APPENDIX A: SUMMARY OF PREVIOUS REPORTS

Summary of Previous reports

Port Stephens / Myall Lakes Estuary Processes Study, MHL (1999)

As part of the Estuary Processes Study for the Port Stephens / Myall Lakes Estuary, the issue of foreshore erosion within the estuary was discussed. The report makes note that fluctuations (erosion – accretion cycles) on unconsolidated shorelines is a natural process, occurring in response to variability in wind, waves and currents, and has been ongoing over geological time scales. However, the positioning of development near to the shoreline has inhibited natural shoreline movement in some regions of the estuary, presenting an erosion issue. Furthermore, attempts to stabilise the shoreline at such locations frequently results in problems at adjacent locations, as the problem is transferred. In other regions of the estuary, natural vegetation such as mangroves has been removed, which has caused exposure and erosion of unconsolidated sedimentary shorelines. We note that all of these processes are relevant to the issue of foreshore erosion in the Pindimar study area.

A description of the geomorphology of the estuary was given in the MHL (1999) study. The eastern section of Port Stephens extends from the harbour mouth at Yacaaba and Tomaree headlands to the bed rock ridge at Soldiers Point. The western basin of the harbour extends from Soldiers Point to the outlet of the Karuah River into the estuary, in the west. The Karuah River provides the only significant fluvial sediment input to the estuary. The Pindimar study area lies within the eastern basin of the estuary.

At the entrance to the estuary is an extensive marine tidal delta, built by the complex interaction of tides, waves, wind waves, and outflow from the Lower Myall River. The marine tidal delta and associated sand shoals extend into Port Stephens Harbour as far as Corlette. The delta is composed of clean, quartzose marine sands and is relatively shallow typically less than 4 – 8 m in depth. A steep drop over at the edge of the delta into deeper water extends roughly north-south from Corlette Head to the western side of Corrie Island. West of the drop over, water depths deepen to up to 20 m, with the deepest section (33 m) at Soldiers Point, where the harbour width narrows (MHL, 1999).

Waves frequently break across the shallow sand bars of the delta, particularly at low tide, when ocean swells penetrate into the harbour or are large wind waves formed within the estuary. The shoals, bars and channels are highly mobile, varying in location and height / depth over time [depending upon tidal currents, ocean waves, wind waves and currents]. Large sand shoals of the delta are noted around Corrie Island, across Paddy Marrs Bar, Middle Ground to Nelson Bay and extending westward to Corlette Head. MHL (1999) noted that attempts to remove the sand shoals may modify the hydraulics within the estuary, which may variously cause changes in the pattern or location of shoreline erosion, and accretion that may smother seagrass beds (and affect fish productivity).

The Lower Myall River extends into Port Stephens along the north eastern boundary, through the channel between Corrie Island and Winda Woppa, and also through a constructed ‘back’ channel behind Corrie Island into Pindimar Bay. The Lower Myall River is said to be a tidal channel with little fluvial input (MHL, 1999).

The tidal Delta comprises quartzose sands of coarse to fine grain size, with less than 10 % lithic and felspathic fragments (i.e., rock fragments) and variable carbonate content of 0 to 30% consisting of whole shells and shell fragments.

Estuarine shorelines are typically of the form of an active [high tide] estuarine beach with adjacent mud terraces that are exposed at low tide. Clean, well to very well sorted sands are found on the beach and nearshore terrace, with some mud on the outer terrace (MHL, 1999), and this is consistent with observations during the field inspection conducted by BMT WBM, refer Section X).

One of the wetlands of Port Stephens Estuary is located at Bundabah, at the outlet of Bundabah Creek. It is said that groundwater discharges close to the creek. The local groundwater system in this area is thus crucial in maintaining the viability and health of this wetland.

The Port Stephens estuary is a state significant waterway, containing the largest area of mangroves in NSW, approximately 18% of NSW's saltmarsh and extensive seagrass beds. These habitats are believed to currently be in a healthy condition. Mangroves, saltmarsh and seagrass provide habitat, food and shelter for migratory wading and other birds, fish and other aquatic species, including both threatened and endangered species as well as commercially important fish species (MHL 1999).

Not surprisingly then, the estuary supports large recreational and commercial fishing industries. Recreational fishing and tourism contribute at least $151 million (in 1999) and $60 million to the local economy alone (MHL, 1999). These important economic industries are dependent upon healthy foreshore habitats that include mangroves and saltmarsh.

MHL (1999) also made comment upon the likely effects of sea level rise and climate change. They noted "shoreline position and alignment may change as foreshores adjust to increased storminess, higher waves, changed current and tidal regimes, increased sea levels and changes to the direction of wave attack". Rises in sea levels and changes to wave direction and height during storms may affect the patterns of shoal formation and adjacent shorelines, as well as the height of foreshore inundation and wave breaking at the shoreline.

Port Stephens / Myall Lakes Estuary Management Plan, Umwelt (2000)

The Estuary Management Plan for Port Stephens / Myall Lakes Estuary was developed to provide actions for sustainable management of the estuary. One of the "priority actions to improve baseline information" was to "investigate causes of shoreline erosion at Pindimar". The Pindimar Study area was included in Management Zone E of the Plan. For this Management Zone, conservation of natural and cultural values, community lifestyle values and waterway access and community facilities were listed as the most important management themes.

The Pindimar study area was described as a sandy, mangrove lined shoreline with low lying flood prone land. Erosion of this sandy, mobile shoreline was noted as causing community concern. Foreshore erosion and retreat, and the impact on mangroves was noted as an issue in this area requiring assessment. The report suggested that the completion of the Sydney to Bulahdelah freeway connection would likely create pressure for urban development along Port Stephens northern shoreline. Thus, appropriate zoning and a Development Control Plan to protect vegetation along the foreshores (and steep areas) was highlighted as a planning priority for the northern shoreline, including the Pindimar Study area.

Living on the Edge: A Foreshore Management Plan for Port Stephens, Umwelt (2009)

The Foreshore Management Plan for Port Stephens (Umwelt, 2009) outlines management actions to protect, maintain and improve the environmental condition and allow for sustainable use of the Estuary and foreshore over time. As part of the Foreshore Management Plan, a broad scale assessment of foreshore erosion and stability was conducted. This included an overview of foreshore erosion causes and proposed management actions in the Pindimar study area.

The Umwelt (2009) report built upon the work by MHL (1999), noting that historically major storm events have been reported to dramatically change shoaling patterns [including shoal height/depth and location], which then affects ongoing wave refraction and wave height along the shoreline, [resulting in erosion / accretion on these shorelines].

The report also noted the impact of foreshore structures in generating localised erosion, such as edge effects from incorrectly designed and sited seawalls. In fact, Umwelt (2009) commented that the majority of seawalls around Port Stephens are unauthorised and are not designed to standard, being typically vertical and rigid. There are also many unauthorised private jetties, boat ramps and accessways.

The report highlighted the reduced effectiveness of existing sea walls and foreshore protection structures (overtopping and undermining) associated with sea level rise and climate change. Potential impacts of climate change and sea level rise include:

- Erosion of foreshore parks/reserves, reduced public access, condition of steps, ramps onto beaches
- More frequent inundation of foreshore land
- Toppling of undermined trees

The Pindimar study area was described by Umwelt (2009) as being characterised by sandy, mangrove lined shorelines backed by flood prone land at the base of steep slopes. Seagrass habitat is found in the waterway along the shoreline at Pindimar. The shallow, gently sloping beach at Lower Pindimar is exposed at low tide, as the tide recedes more than 150 m from shore. Boat launching from both the formal and informal ramps is only possible at high tide. The area is said to be popular with swimmers.

Pindimar was described as a depositional zone, due to the healthy mangrove stands. The report concluded that the Pindimar foreshore should be well protected from ocean wave penetration, and from wind wave action due to the narrow fetch length. Instead, the report notes that considerable reclamation of land has occurred along the Pindimar foreshore, using ad hoc seawall and groyne protection works.

The western foreshore of Lower Pindimar had a healthy profile with no protection structures at the time of the investigations conducted for the Umwelt (2009) study. The Umwelt (2009) report stated that structures should not be authorised or constructed along this section of foreshore. Unfortunately, a number of unauthorised structures now exist along this shoreline, as noted during the BMT WBM site inspection (refer Section 4.9).

Urban areas of Pindimar and Lower Pindimar are bordered by a fringe of mangroves. Cases of mangrove removal by local residents to view the waterway have been reported. Such cases have often resulted in foreshore erosion and a subsequent perceived need for protection structures. Mangroves form a natural barrier to wind and ocean waves. (Umwelt, 2009)

Public boat access is noted at the end of Curlew Street, comprising a one lane concrete / gravel ramp. It provides access to the beach at low tide, with boat launching possible ~ 2 hours either side of high tide. The Umwelt (2009) report also notes there are few publicly accessible vantage points along northern shoreline, with small public foreshore reserves at Lower Pindimar and Bundabah. And while there are no public jetties, there are described to be numerous private jetties in the Pindimar area, many not authorised. It was noted during the BMT WBM site inspection that there were only a few remaining jetties, most of which appeared very old, reported by local residents to have been built in the 1930s and 40s.

