Park where much wildlife grazes.

Footnote 2) Simple low & cheap sea dikes have extended the coast of Frisia over many years and by kilometres by capturing mud and sand sediment at high tide. Once the surface inside was high enough a new small dike further out was constructed to capture more sediment, etc.

FURTHER CONSIDERATION FOR FISH-TRAP ROCKS SEA-WALL

There is little to be added to the proposal above (Stage 1 Fish-Trap Rocks).
Clearly this sea-wall could be extended to Major's Rocks , but this would not significantly narrow the opening of the bay further. Like the Griffith's Pt section construction can take place over 10-20 years.
Restoration of the Fish Trap would provide an interest for locals and visitors alike. The fishtrap part of the sea-wall would need to be porous. It would be made of largish rocks without a fill of small rocks or sand in between.
This section would be very accessible from Hawley and would invite rock fishing all year round.

GRADUAL CLOSURE OF RUBICON BAY

This is of concern only in the more distant future when SLR reaches about 1m.

Partial closure could be considered eg for the purpose of building a Marina behind the Western part of this sea-wall. This Marina could serve the community for hundreds of years and continue to have access to Bass Straight if a lock is constructed in the final sea-wall.

This gradual closure would also depend on the effectiveness of the two sea-walls proposed above. If as intended they reduce NE storm surge in the bay the need for closing the bay would reduce.

It might be sufficient to initially build only say 700m of the final seawall leaving a gap of about 200m for boat traffic. This would maintain salt water in the bay, possibly for decades.

It is expected that ultimately complete closure will be necessary, except for a small lock to allow pleasure craft access to Bass Straight. For a long period excess storm and river water could still be allowed to flow into Bass Straight at low tide, eg through the lock.

CONCLUSION

This proposal has the merit of providing a bold and certain abatement of the effect of SLR for hundreds of years and can be achieved gradually in an incremental manner with mainly incremental costs.

It avoids a piecemeal, ad hoc and expensive response to the inexorable advance of the ocean where money spent one year would be subsumed and lost by future works.

Finally we see this response to an apparently negative scenario resulting in the Rubicon estuary achieving a new level of its recreational potential, ultimately linking the residential precinct to the national park.

We commend Latrobe Council to study our proposal seriously and commit engineering time to it.

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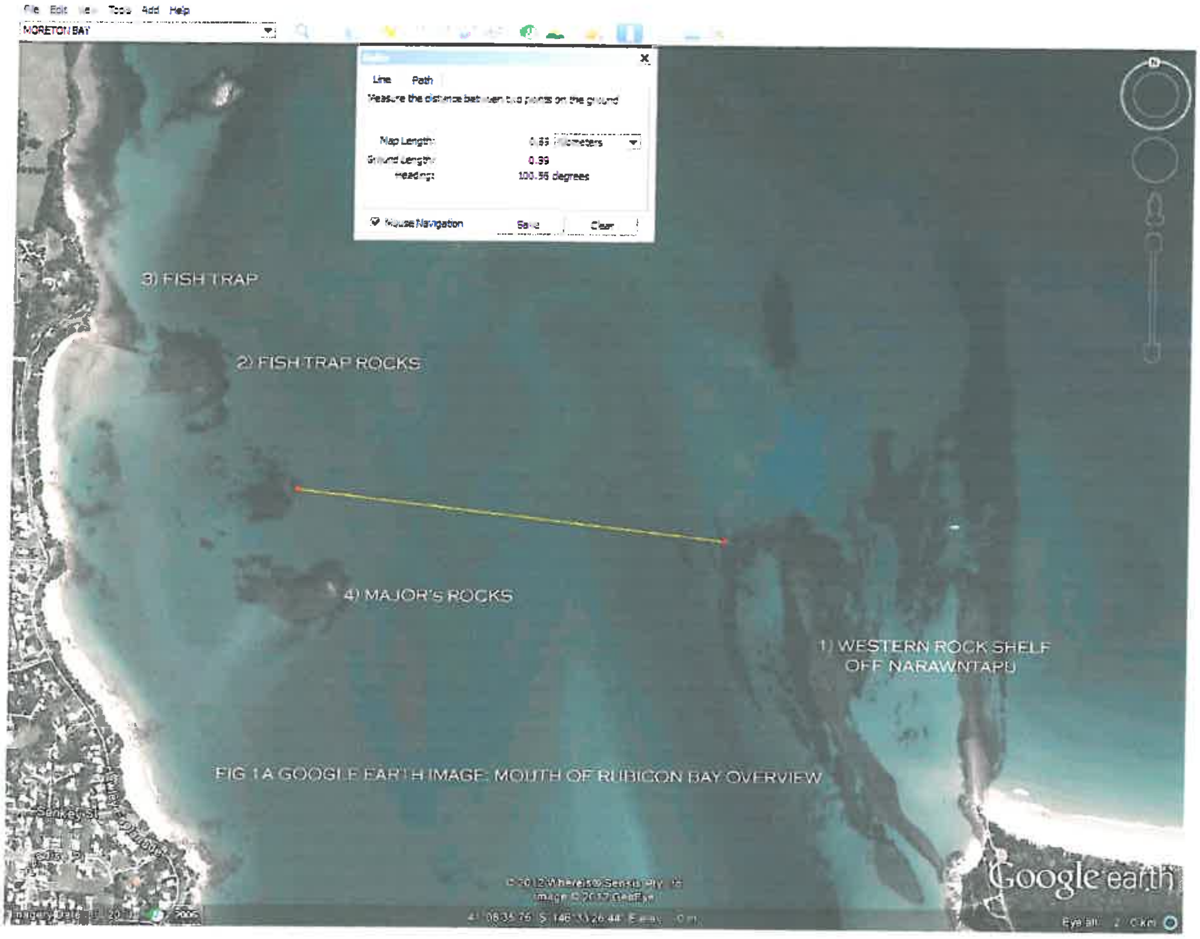