The following conclusions can be made regarding the foreshores of the Pindimar study area from the Umwelt (2009) report.

- There is a prevalence of ad hoc, poorly designed and ineffective seawalls located along shorelines of the study area. Virtually all of the structures should be replaced and / or rehabilitated. Many of the structures are associated with land reclamation by residents.
- The existing log groynes have also been poorly constructed and designed, and are not performing as protection structures. In fact, these features pose a threat to public safety and foreshore access and should be removed.
- There are numerous unauthorised jetties in the study area.
- Foreshore recession is notably evident where mangroves are absent from the shoreline.

Recommendations for management of foreshore erosion given in the Plan noted the following:

- It is likely to be unviable to procure the removal of existing unauthorised foreshore protection structures such as seawalls, log groynes and jetties at this point in time. This was said to be due to the high costs involved in replacing the structures with properly designed works, the complexities involved in identifying who is responsible for removal and replacement; and the likely vigorous opposition from landowners regarding the removal of structures. However, the report highlights that such structures will become increasingly less viable as sea level rises.
- A program of foreshore rehabilitation should be developed that could be implemented in conjunction with new development applications submitted for individual properties. That is, development approval would be given where the removal and rehabilitation of foreshore structures was proposed. Such an approach would be most appropriate for private land.
- On public land, a whole of foreshore approach could be undertaken, with foreshore areas targeted for improved public access and associated walkways, cycleways and so on.
- Soft engineering solutions are favoured, with a minimisation in the number of private structures over time. Hard engineering protection on previously unprotected shorelines should be a last resort and only where supported by environmental impacts and engineering assessments.
- “Native vegetation, which protects the foreshore against soil erosion and also provides important habitat, should be encouraged around the length of the foreshore” (p67, Umwelt, 2009). The

report highlights that foreshore protection could be provided by allowing nearshore mangroves to regenerate, but perhaps the mangroves could be "coppiced" to retain water views for residents.

- Community education should be undertaken to provide information about the importance of mangroves in providing foreshore stability.
- Seawalls should only be constructed as a last resort, with potential impacts upon coastal processes, ecology, public access, safety and visual amenity thoroughly assessed prior to such a decision.
- Local community has suggested Kyah Street Road Reserve (from Bulga St to water's edge) and Lot 29 Bulga St to be suitable for development of a boat ramp, car parking and community park, with safe swimming areas.
- As part of management zone E, upgrade of the Bundabah boat ramp, the Lower Pindimar boat ramp and installation of a jetty at Lower Pindimar, and a local-scale boat ramp at Pindimar were recommended, with landscaping and facilities at the small foreshore reserves within the villages also improved.

Specific management actions pertaining to the study area from the Foreshore Management Plan for Port Stephens (Umwelt, 2009) include:

- Management action 322 & 323: Improve and maintain general landscaping and facilities of Bundabah Reserve at Pleasant View Parade (Asset No. E_13) and at Bundabah Road (Asset No. E_12)
- Management Action 325 & 327: Investigate feasibility of reconstructing seawalls and rock revetment (entire northern foreshore) to coastal eng standard. Applies to Bundabah Reserve (Bundabah Road) (i.e., 325) and to the majority of existing seawalls and foreshore structures (particularly private structures) in the Lower Pindimar and Pindimar areas (i.e., 327).
- Management Action 328: Implement community education program to inform people about importance to ecology and foreshore stability provided by mangroves and saltmarsh, and provide information about the legislation and potential penalties for their removal. Applies to removal of mangroves which appear to have resulted in erosion in the Lower Pindimar/Pindimar area
- Management Actions 336 refers to upgrade of Bundabah boat ramp, 337 to upgrade of Lower Pindimar Boat ramp, 339 to installation of local scale boat ramp at Pindimar, and 340 to installation of public jetty at Lower Pindimar (to complement upgraded boat ramp), as noted above.

Umwelt (Australia) Port Stephens Foreshore Management Plan Coastal Engineering Advice Report (SMEC, 2006)

As part of investigations for the Umwelt (2009) Foreshore Management Plan for Port Stephens, an assessment of foreshore erosion in Port Stephens was commissioned from SMEC (2006). The report included a site inspection and discussion of foreshore erosion and protection at various locations along the Port Stephens shoreline including the Pindimar study area. The report also provided recommendations as to guidelines for the design and rehabilitation of foreshore protection structures, such as seawalls.

The SMEC (2006) report concluded that there was a prevalence of unauthorised, *ad hoc* protection structures throughout the Pindimar region (and throughout Port Stephens in general), many of which are ineffective, many involving reclamation of estuarine foreshores, and many of which required rehabilitation or removal. Outcomes from the SMEC (2006) study that are specific to the Pindimar study area are given below.

For the Lower Pindimar region, SMEC (2006) noted:

- foreshore recession was evident where mangroves are absent from the nearshore zone;
- localised erosion was evident next to the boat ramp structure (off Curlew Street), and the existing rock revetment and vertical timber retaining wall protection works have not been designed or constructed to best practice coastal engineering standards;
- the strewn rock rubble at the eastern end of the Curlew Street boat ramp may potentially cause injury to beachgoers;
- the log retaining wall around the pine tree (Curlew Street boat ramp) reflects wave energy to the adjacent foreshore, and may pose a danger to the public;
- there was a prevalence of erosion protection in the form of unauthorised seawalls and log groynes and land reclamation at private residences with absolute foreshore frontage;
- the log groynes in front of residential development are entirely ineffective, and pose a hazard to public users of the reserve;
- the grouted boulders as protection aren't to engineering standards and are not an appropriate foreshore protection; and
- the stretch of foreshore at the western end of Lower Pindimar has a natural beach frontage that is in good condition with no evidence of erosion, and this provides evidence that there is no long term erosion issue in Lower Pindimar, except where interference with the shoreline in the form of *ad hoc* seawall protection and mangrove removal has occurred
- Unfortunately, during the BMT WBM site inspection, a number of small wooden vertical walls have been emplaced on this natural foreshore.

For Pindimar (Orungall Point) SMEC (2006) noted the following:

- "everywhere there is foreshore erosion the mangrove stands appear to have been cleared, apparently to allow boat access to the Port Stephens waterway", allowing greater wave energy impact to the shoreline, causing erosion;
- areas where mangroves have been retained shows healthy sand accumulation; and
- the healthy mangrove growth from Orungall Point to the north illustrates this to be a depositional area.

SMEC (2006) observed the following at Upper Pindimar:

- the foreshore is well protected from wave action, exposed to narrow wind wave fetch from the south east direction;
- there does not appear to be a signature for long term foreshore recession;

- considerable reclamation is evident, with ad hoc rock wall and groyne protections and several jetties;
- the groynes are ineffective as foreshore stabilisation structures, and may present a danger to the public;
- none of the seawalls have been constructed to the required engineering standard; and
- the drainage outlet along this foreshore has not been maintained, and the outfall structure appears unauthorised.

Overall, SMEC (2006) concluded the following with respect to foreshore erosion and existing protection works in the Pindimar study area.

- Groynes, seawalls, offshore breakwaters and other such features can provide realistic foreshore protection, however, this is only when they are correctly designed, including investigation of their impacts to surrounding areas and the wider marine environment.
- Groynes, artificial headlands and offshore breakwaters when installed without proper design, such as in the Pindimar study area, have the greatest potential for adverse impact because they interrupt natural sand drift, causing erosion at adjacent shorelines and siltation or erosion of offshore seagrass areas. The report concludes strongly that such structures are entirely inappropriate for erosion management at individual properties such as has occurred in the Pindimar study area.
- Seawalls were also noted to be inappropriate for providing protection for individual properties, because they cause erosion on adjacent unprotected shorelines and the erosion at the ends of a seawall may cause undermining and collapse of the seawall. Seawalls need to be designed as continuous uniform structures across the entire length of the shoreline (and properties) experiencing erosion in order to be effective as a protection action.
- Vertical seawalls are particularly inappropriate because they reflect wave energy (rather than dissipating it, as natural shorelines do), resulting in greater erosion of the beach and shoreline at the base (toe) of the vertical wall. Such scour at the toe of the wall will eventually cause collapse of the wall. Seawalls must be sloped to absorb wave energy and minimise run-up and reflection.
- Beach nourishment is a preferred method of foreshore stabilisation because it does not have any of the negative impacts of the other methods described above. However, it is also expensive, as it must be repeated periodically and requires stabilisation to prevent windblown sand loss.

The SMEC (2006) report provided management guidelines for foreshore protection. Rehabilitation of the existing vertical seawalls is required. In the least, the walls should be converted to porous, sloping rock rubble revetments (with slope of 2:1 H:V). Such rehabilitation could be done by placing geotextile then armour stone in a wedge in front of the wall, and masonry vertical walls would need to be broken out also. All unauthorised groyne structures should be removed.

The foreshores of Port Stephens may be expected to experience a breaking wave height of 0.9 m (taken from MHL (1997), see review below), as such, a revetment stone size of D_{50} of 420 mm and W_{50} of 125 kg are appropriate. Correct armour stone sizes and revetment crest levels should be determined accurately with a nearshore and foreshore survey to determine existing levels. Figures for structural design guidelines were provided with the report, and have been considered when developing the recommendations given for this project (refer Section 9).

Port Stephens Flood Study – Stage 2 Design Water Levels and Wave Climate (MHL, 1996)

The Port Stephens Flood Study Stage 2 (MHL, 1996) involved assessing the design levels for inundation which included not only rainfall and flooding in tributaries to the estuary, but inundation at foreshore areas around the Port which are dependent upon ocean swell wave height, wind wave height, wind set up, barometric pressure set up and still water levels (including tides). These processes affect the height of water levels during an extreme storm at the Pindimar study area. We note that elevated water levels increase the height at which waves impact upon the shoreline during storms, and the subsequent extent of erosion.

MHL (1996) concluded that, in addition to rainfall, flooding levels around Port Stephens are affected by:

- elevated ocean levels, including barometric pressure set up, tides and water level anomalies;
- Wind set up, which may vary the water level by up to 0.3 m, depending upon direction of wind [and fetch length]
- Wind waves and ocean waves, which may significantly impact upon inundation levels at the foreshore.

MHL (1996) found the wave climate within the Port Stephens estuary to be influenced by:

- Local wind conditions (speed and direction);
- Bathymetry;
- Offshore wave climate;
- Water level in Port Stephens;
- Wave refraction and diffraction.

As part of their flood study MHL (1996) used local wind conditions with a numerical model to estimate the wind wave climate in the Port Stephens estuary. To determine ocean swell wave heights where ocean waves penetrate the estuary entrance, wave data recorded from offshore wave rider buoys were propagated to the Port Stephens shoreline with the use of a wave model and empirical formulas. The modelled data was cross checked against wave staff recordings at Jimmys Beach and Nelson Bay.

As an outcome from these analyses, MHL (1996) provided design peak water levels, plus design wind wave and ocean wave conditions. The final flood levels along the foreshore were said to be dependent upon the wave approach to shore combining with still water level and the local bathymetry and foreshore structures, to result in a certain wave run up and inundation. The results for flood levels along the Pindimar study area are reproduced in

Table 10.1 below.

The findings of the MHL (1996) study, particularly for wind set up and empirical wave calculations are of use for comparison wave modelling conducted as part of this study (refer Section 4.10), to reasonable consistency and outcomes from the modelling.

Table 10.1 Design Inundation Levels for Pindimar Study Area, from MHL (1996)

		Design Peak Water Level: Storm tide + flood + wind set up, no waves		Combination A (Westerly wind)			Combination B (East to South East wind and swell)				
ID	**Site Name**	**Extreme**	**1 % AEP**	**Water Level (m)**	**Wind wave (Hs,m)**	**Wind Wave (Tp, s)**	**Water Level (m)**	**Wind wave (Hs,m)**	**Wind Wave (Tp, s)**	**Ocean wave (Hs,m)**	**Ocean Wave (Tp, s)**
32	North Arm Cove	1.81	1.78	N/A	N/A	N/A	1.78	N/A	N/A	N/A	N/A
33	Dead Mans Point	1.82	1.75	N/A	N/A	N/A	1.75	N/A	N/A	N/A	N/A
34	Fame Point	1.80	1.75	1.52	0.8	3.1	1.75	0.4	2.2	0.3	12/15
35	Lower Pindimar	1.75	1. 71	1.50	0.6	2.8	1.71	0.5	2.5	0.6	12/15
36	Orungall Point	1.72	1.68	1.53	0.6	2.6	1.68	0.4	2.3	0.3	12/15
37	Pindimar	1.73	1.69	1.57	0.4	2.3	1.69	0.4	2.3	0.3	12/15

MHL (1996) compared wind data recorded at Jimmys Beach (Public Works Department between 19/01/1984 and 06/03/85) with simultaneous data at Williamtown Air Base. MHL (1996) conducted a wind direction correlation and wind speed correlation analyses between the two sites, and found the median directional difference between Jimmys Beach and Williamtown was 5 ^{o}. Wind speed between the sites also showed good agreement. A similar analysis of Nelson Bay and Williamtown data also showed remarkable similarity with Jimmys Beach records. Thus, MHL (1996) concluded that Williamtown Air Base data provided realistic wind data for Port Stephens.

The Williamtown wind data indicated that the 100 year Average Recurrence Interval (ARI) one-hour duration wind speeds were strongest from the west, north west and south west directions. However, as noted by MHL (1996), east, south east and southerly wind directions are most likely to occur in combination with an ocean storm and swell waves.

MHL (1996) used Williamtown wind data in a hydraulic model to calculate wind set up at the shoreline. Data from the various simulations conducted by MHL is reproduced in Table 10.2 to Table 10.4 below. The following conclusions for wind set up generation in the Pindimar Study area are made.

- In North Arm Cove, highest wind set up at 0 m AHD water level, occurs during winds from the west, south and south east, and during south, south west and east winds at 1.5 m AHD water level, for 1 hour duration winds.
- In North Arm Cove, easterly wind directions generate the greatest wind set up for 2.5 hour duration winds at 1.5 m AHD water level.
- Generally for North Arm Cove, higher wind set up occurs during the higher water level condition, except at Dead Man's Point under westerly wind conditions, where 0.27 m set up occurs for a 0 m AHD water level and 1 hour duration wind.

- Lower Pindimar typically experiences lower wind set up levels overall, with easterly and south easterly winds important for the 1 hour duration wind, for 0 m and 1.5 m AHD water levels respectively. There is little variation in wind set up level between the two water level conditions.
- The highest wind set up of 0.15 m at Lower Pindimar occurs under easterly wind conditions at 2.5 hour duration at 1.5 m AHD water level.
- For Pindimar and Orungall Point, southerly winds generate the highest wind set up, for all wind duration and water level conditions. The highest wind set up occurs during 0 m water levels and 1 hour duration winds, of 0.17 m.

For the purpose of modelling wind waves at Pindimar, a longer duration wind condition is important, to enable generation of larger waves. Across the Pindimar study area, there does not appear to be a trend for wind set up levels with respect to wind duration and water level. In general, south to easterly wind directions appear to generate the largest wind set up on the shoreline in the study area.

MHL (1996) also analysed the attenuation of ocean swell waves within Port Stephens Harbour. The nearest offshore waverider buoy for Port Stephens is located at Sydney. MHL (1996) considered the offshore wave climate at Sydney to be sufficiently similar to that offshore of Port Stephens, utilising this data for the study.

MHL (1996) collected wave data with zwartz wave pole recorders at Jimmys Beach (between December 1983 and October 1985, 160 m offshore of beach) and Nelson Bay (June 1986 to April 1988 in 5 m water depth near to where the end of northern breakwater is now located). The data was compared with the offshore wave climate data, to determine wave attenuation within the Port. There was considerable scatter within data, but general trends illustrated:

- Wave heights at Jimmys Beach are 22 % of offshore wave heights (i.e., wave attenuation coefficient of 22 %)
- Wave heights at Nelson Bay are 4 % of offshore wave heights (i.e., wave attenuation coefficient of 4 %)

To account for scatter in the data, MHL (1996) adopted a wave attenuation coefficient of 30% for the study.

MHL (1996) assessed design ocean wave heights at various locations around the Port Stephens shoreline. Design wave heights for the 1 % Average Exceedence Probability (AEP, which is equivalent to the 100 year ARI) for the locations which are relevant to the study area are given in

Table 10.1. The wave parameters were derived by taking the wave climate for Soldiers Point for North Arm Cove locations (32 to 34) and the wave climate for Jimmys Beach for the Pindimar region (IDs 35 to 37), then applying the diffraction method given by CERC (1984).

The MHL (1996) report also detailed characteristics of Port Stephens estuary which are worth noting for further consideration during the analysis of the Pindimar study area. MHL (1996) discuss the issue of wave focussing, that is, where the bathymetry (particularly sand shoals and shallow areas contrasting with deeper areas) causes greater wave heights at particular locations along the shoreline. The mobility of sand shoals throughout the port indicates that wave focussing may occur at various locations around the port, as the bathymetry changes naturally over time. Wave focussing

and subsequent shoreline impacts are possible at shorelines throughout the port, and particularly in proximity to the harbour entrance and tidal delta.

For the purpose of this project, the analyses by MHL (1996) for both wind and ocean waves provide a source of data with which to compare wave modelling outputs, to ensure reasonable parameters are derived from the wave modelling conducted for this study.