FIG 1A GOOGLE EARTH IMAGE: MOUTH OF RUBICON BAY OVERVIEW

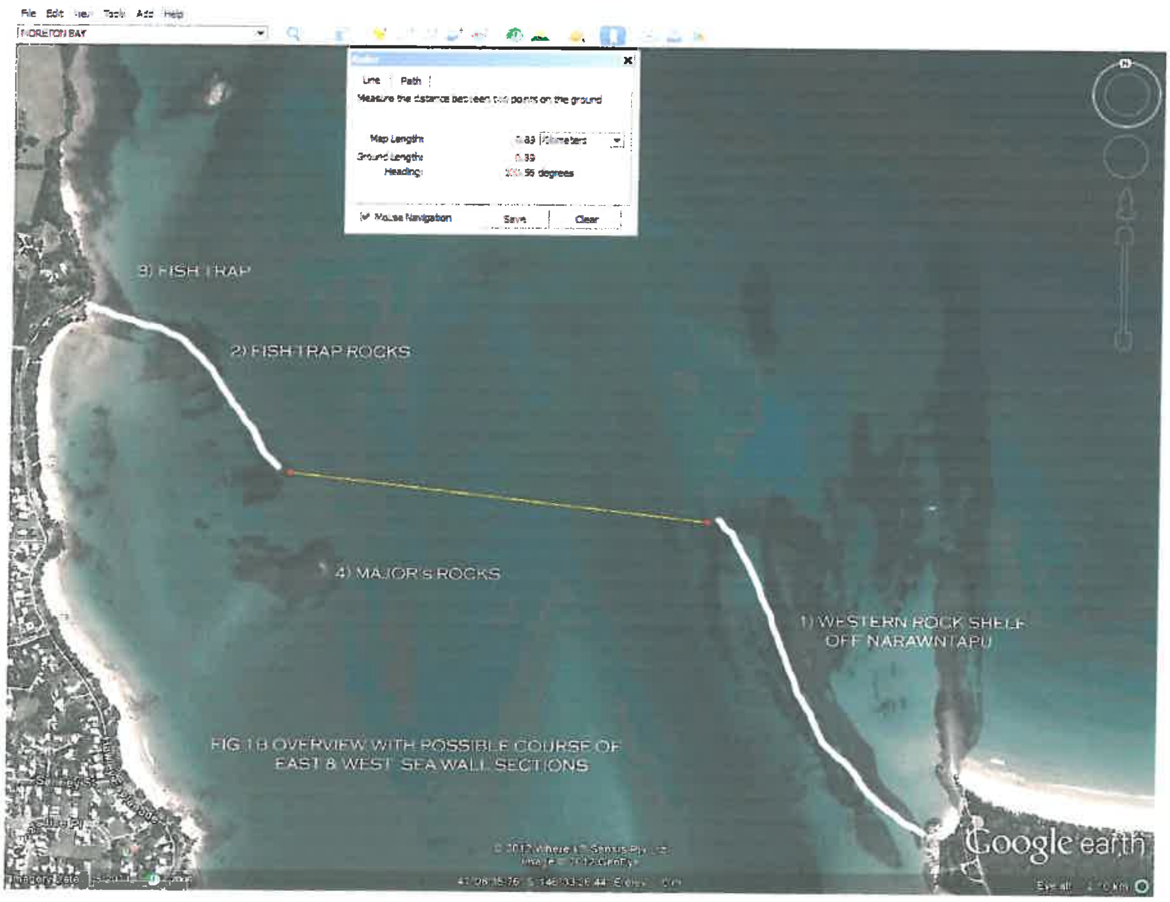

FIG 1B OVERVIEW WITH POSSIBLE COURSE OF EAST & WEST SEA WALL SECTIONS

FIG 2A TWO ROCK SHELVES EXTENDING SEAWARD FROM GRIFFITH POINT

FIG 2B ROCK SHELVES AT GRIFFITH POINT

FIG 3 FISH-TRAP ROCKS (SEEN FROM BAY) WITH FISH-TRAP REMAINDER

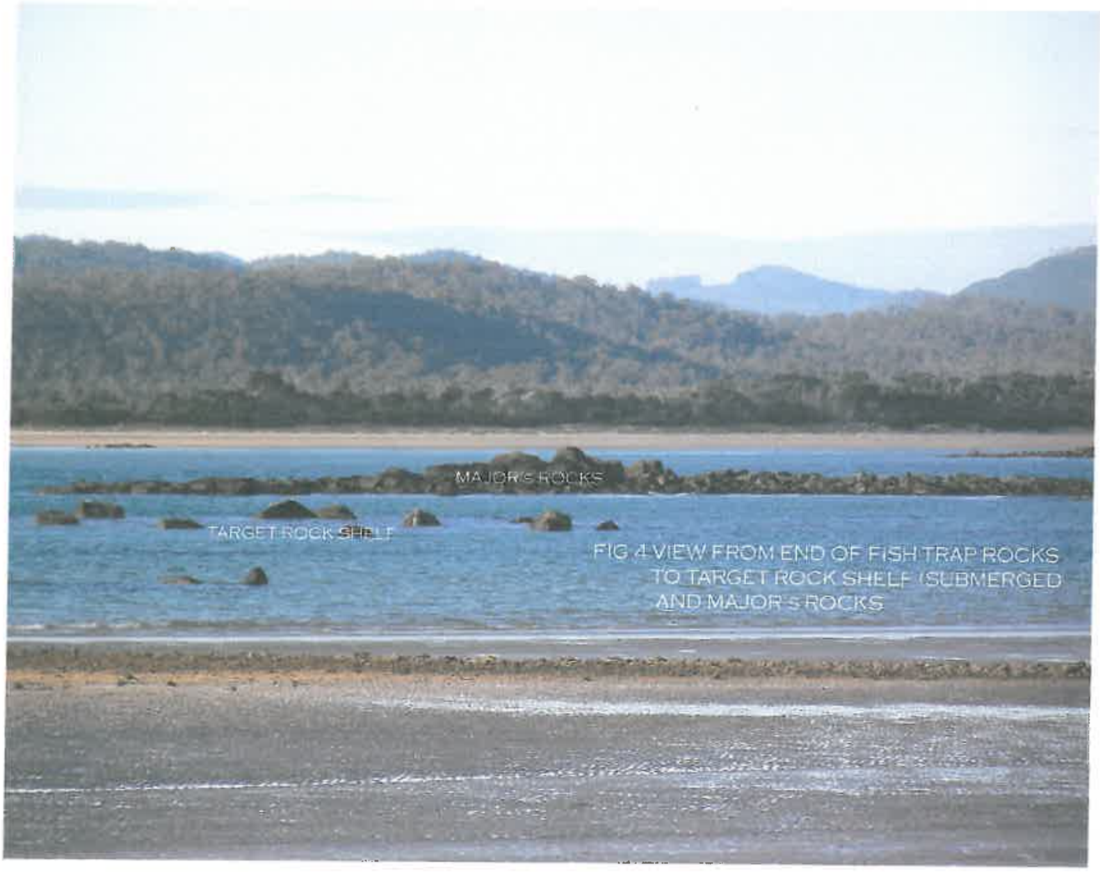

FIG 4 VIEW FROM END OF FISH TRAP ROCKS TO TARGET ROCK SHELF (SUBMERGED AND MAJOR'S ROCKS