Table 10.2 Maximum Wind Setup Increments (m) for the 100 year ARI – 1 hour duration, with an initial water level of 0 m AHD, from MHL (1996)

ID	Site	NE	E	SE	S	SW	W	NW	N
32	North Arm Cove	0.01	0.08	0.10	0.13	0.10	0.09	0.00	0.00
33	Dead Man's Point	0.00	0.05	0.09	0.18	0.20	0.27	0.09	0.00
34	Fame Point	0.02	0.07	0.09	0.07	0.05	0.05	0.00	0.00
35	Lower Pindimar	0.01	0.06	0.08	0.07	0.05	0.01	0.00	0.00
36	Orungall Point	0.00	0.03	0.08	0.11	0.09	0.06	0.00	0.00
37	Pindimar	0.00	0.04	0.11	0.17	0.16	0.11	0.00	0.00

Table 10.3 Maximum Wind Setup Increments (m) for the 100 year ARI – 1 hour duration, with an initial water level of 1.5 m AHD, from MHL (1996)

ID	Site	NE	E	SE	S	SW	W	NW	N
32	North Arm Cove	0.05	0.12	0.11	0.12	0.11	0.07	0.00	0.00
33	Dead Man's Point	0.03	0.10	0.10	0.15	0.19	0.17	0.04	0.00
34	Fame Point	0.04	0.10	0.10	0.07	0.05	0.05	0.00	0.00
35	Lower Pindimar	0.04	0.09	0.09	0.06	0.04	0.00	0.00	0.00
36	Orungall Point	0.01	0.07	0.08	0.09	0.07	0.03	0.00	0.00
37	Pindimar	0.01	0.07	0.10	0.14	0.12	0.08	0.00	0.00

Table 10.4 Maximum Wind Setup Increments (m) for the 100 year ARI – 2.5 hour duration, with an initial water level of 1.5 m AHD, from MHL (1996)

ID	Site	NE	E	SE	S	SW	W	NW	N
32	North Arm Cove	0.08	0.19	0.16	0.11	0.10	0.06	0.00	0.00
33	Dead Man's Point	0.07	0.17	0.16	0.14	0.16	0.16	0.03	0.00
34	Fame Point	0.09	0.17	0.14	0.06	0.05	0.05	0.00	0.00
35	Lower Pindimar	0.08	0.15	0.12	0.06	0.03	0.00	0.00	0.01
36	Orungall Point	0.05	0.12	0.11	0.09	0.06	0.03	0.00	0.00
37	Pindimar	0.05	0.12	0.13	0.13	0.11	0.07	0.00	0.00

Port Stephens Foreshore (Floodplain) Management Plan, WMA (2002)

WMA (2002) compiled a Foreshore Floodplain Management Plan for Port Stephens in 2002, which used the design foreshore flood levels, as derived during Stages 1 to 3 Flood Studies (completed by MHL) and developed actions to manage foreshore floodplain risks. Aspects of this plan that are relevant to the assessment of foreshore erosion in the Pindimar study area are outlined below.

The WMA (2002) report described the results of a questionnaire survey. From the survey, there are historical accounts of wind wave activity resulting in erosion of the foreshore and waves breaking above the high tide water level, with inundation of low lying foreshore land during storms, most notably, the storms of May 1974. The survey also indicated there to be no historical or accurate record of damage to buildings or structures, except for seawalls and other structures upon the immediate foreshore (WMA, 2002).

The Plan report states that erosion events occur regularly, around twice a year, however the location and extent of damage varies considerably. The largest event in recent times was reported to be May 1974, which also caused extensive damage along the entire middle coast of NSW (WMA, 2002).

The WMA (2002) report noted issues in foreshore regions such as the removal of native vegetation and growth of exotic species, continuing pressure for development on foreshore land, and residents undertaking ad hoc works on foreshore lands, all of which are relevant to the Pindimar study area. The WMA (2002) report also noted that land in Pindimar was likely to be in danger of inundation during elevated water levels or wave run up processes.

To incorporate the coastal issues of wave run up (and erosion) within the flood management and planning process, WMA (2002) included a 50 m zone landward from the Mean High Water mark within the flood planning area. WMA (2002) noted the extent of this zone should be reassessed upon completion of a Coastal Management Plan (which they recommended as an action within the Plan).

The Plan identifies the following high priority actions which are relevant to the management of foreshore erosion in Pindimar:

- F2 – Conduct a community education / information program to advise residents of the value of vegetation barriers along the foreshore;
- F7 – Ensure all proposed foreshore developments are assessed in regard to wind wave run up, erosion and other coastal hazards. In the future both Councils (Great Lakes and Port Stephens Councils) should develop a DCP covering all aspects of foreshore development;
- PL3 – Prepare a Development Control Plan for foreshore lands affected by flooding and other coastal hazards.

WMA (2002) investigated the feasibility of using offshore breakwaters or strategic dredging, to reduce the impacts of wave breaking, run up and inundation on foreshore land, as part of action F1: ‘Evaluate if future development can form part of a levee system’. It was found that offshore breakwaters and dredging have a low benefit to cost ratio, meaning they are expensive yet have little effect in reducing wave run up and no effect upon reducing still water inundation levels. Furthermore, offshore breakwaters restrict waterway usage and breakwaters and dredging have a high environmental impact. The report concluded that such measures were not recommended as foreshore flood mitigation or erosion protection measures.

Levees, walls and artificial dunes were also investigated. While such measures have been implemented widely, the negative aspects of such measures include reduced visibility and visual amenity, reduced public foreshore access, runoff and drainage issues, and a low ratio of benefit to cost (WMA, 2002).

The WMA (2002) report provided discussion of the benefits associated with Action F2 (given above) and Action F3: 'Promote revegetation of the foreshore in the most favourable areas'. It was found that vegetation, particularly mangroves, provide an effective, natural physical barrier to the action of wave run up. However, a large amount of this vegetation has been removed to improve water views and / or foreshore access. The report found the main negative aspect of floodplain actions F2 and F3 was the lack of support from foreshore residents who would have their access or views reduced (WMA, 2002).

WMA (2002) identified Lower Pindimar as a location where revegetation could be undertaken in a cost effective manner, particularly with the support of local residents. However, comprehensive community education will be required, to ensure the community supports the revegetation and does not destroy plantings.

Discussion of Action F7 (given above) noted the large number of revetment walls that have already been constructed. However, such "hard" engineering solutions were not recommended as they are expensive to construct, are often unsightly and incompatible with the local surroundings, and as such should be considered as a last resort. "Soft" engineering solutions such as revegetation and beach nourishment were recommended. The report also stressed the need for proposed developments to consider the impact of wave run up and erosion not only on the subject property, but for neighbouring properties as a result of the development. Proposed standard conditions for assessing development applications within the foreshore were provided in the Plan (WMA, 2002).

NSW Fisheries (2003) Letter Re: Mangrove Dieback at Pindimar, Port Stephens

The Department of Primary Industries: Fisheries (then NSW Fisheries) conducted an investigation into the health of grey mangroves (*Avicennia marina*) along the foreshore of Pindimar for the then Department of Land and Water Conservation (now Office of Environment and Heritage (OEH)). The investigation involved inspection and photographic study at high tide by boat of the foreshore area.

The letter concluded that there was clear evidence that mangroves over the length of several kilometres of foreshore were experiencing severe stress. The smaller patches of mangroves showed signs of stress such as dropping foliage, dead plants, with plants that had survived re-shooting leaves and presenting a crowned appearance. While DPI Fisheries were unable to give an exact determination upon the primary cause for destruction and damage to the mangrove trees, they concluded several mechanisms were operating.

Cutting down and removal of mangroves to improve water views from certain properties was clearly evident, with DPI Fisheries providing photographs to demonstrate this (refer Figure 10-1).

Some of the larger mangrove trees showed clear evidence of being poisoned, again to provide water views for the properties (refer Figure 10-2).

It was not possible to determine exactly the cause of the widespread and extensive defoliation of smaller mangroves along the foreshore, and DPI Fisheries suggested that there is strong circumstantial evidence that these trees have been subject to an insect attack. Similar damage and dieback as is evident in this case for the trees was also noted for mangroves in the Hunter River, Fullerton Cove and Lemon Tree Passage in 2002, at a similar time to the dieback observed at Pindimar. This type of damage was caused by a plague of the phycitine genus Moth larvae (a caterpillar / moth pupae ~ 15 mm in length and green in colour).

However, the letter concluded that while it was possible that some of the dieback observed at Pindimar may be due to attack by the Moth larvae, the illegal destruction of mangroves was also clear and evident. DPI Fisheries reinforced that cutting down mangroves without a permit is a punishable offence under Section 205 of the *Fisheries Management Act 1994*, incurring fines of up to $220,000. Further, permits to harm mangroves would not be issued for the simple act of improving water views or aesthetics. The letter iterated that on the spot penalties or court prosecution would be issued to any resident caught damaging mangroves.

Figure 5: Pindimar – Port Stephens, (saw cut).

Figure 10-1 Photograph 5 by NSW Fisheries (2003), illustrating illegal cutting of mangrove trees at Pindimar

Figure 10-2 Photograph 4 by NSW Fisheries (2003), illustrating illegal poisoning of large mangrove trees at Pindimar

APPENDIX B: LEGISLATIVE FRAMEWORK SUMMARY

Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the central piece of environmental legislation of the Australian Government. The EPBC Act provides for the protection and management of nationally and internationally important flora, fauna, ecological communities and heritage and cultural sites, and conservation of Australian biodiversity. The EPBC Act covers both terrestrial areas and Commonwealth marine areas, including marine areas managed by the Commonwealth.

The EPBC Act provides the Australian Government's tool for the assessment and approval of actions which may affect matters of national environmental significance. States and territories are responsible for matters of state and local significance. The EPBC Act is administered by the Minister for the Environment through the Department of the Environment, Water, Heritage and the Arts of the Australian Government.

There are seven matters of national environmental significance to which the EPBC Act applies, namely: world heritage sites; national heritage places; wetlands of international importance (i.e. Ramsar wetlands); nationally threatened species and ecological communities; migratory species; Commonwealth marine areas; and nuclear actions.

The EPBC Act also aims to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources and controls the international movement of plants and animals and related products. The objectives of the EPBC Act include recognising and promoting indigenous people and their knowledge of biodiversity in conservation and ecological sustainable use of biodiversity and resources.

Any group or individual whose actions have, will or are likely to have a significant impact upon any of the seven matters of national environmental significance must apply for approval from the Minister for the Environment under the EPBC Act. This includes the actions of companies, land owners, developers, farmers, councils and state and territory agencies. A significant impact includes indirect impacts, for example, a development may still impact upon a habitat or species whether located within or outside of the habitat boundaries.

Where a development or other action does not affect any of the seven matters of environmental significance, but still may be harmful to the environment, the Australian Government does not have authority to intervene (e.g. by refusing approval for the development or activity). The states have primary responsibility for protection of the environment in other matters.

The EPBC Act also provides protection to species and ecological communities through a process for and listing of threatened species and communities (including marine species), including: species that are extinct in the wild; critically endangered, endangered and vulnerable species; critically endangered and endangered communities; and migratory species (including marine species, most notably, whales and other cetaceans), as listed within international conventions such as JAMBA, CAMBA and Bonn. In addition to the approvals process described above, the EBPC Act requires permits to be obtained for actions in a Commonwealth area that involve the killing, injury or taking of a

listed threatened species or endangered community. For matters of national heritage significance, the EPBC Act has established a national heritage list.

Thus, any action undertaken by any party (Council or landowners) in the Pindimar area that affects matters of national environmental significance, such as an impact to a listed threatened species or its habitat, are governed by the EPBC Act. Such actions would require assessment by the Federal Minister for the Environment.

Environmental Planning and Assessment Act 1979

One of the key pieces of NSW legislation is the *Environmental Planning and Assessment Act 1979* (EPA Act). The EPA Act provides a system of environmental planning and assessment for NSW, and involves developing plans to regulate competing land uses, through 'environmental planning instruments'.

The Act establishes three types of environment planning instruments (EPI):

- Local Environmental Plans;
- Regional Environmental Plans; and
- State Environmental Planning Policies.

The objectives of the EPA Act are to encourage:

- proper management, development and conservation of natural and artificial resources, including agricultural land, natural areas, forests, minerals, water, cities, towns and villages for the purpose of promoting the social and economic welfare of the community and a better environment;
- promotion and co-ordination of the orderly and economic use and development of land;
- protection, provision and co-ordination of communication and utility services;
- provision of land for public purposes;
- provision and co-ordination of community services and facilities;
- protection of the environment, including the protection and conservation of native animals and plants, including threatened species, populations and ecological communities, and their habitats;
- ecologically sustainable development;
- the provision and maintenance of affordable housing;
- promotion of the sharing of the responsibility for environmental planning between the different levels of government in the State;
- provision of increased opportunity for public involvement and participation in environmental planning and assessment.

In the administration of the EPA Act, the likely effect on threatened species, populations or ecological communities, or their habitats is to be taken into account and an assessment to be undertaken in accordance with any assessment guidelines under the *Fisheries Management Act 1994* and the *Threatened Species Conservation Act 1995*. Planning authorities must also have regard for the

register of critical habitat kept by the Director-General of National Parks and Wildlife under the *Threatened Species Conservation Act 1995*.

Approval processes for "development" and "works" in NSW are provided for in Part 3A, Part 4, Part 5 and Part 5A of the EPA Act. Key provisions are outlined briefly below.

Part 3A – Major Infrastructure and Other Projects

Part 3A came into operation in August 2005 and applies to development that is declared to be a project to which the part applies. A project can be declared by:

- A State Environmental Planning Policy, or
- By order of the Minister for Planning published in the Government Gazette.

There are two types of development that may be declared:

- Major infrastructure or other development that in the opinion of the Minister is of state or regional environmental significance, or
- Old Part 5 activity approvals where the proponent is the determining authority and an EIS would have been required.

Guidelines regarding Part 3A projects have been provided by the Department of Planning.

The foreshore works proposed for use by individual landholders in the Pindimar study area within this project are unlikely to be considered Part 3A projects.

Part 4 – Development Assessment

Part 4 of the EPA Act lays out the legislative regime for the standard process for lodgement and consideration of development applications. Part 4 processes essentially apply where the local authority (Council) is the consent authority. The majority of land based development within the Pindimar study area will fall within Part 4 of the EPA Act.

The controls and permissibility for development of particular sites and / or uses are found in Council's LEP and DCPs.

Division 5 of Part 4 relates to the special procedures for integrated development, which is development that requires a separate approval under other legislation, in addition to development consent under the EPA Act. Actions and works such as land reclamation, construction of foreshore protection structures, and damage to mangroves that have occurred along the Pindimar foreshores in the past are in fact integrated development under the EPA Act. Such actions /works require additional approvals, namely:

- a permit is required to carry out dredging or reclamation works (s 201 of the FM Act)
- a permit is required to cut, remove, damage or destroy marine vegetation on public or private foreshore or water land (s 205 of the FM Act);
- a controlled activity approval is required for works within 40 m of any watercourse, under Part 3 of Chapter 3 of the *Water Management Act 2000*.

Section 79BA of the Act requires development within bushfire prone areas (with the exception of subdivision of land that could lawfully be used for residential or rural residential purposes or development for a special fire protection purpose) to comply with the specifications and requirements of *Planning for Bushfire Protection* and the Commissioner of the NSW Rural Fire Services to be consulted. Such provisions may affect development generally within the Study Area, but are unlikely to be relevant to foreshore protection works in the study area.

Part 5 – Environmental Assessment

Part 5 of the Act applies to an "activity" which is not subject to development control i.e. where a particular proposal does not require development consent under Part 4 of the EPA Act but requires approval from a Minister or Public Authority, or is proposed to be carried out by a Minister or Public Authority. Part 5 only applies to those proposals which are permissible without requiring development consent.

Part 5 focuses on the obligation of the "determining authority" to consider the environmental impact of any "activity". A "determining authority" is the public authority which is proposing to carry out the activity and also any public authority which is required to approve an activity proposed by the person who wishes to carry out the activity.

Part 5 identifies the requirements and process for the determining authority in terms of when an Environmental Impact Statement (EIS) is required, the exhibition of the EIS, having regard to critical habitat, endangered fauna, vulnerable species, conservation agreements, plans of management, and joint management agreements and bio-banking agreements under the *Threatened Species Act, 1995*, consideration of representations made to the exhibition and where an Inquiry is required.

Part 5 of the EPA Act would apply where Council is required to undertake an EIS for a proposed development activity. However, Council is permitted to undertake activities for environmental management (as applies to the study area) under SEPP (Infrastructure) 2007 (see below).

Part 5A (Development by the Crown) essentially provides a legislative regime for consideration of Development Applications made by, or for and on behalf of, the Crown.

The remaining parts of the EPA Act relate to:

- Part 6 – Implementation and Enforcement
- Part 7 – Finance
- Part 8 – Miscellaneous

Great Lakes LEP

Zoning of Land in Study Area according to the Great Lakes LEP 1996 (as illustrated in Figure 1-2) is:

- 1(a) – Rural Zone. The objective of this zone is to restrict development to uses which allow for or promote agricultural production. Developments which are likely to generate traffic, ribbon developments along roads greater than the capacity of the road, adversely impact upon water resources or create unreasonable (uneconomic) demands for the extension / provision of public amenities or services are not permitted under this zoning. Development for the purpose of

agriculture or bushfire hazard reduction is permitted without consent. Prohibited development includes premise for commercial use, hotels, medical centres, boarding houses, multiple dwellings, residential flats, shops, and industrial uses (such as for vehicles, bulky goods)

- 2 (a) – Low Density Residential Zone. Low Density residential zoning aims to enable low density residential buildings (primarily for housing) generally not exceeding a height of 2 storeys. Development shall be compatible with this low density environment, afford services at a local level, and shall not place demands upon services beyond the level reasonably required for low density development, or adversely affect the amenity of development within the zone. Within this zone low scale development such as dwelling-houses, community facilities, hostels, medical centres, motels, multiple dwellings, child care centres, recreation areas and facilities, animal establishments and vet centres are permitted with development consent. Development for the purpose of bushfire hazard reduction is permitted without consent.
- 7(a) – Wetlands and Littoral Rainforest, covering lands adjacent to Kore Kore Creek. This zone aims to restrict the type and scale of development to that which is compatible with the ecological or scientific values of the wetlands, and which is unlikely to have a detrimental/adverse effect on the growth of native plant communities, the survival of native wildlife or the provision and quality of habitats for indigenous or migratory species. There is no development permitted without consent in this zone, and developments permitted with consent are limited to: agriculture, aquaculture, bushfire hazard reduction, dwelling-houses, recreation areas, roads, utilities and works for drainage purposes.