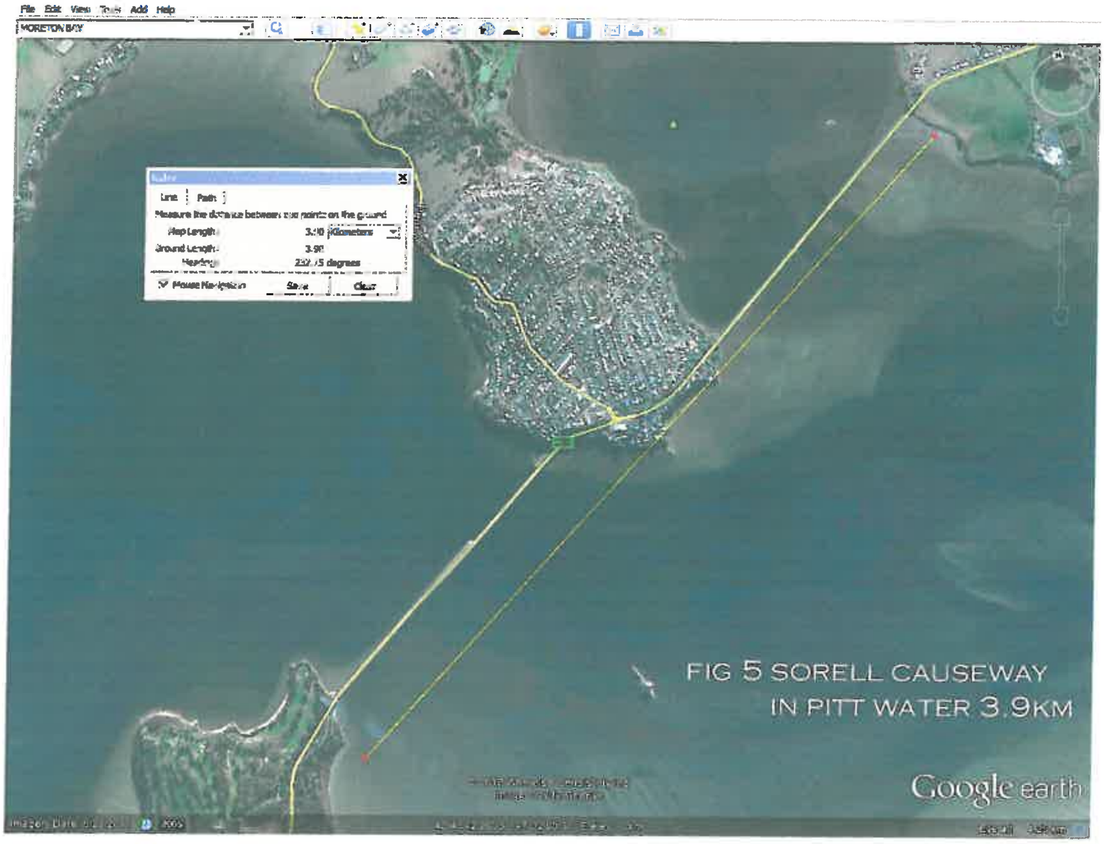

FIG 5 SORELL CAUSEWAY IN PITT WATER 3.9KM

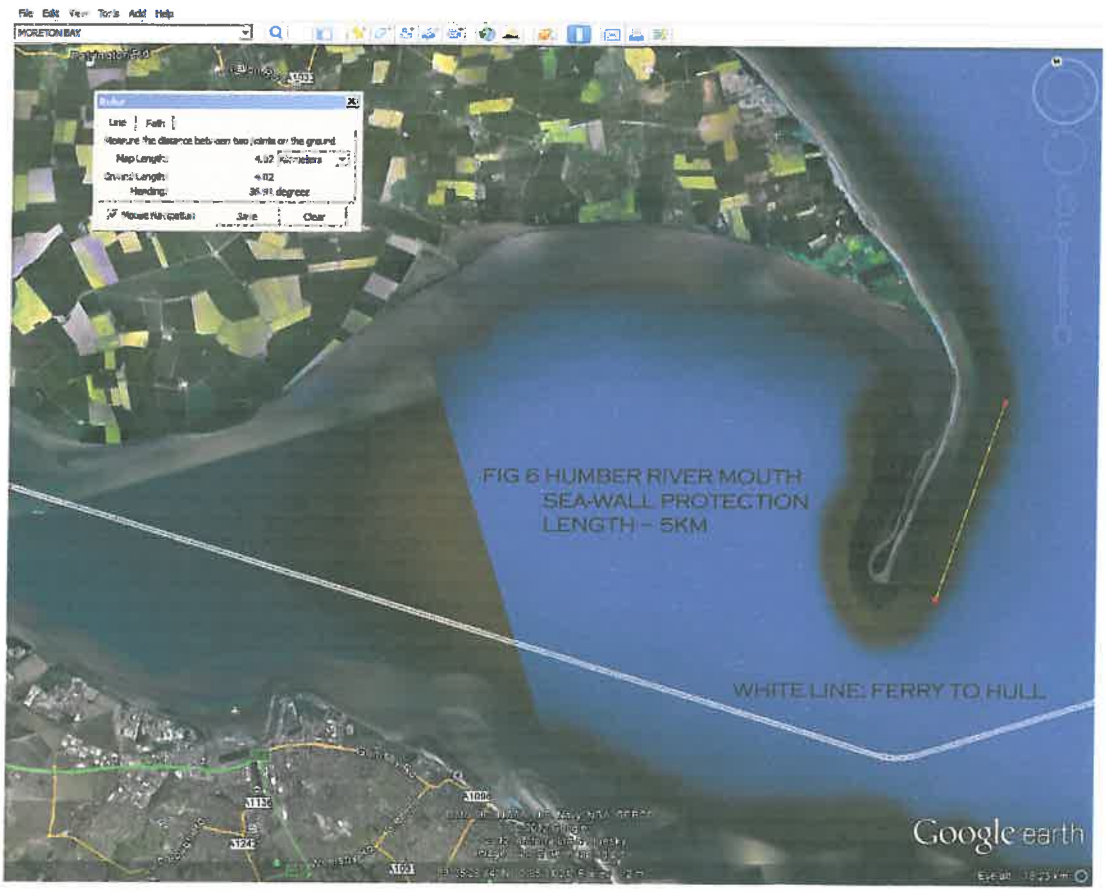