Nearby areas in Fame Cove are zoned 8(a) National Parks and State Recreation Areas Zone (which is dedicated land managed by the NPWS as part of Myall Lakes National Park), and 7(b) Conservation Zone, however these areas are not within the study area.

Under the rural zonings and residential zonings given above, foreshore protections works may be permitted with development consent. However, such works would need to be consistent with the additional legislation, as discussed herein.

Existing foreshore zonings in Lower Pindimar and Pindimar do not adequately protect the SEPP14 Wetlands and Coastal Saltmarsh EECs located on these lands.

At present, there is no relevant Great Lakes Development Control Plan to specify the appropriate type, location, design, or construction method for foreshore protection works, jetties or boat ramps in Pindimar (or other) areas.

Standard Instrument (Local Environmental Plans) Order 2006

The Standard Instrument (LEPs) Order 2006 was gazetted on 31 March 2006 and is part of a package of local planning reforms aimed at reducing the number of plans and improving the consistency in planning instruments. It was further amended on the 25th June 2008.

The Standard Instrument requires all draft principal LEPs to be prepared in accordance with the Standard Instrument and incorporate relevant mandatory provisions before they can be publicly exhibited and recommended for gazettal. It seeks to standardise the zones in Local Environmental Plans, identifying 34 standard zones for Councils to use when preparing new principal LEPs for the local government areas. Local Councils have until 2011 to prepare their new standard LEPs.

It is likely that Great Lakes Council will use the specified Waterways and Environmental Protection Zones for the estuary waterway and foreshores of Pindimar. Such zone provisions will be given consideration in the development of foreshore management guidelines as part of this study. Land based zones may be applied to smaller waterways (such as streams and intermittent creeks). Waterway zones are generally intended for application to the waterways' channel and banks. A brief outline of such zones is given below.

W1 Natural Waterways zone: is generally intended for waterways that are to be protected due to their ecological and scenic values. A limited number of low impact uses that do not have an adverse effect on the natural value of the waterway can be permitted in this zone.

W2 Recreational Waterways zone: is generally intended for waterways that are used primarily for recreational purposes such as boating, fishing and waterskiing, but which may have also have ecological, scenic or other values that require protection.

E1 National Parks and Nature Reserves zone: This zone is generally intended to cover existing national parks and nature reserves. All uses currently authorised under the *National Parks and Wildlife Act, 1974* will continue to be permitted without consent within this zone.

E2 Environmental Conservation zone: is generally intended to protect land that has high conservation value. A number of land uses considered to be inappropriate for this zone have been mandated as prohibited uses.

E3 Environmental Management zone: is generally intended to be applied to land that has environmental or scenic values or hazard risk, but where a limited range of development including dwelling houses and other uses could be permitted. This zone might also be suitable as a transition between areas of high conservation value and other land uses such as rural or residential.

E4 National Parks and Nature Reserves zones: is generally intended for land with special environmental or scenic values where residential development could be accommodated.

Fisheries Management Act 1994

The aim of the *Fisheries Management Act 1994* and *Fisheries Management Amendment Act 1994* (the FM Act) is to conserve, develop and share the fishery resources for the state's benefit for present and future generations. The FM Act applies specifically to aquatic flora and fauna, primarily fish, invertebrates and some algae. The FM Act promotes ecologically sustainable development, including conservation of biological diversity.

The FM Acts protects marine vegetation, including mangroves, saltmarsh and seagrass. Under the FM Acts, a permit is required to destroy or damage marine vegetation such as mangroves, seagrass, and saltmarsh. The Act also includes schedules of endangered aquatic species, populations and ecological communities, which must be considered in the same manner as species listed under the *Threatened Species Conservation Act 1995*.

All developments under the EPA Act must also be consistent with the objectives and permissible uses of aquatic reserves as contained within the FM Act and any management plans where they exist for the aquatic reserve.

Dredging and reclamation activities also fall under the FM Act. Reclamation of land in the waterway shall be managed so as to conserve the biodiversity of fish, aquatic vegetation and fish habitat and be consistent with the principles of ecologically sustainable development. Persons (i.e., not a public or local authority) must have a permit issued by the Minister for Fisheries before they may proceed with reclamation or dredging activities.

Under the FM Act it is an offence to harm or cause damage to (by an act or an omission) any fish, marine vegetation or habitat of a threatened species, population or ecological community, or critical habitat. This includes damage caused in the act of carrying out a development or as a failure to comply with a development consent or approval. Licences to cause harm or damage will only be granted for: scientific purposes; the welfare of fish or marine vegetation; or where there is threat to life or property.

The FM Act also includes and allows for the preparation of Habitat Protection Plans. Those plans relevant to the study area include:

Habitat Protection Plan No. 1 General

This is an advisory document summarising various protective measures in relation to dredging and reclamation activities, fish passage requirements, and the protection of mangroves, other marine vegetation and snags.

Habitat Protection Plan No. 2 Seagrasses

The Plan deals specifically with the protection of seagrasses across NSW, and discusses activities which impact on seagrasses, including the construction of jetties, wharves, and bridges, dredging and reclamation, and the collection of seagrasses.

Threatened Species Act 1995

The *Threatened Species Conservation Act 1995* (the TSC Act) aims to conserve biological diversity and promote ecologically sustainable development, by providing for the identification, protection and recovery of threatened species, populations, endangered ecological communities and their critical habitats. The TSC Act also aims to eliminate or manage processes that may threaten the survival of threatened species, populations or ecological communities.

Within the TSC Act:

- Schedule 1 lists endangered species, endangered populations, endangered ecological communities, species presumed to be extinct and critically endangered species and ecological communities (Schedule 1A);
- Schedule 2 lists vulnerable species and vulnerable ecological communities; and
- Schedule 3 lists key threatening processes.

The TSC Act has established a committee that is responsible for determining species, populations, ecological communities or threatening processes that should be included in Schedules 1, 2 or 3, or such can be listed upon request by the Minister (for the Environment, Climate Change and Water who administers this act).

The TSC Act does not include fish or marine vegetation as defined within Part 7A of the FM Act, i.e., such threatened species are covered by the FM Act. However, there is some overlap between the acts, and where a plant or animal may inhabit a terrestrial environment at some stage during its biological development, in concurrence with the Minister administering the FM Act, it may be listed in the TSC Act.

It is an offence under the TSC Act (and the *National Parks and Wildlife Act 1974* (NPW Act)) to harm, damage or pick an animal or plant that is, is part of, is critical habitat for, or is habitat for a threatened species, population or ecological community, unless a licence has been obtained under the TSC Act or NPW Act.

One example of an endangered ecological community located within the Pindimar study area are coastal saltmarsh.

National Parks and Wildlife Act 1974

The objectives of the National Parks and Wildlife Act 1974 are:

- the conservation of nature, including habitats, ecosystems, ecosystem processes, biological diversity at the community, species and genetic levels, landforms of significance including geological features and processes, and landscapes and natural features of significance including wilderness and wild rivers;
- the conservation of objects, places or features (including biological diversity) of cultural value within the landscape, including of Aboriginal significance, of social value to the people of NSW and of historic, architectural or scientific significance;
- fostering public appreciation, understanding and enjoyment of nature and cultural heritage and their conservation; and
- providing for the management of land reserved under the NPW Act.

The objectives of the NPW Act are to be achieved by applying the principles of ecologically sustainable development (ESD).

The NPW Act was responsible for the establishment of the NSW National Parks and Wildlife Services (NPWS) which is now part of OEH. The officers are responsible for administering the NPW Act including national parks and other lands under this act, and also administration of the *Wilderness Act 1987* and the TSC Act 1995.

For the Pindimar study area, the NPW Act provides support to the conservation of threatened species as listed in the TSC Act. In addition, it is an offence under the NPW Act to damage, deface or destroy items of Aboriginal heritage (places, objects) without approval from the Director-General for OEH. The study area does not include any areas of National Parks, although it is adjacent to areas of the Myall Lakes NP.

Marine Parks Act 1997 and Marine Parks Regulation 2009

The Marine Parks Act 1997 (the MP Act) objectives are:

- To conserve marine biological diversity and marine habitats by declaring and providing for the management of a comprehensive system of marine parks;
- To maintain ecological processes in marine parks;
- To provide for ecologically sustainable use of fish (including commercial and recreational fishing) and marine vegetation in marine parks; and
- To provide opportunities for public appreciation, understanding and enjoyment of marine parks.

The Minister for Environment, Climate Change and Water in combination with the Minister for Industry and Investment (Fisheries) administer this act.

The MP Act provides for the creation of marine parks. Once a marine park has been created it cannot be revoked, except by an Act of Parliament. Once a marine park has been declared, a zoning plan is created to regulate activities within the marine park in a manner that is consistent with the objectives of the MP Act. A zoning plan may include:

- classification of areas within a marine park, e.g. as sanctuary zones, habitat protection zones and general use zones;
- uses that are permitted or prohibited in these zones; and
- management of such zones.

The declaration of an area as a (or part of a) marine park overrides the declaration of the area as an aquatic reserve under the FM Act. Further, areas within a marine park cannot be declared as aquatic reserves under the FM Act. Marine parks cannot be declared for areas above the mean high water mark without the consent of the owner of the land, or the Minister administering the Crown Lands Act 1989 for Crown Lands.