FIG 6 HUMBER RIVER MOUTH SEA-WALL PROTECTION LENGTH ~ 5KM

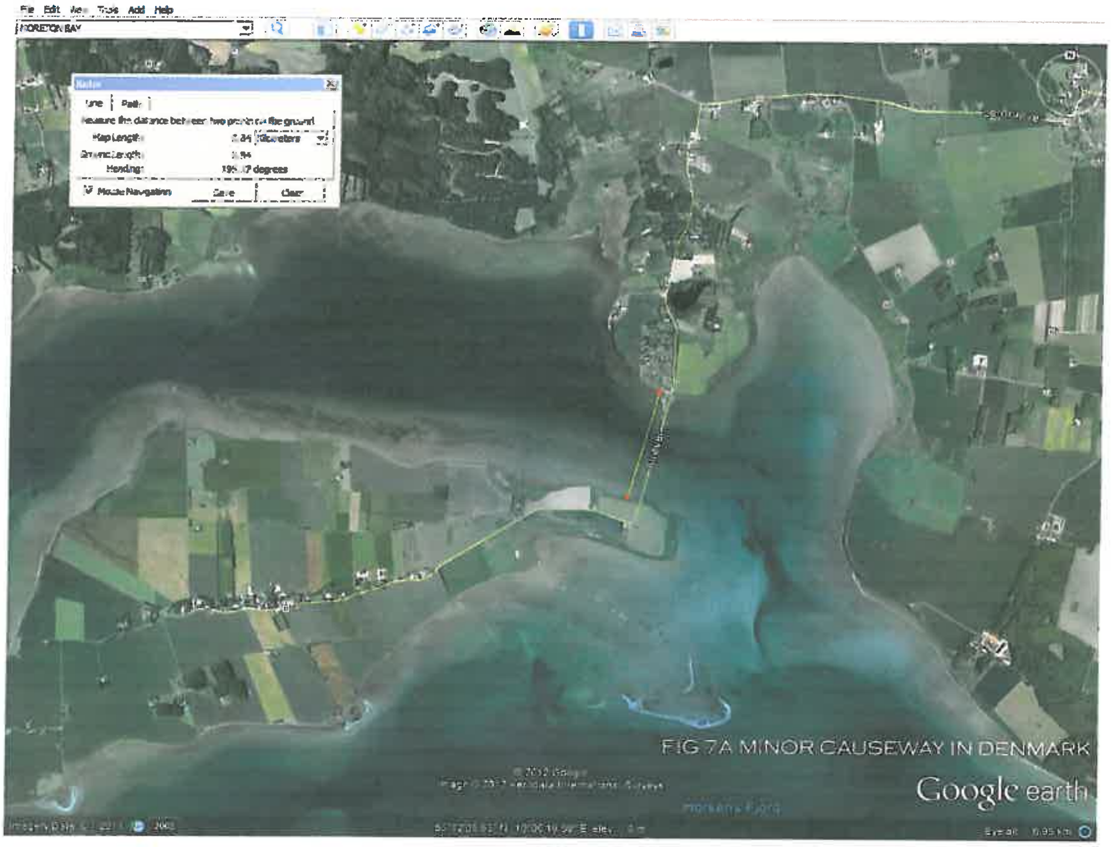

FIG 7A MINOR CAUSEWAY IN DENMARK