The Pindimar study area lies within the Port Stephens-Great Lakes Marine Park, which extends from Cape Hawke (Forster) to Birubi Beach (the northern end of Stockton sand spit), and includes Port Stephens estuary, the Karuah River, the Myall River, Myall and Smiths Lakes and all of their creeks and tributaries to the tidal limit. Thus, the marine park covers tributaries and creeks within the Pindimar study area (e.g., Duck Hole Creek, Kore Kore Creek, unnamed creek on Cambage St), in addition to the estuary foreshores. According to the Zoning Plan for the park:

- Piggies Beach (as well as Nanabah Creek flowing into Fame Cove, and the northern end of North Arm Cove) is within the sanctuary zone as shown in Figure 10-3, meaning only non-extractive activities are permitted such as navigation, scuba diving, snorkelling, with permits required for indigenous fishing, non-extractive charter tours, research and organised sporting activities;
- The remaining foreshore of the Pindimar Study area is within the General Use Zone; and
- The shoreline and waterway between Fame Cove and Soldiers Point, which lies between the Bundabah and Pindimar study area foreshores, is classed as Habitat Protection Zone.

The table of permissible uses for each of these zones is given in Figure 10-4.

Consent authorities (either local government under Part 4 or the Minister under Part 5 of the EPA Act) must take into consideration the MP Act and permissible uses of the park and areas according to the zoning plan, as well as consult with the relevant Ministers prior to granting approval for an activity or development. This applies to all foreshore development in the Pindimar study area. While foreshore land above the mean high water mark may be owned privately, development upon this land may affect the marine park (including its plants, animals and / or habitat) and thus must be assessed in this manner.

Consent is required from the Minister under the provisions outlined in the *Marine Parks Regulations 2009*, for undertaking works in marine parks that will potentially harm marine animals. However, the regulations state that there are certain circumstances within which consent must be refused, including:

- carrying out any activity in a marine park that is inconsistent with the objects of the MP Act;
- carrying out any activity in a zone of a marine park that is inconsistent with the objects of the zone (except in an emergency); and
- carrying out any activity that is contrary to provisions of any determination in force, such as restrictions on the number of permits issued within a marine park or zone.

Consent given must be consistent with the assessment criteria outlined within the regulation, which ensures the activity is consistent with the objectives of the park, zone, park operational plan, effects upon threatened species (i.e. as listed in the FM Act, NPW Act 1974, TSC Act 1995); form of transport to be used, type of equipment to be used, and the proposed arrangements for repairing ('making good') any damage to the marine parks arising from the activity. The regulation makes particular note that nothing in the regulation shall be construed as authorising the harm (by any method) of any particular species (fish or plant).

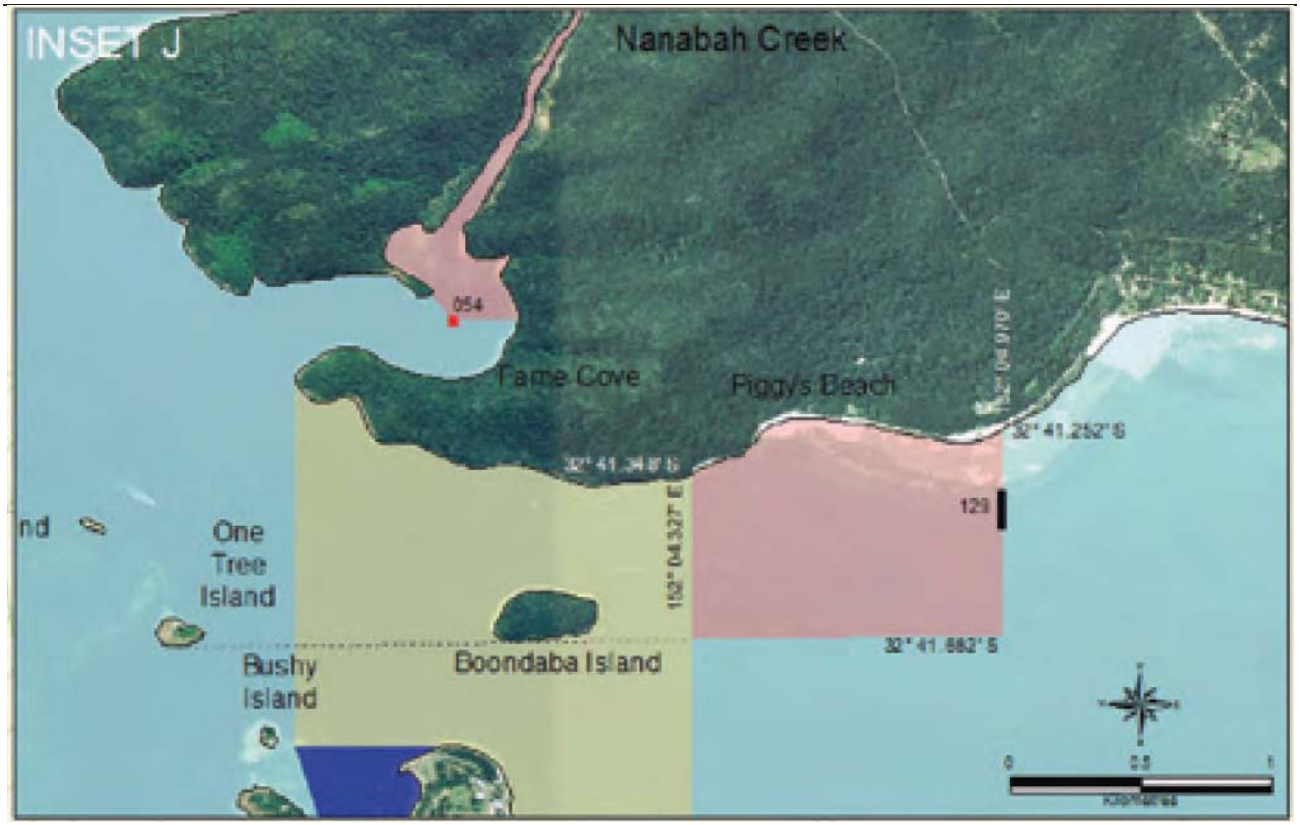


Figure 10-3 Piggy's Beach and Fame Cove Marine Park Zoning

ACTIVITY	General Use Zone	Habitat Protection Zone	Sanctuary Zone
RECREATIONAL FISHING[1]		*	
Line fishing	✓	✓*	×
Spearfishing	✓	✓*	×
Trapping	✓	✓*	×
Nets (scissor, hand hauled, scoop, landing, hoop)	✓	✓*	×
COLLECTING[1]			
Recreational shell collecting	✓[2]	✓*[2]	×
Collecting for aquariums - commercial and private	P	P*	×
Recreational seaweed collection	✓[2]	✓*[2]	×
TRADITIONAL			
Indigenous fishing	✓	✓	P
NON-EXTRACTIVE RECREATIONAL ACTIVITIES			
Navigation of vessels	✓	✓	✓
SCUBA diving and snorkelling	✓[3]	✓[3]	✓[3]
Motorised water-sports	✓	✓	×[4]
Hovercraft, airboat and seaplane	P	P	P
Domesticated animals	✓[5]	✓[5]	✓[5]
COMPETITIONS			
Line and spearfishing	P	P*	×
Other (non-extractive)	P	P	P
OTHER ACTIVITIES			
Aquaculture	✓[1]	P[1]	×
Anchoring	✓	✓	✓[6]
Organised sporting or other activity	P	P	P
Research	P	P	P
COMMERCIAL TOURIST ACTIVITIES			
Commercial tour operators (non-extractive)	P	P	P
Charter fishing	P	P*[1]	×
COMMERCIAL FISHING[1]			
Fish and prawn trawling	✓[7]	×	×
Beach hauling/purse seine/lift net	✓	×[8]	×
Line fishing	✓	✓*	×
Fish and lobster trapping	✓	✓*	×
Hand gathering	✓	✓*	×
Longline/setline/dropline	×	×	×
Estuary prawn netting	✓	×[9]	×
Estuary – mesh and haul netting	✓[10]	×	×
Crab and eel trapping	✓	✓*	×

A summary of activities permitted and restrictions which apply are detailed above.
Refer to the *Marine Parks Regulation 1999* for full details.
Note: All other relevant legislation continues to apply in addition to the zoning plan.