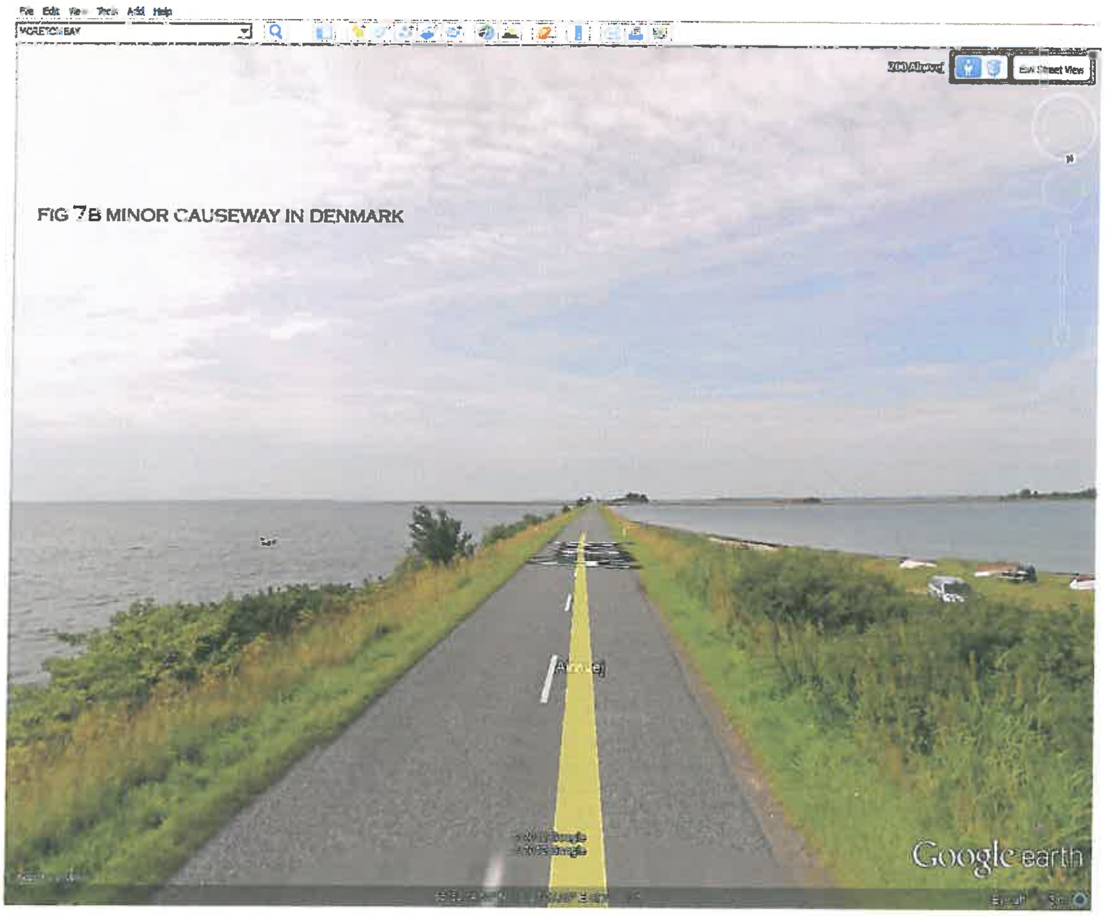

FIG 7B MINOR CAUSEWAY IN DENMARK

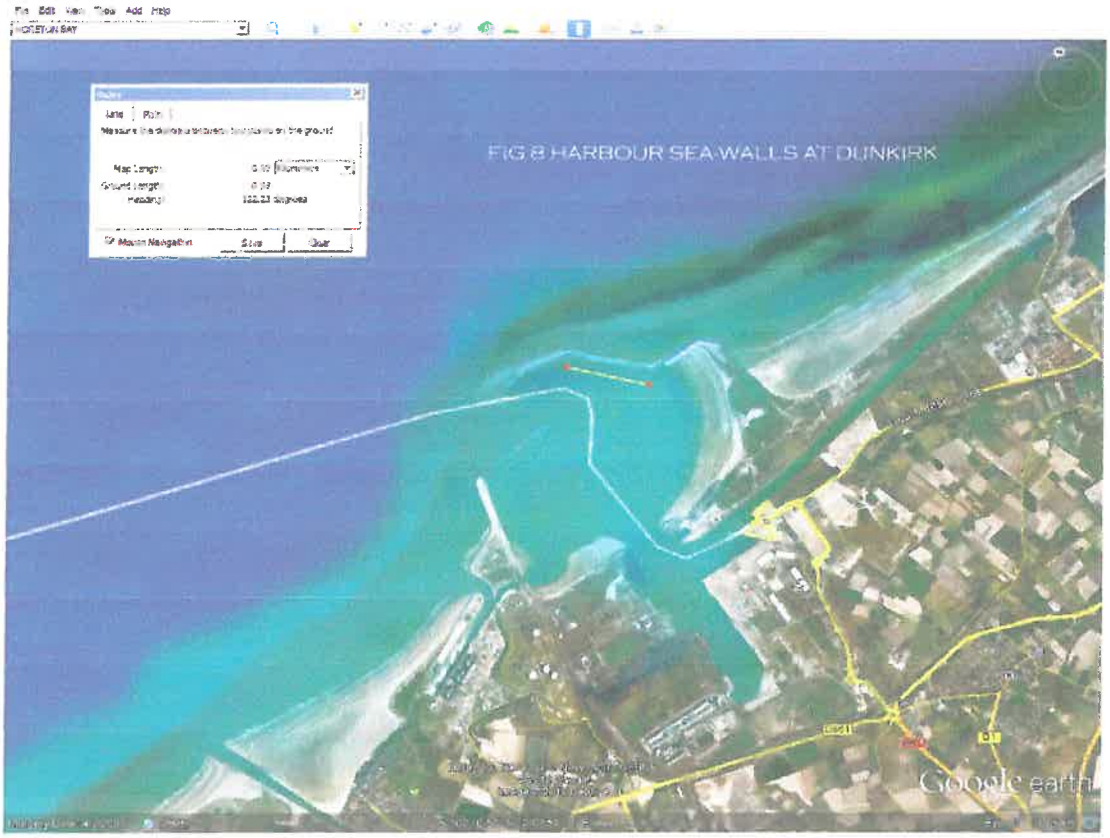

FIG 8 HARBOUR SEA-WALLS AT DUNKIRK

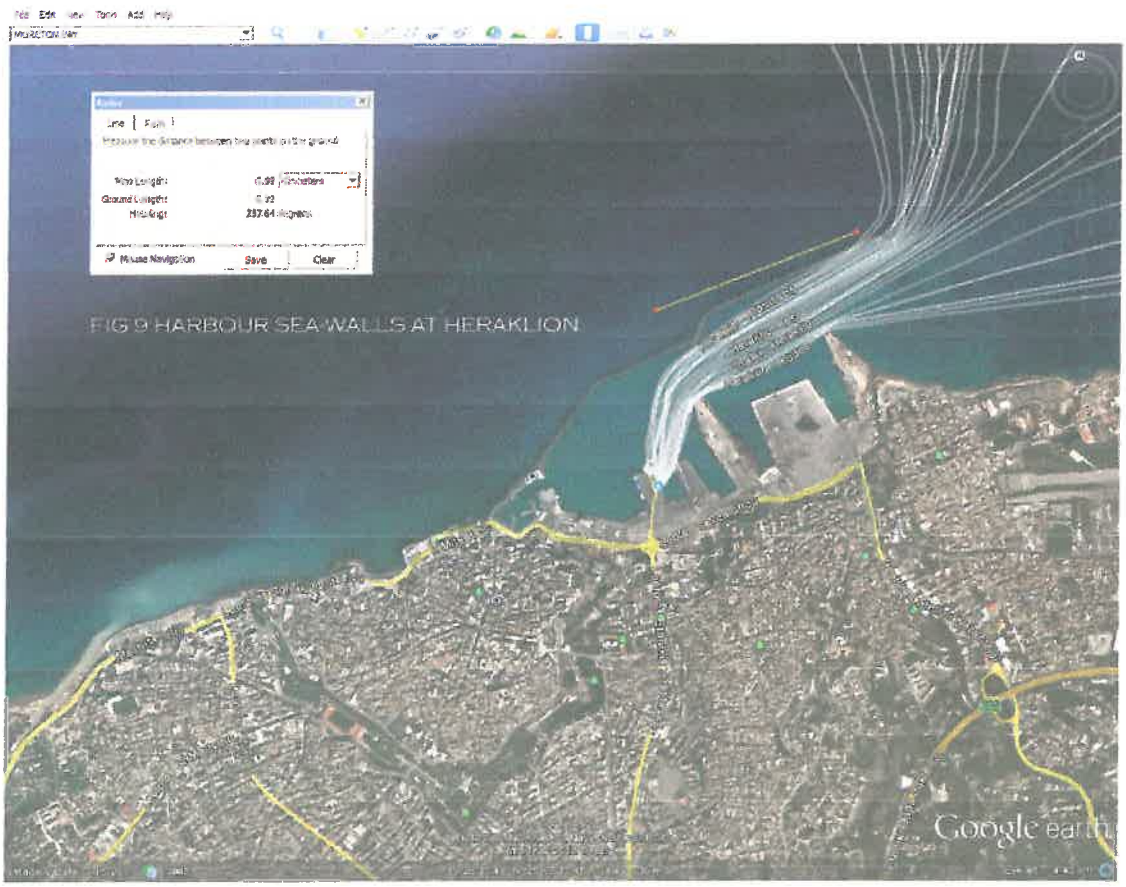

FIG 9 HARBOUR SEA-WALLS AT HERAKLION

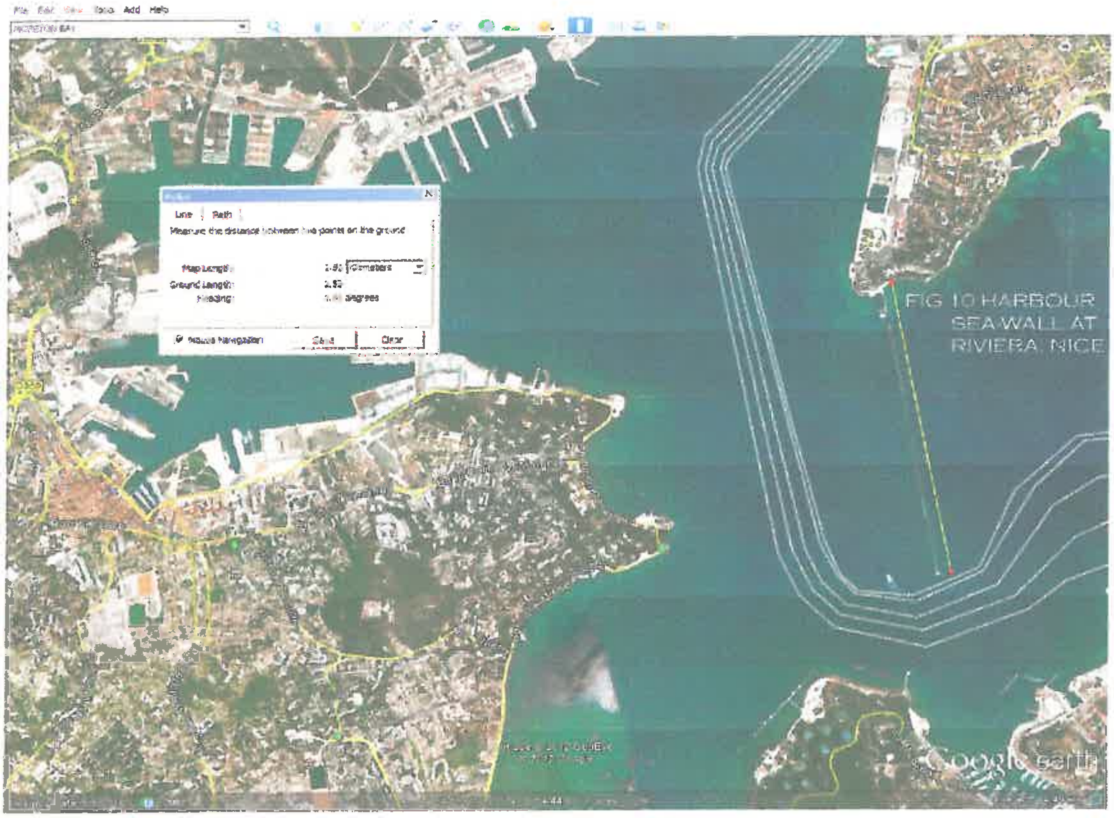

FIG 10 HARBOUR SEA-WALL AT RIVIERA, NICE