Activity table Symbols

*	(a) Land based line fishing is the only method of fishing permitted in the Little Beach Habitat Protection Zone. Fishing is only permitted from the wheelchair access jetty, the Little Beach jetty and from the beach between these jetties. (b) No collecting in the Dutchmans Beach habitat protection zone. (c) Cabbage Tree Island habitat protection zone restricted to the taking of yellowtail scad, slimy mackerel and garfish only. (d) No fishing with bait in the hatched habitat protection zones of Broughton Island, Sawtooth and Edith Breakers. (e) No fishing from anchored vessels in Broughton Island and Sawtooth cross-hatched habitat protection zones. (f) Recreational trolling only permitted in the stippled Open Ocean restricted habitat protection zone (offshore Broughton Island) from 1 December to 30 April (inclusive) each year. No fishing from anchored or drifting vessels (trolling only) and no fishing permitted outside specified timeframe. **Refer to General Activities Guide overleaf.**
✓	Activity is permitted in the zone.
×	Activity is not permitted in the zone.
P	Marine Parks Authority permit required.
1	Requires licence/lease under the Fisheries Management Act 1994, and is subject to the provisions of the zoning plan.
2	Restrictions apply. Daily possession limit of 5 shells of any one species and 20 litres of seaweed. No collecting at Little Beach, Dutchmans Beach or Cabbage Tree Island habitat protection zones.
3	Restrictions apply in grey nurse shark critical habitats. Refer to General Activities Guide overleaf.
4	Permissible in Smiths Lake and Boolambayte Lake sanctuary zones, and (by permit) in the Fly Point – Corrie Island sanctuary zone.
5	Subject to restrictions - refer to General Activities Guide overleaf.
6	Not permissible to anchor on seagrass in sanctuary zones.
7	Fish trawling and prawn trawling are not permitted in estuaries, lakes and rivers.
8	Permissible only at designated locations. Refer to General Activities Guide overleaf.
9	Permissible only in Smiths Lake habitat protection zone and Myall River Camp habitat protection zone.
10	Bombah Broadwater annual seasonal commercial netting closure – between 1 May and 31 August (inclusive) in any year.

Figure 10-4 Permissible Uses in Marine Park Zones

Water Management Act 2000

The *Water Management Act 2000* (the WM Act) seeks to promote the integrated and sustainable management of the States waters for the benefit of both present and future generations. Of key relevance to the Study area, the Act aims in particular "to protect, enhance and restore water sources, their associated ecosystems, ecological processes and biological diversity and their water quality". The Water Management Act 2000 replaced the Rivers and Foreshores Improvement Act 1948 (RFI Act 1948) in February 2008.

With respect to the Pindimar foreshores, the WM Act outlines those activities for which a 'controlled activities approval' is required for works on waterfront land. The WM Act defines waterfront land as all land between the bed of a watercourse and a distance of 40 m from: the top the highest bank of a river (including creeks); shores of a lake; or, mean high water mark of an estuary or coastal waters (including lakes and lagoons). Therefore, controlled activities approval is required for the following activities on all foreshores of the Study area within 40 m of the mean high water mark:

'(a) the erection of a building or the carrying out of a work (within the meaning of the EPA Act), or

(b) the removal of material (whether or not extractive material) or vegetation from land, whether by way of excavation or otherwise, or

(c) the deposition of material (whether or not extractive material) on land, whether by way of landfill operations or otherwise, or

(d) the carrying out of any other activity that affects the quantity or flow of water in a water source.'

Exemptions from the WM Act are defined in Clause 39A of the Water Management (General) Regulation 2004 and include exemptions for government authorities, with the exception of Landcom.

Local Government Act 1993

The *Local Government Act 1993* (the LG Act) creates local governments and grants them the power to perform their functions, which involve management, development, protection, restoration, enhancement and conservation of the environment for the local government area. The functions of the local government are to be performed in a manner that are consistent with and promote the principles of ecologically sustainable development.

The Local Government (Ecologically Sustainable Development) Act 1997 amends this Act, so that the guiding operational principles are ecologically sustainable development and sustainable use of resources.

Under this act, Council is conferred other functions under other state legislation, including (of relevance to the study area) the EPA Act, the *Protection of the Environment Operations Act, 1997*, and the *Coastal Protection Act, 1979*.

The service functions of local councils are defined in Chapter 6 of the LM Act. Of relevance to the management of foreshores in the study area, Council's service functions include environment conservation, protection and improvement services and facilities.

The service functions of council also relate to the classification, use and management of public land, including the process of the preparation of plans of management, and including those areas of public land which comprise "critical habitat" designated under the TSC Act or FM Act.

Crown Lands Act 1989

The *Crown Lands Act 1989* (the CL Act) provides for the administration and management of Crown land for the benefit of the people of NSW. The CL Act provides principles for the proper assessment, development, reservation or dedication and conservation of Crown Lands. Water bodies such as estuaries to the mean high water mark, including beaches and foreshores, are designated as Crown Land. Thus, the CL Act applies to any activity undertaken below the mean high water mark of the study area, as this is Crown Land.

The principles of Crown Land management are that: environmental protection principles be observed; natural resources of Crown Land (including water, soil, flora, fauna and scenic quality) be conserved wherever possible; public use and enjoyment of Crown lands be encouraged; and Crown Land be used and managed in such a manner that the land and its resources are sustained in perpetuity.

The CL Act requires for land assessment to be undertaken to ensure that the reservation, dedication, exchange, vesting or sale of Crown land, or the granting of easements, leases or licences in respect of such land is consistent with the principles stated above. The process for land assessment is specified by the CL Act and the *Crown Lands Regulation 2000*. It requires the physical characteristics of the land to be identified, the land's capabilities to be assessed and suitable uses identified.

SEPP 14 – Coastal Wetlands

State Environmental Planning Policy (SEPP) 14 – Coastal Wetlands was designed to protect and preserve coastal wetlands for the environmental and economic interests of the State. The policy provides protection to specific wetland areas that have been mapped and gazetted by Department of Planning. Development that involves the following activities is not allowed to be carried out unless consent (as 'designated development') is provided by local council or the Director General of Planning: clearing of land, construction of levees, draining of land, and filling of land. If this development is to be carried out, an Environmental Impact Statement first needs to be prepared.

The Director General of Planning must consider a number of matters prior to agreeing to the proposed development including:

- The environmental effect of the proposed development;
- Whether adequate safeguard and rehabilitation methods are proposed;
- Whether the development is consistent with the aims of the policy; and
- Whether any feasible alternatives have been considered and if so, the reason for choosing the proposed development.

There are a number of SEPP14 Coastal Wetlands directly within the study area (Nos 754, 756, 757a, 757b) for which the provisions of the SEPP apply.

SEPP (Infrastructure) 2007

SEPP (Infrastructure) 2007 provides a consistent planning regime for infrastructure and the provision of services across NSW, including consultation with relevant public authorities during the assessment process. The intent of the SEPP is to support greater flexibility in the location of infrastructure and service facilities along with improved regulatory certainty and efficiency for the State.

The SEPP also relates to 'waterway or foreshore management activities' (Division 25), which are defined as:

'(a) riparian corridor and bank management, including erosion control, bank stabilisation, resnagging, weed management, revegetation and the creation of foreshore access ways, and

(b) instream management or dredging to rehabilitate aquatic habitat or to maintain or restore environmental flows or tidal flows for ecological purposes, and

(c) coastal management and beach nourishment, including erosion control, dune or foreshore stabilisation works, headland management, weed management, revegetation activities and foreshore access ways.'

Section 129 of the SEPP states that development for the purposes of waterway or foreshore management activities (such as defined above) may be carried out by or on behalf of a public authority (i.e. Council) without consent on any land. Such activities include:

- construction works;
- routine maintenance works;
- emergency works, including works required as a result of flooding, storms or coastal erosion;
- environmental management works.

Thus for the study area, Council is permitted to undertake foreshore management (such as a revetment wall, environmental rehabilitation etc), provided they undertake a Review of Environmental Factors (REF) and gain approvals under other legislation for foreshore areas noted above.

It should be noted that SEPP (Infrastructure) 2007 repeals SEPP 35 Maintenance Dredging of Tidal Waterways.

SEPP 71 – Coastal Protection

SEPP No. 71 – Coastal Protection aims to ensure that development in the NSW coastal zone is appropriate and suitably located. The policy provides protection of and improvement to public access for coastal foreshores, compatible with the natural attributes of the foreshore, and protects and preserves Aboriginal cultural heritage, visual amenities of the coast, the beach environment and amenity, native coastal vegetation, marine environment of New South Wales, and rocky platforms. In addition, the policy aims to carry out management of coastal zones in accordance with the principles of the Ecologically Sustainable Development (ESD). SEPP 71 applies to all lands within the coastal zone of NSW.

SEPP 71 also outlines the conditions for which the Minister for Planning becomes the consent authority for 'significant coastal development'. SEPP 71 defines this as development in 'sensitive coastal locations' namely land within 100 metres of and below mean high water mark of the sea, a bay or an estuary. Thus, foreshore land in the Study area is classed as a 'sensitive coastal location'. Development applications received by Council on such lands must be sent to the Director-General of Planning, and Council is required to take the 'matters for consideration' given in Clause 8 of SEPP 71 into account when determining the application. The Director-General may specify additional matters for consideration by Council in determining the application. The 'matters for consideration' achieve the intent of the SEPP 71.

A master plan is required to be submitted and adopted by Minister for Planning (prior to Council granting consent) for subdivision of land within a residential zone or rural residential zone if part or all of the land is in a 'sensitive coastal location'. This would apply to any future subdivision of land in the Study area. Generally a master plan is a document consisting of written information, maps and diagrams that outline proposals for development of land.

NSW Coastal Policy 1997 and Coastal Protection Act 1979

The NSW Coastal Policy 1997 sets the strategic framework for coordinated, integrated and ecologically sustainable development of the coastal zone in NSW. The Policy details nine goals and

associated objectives and strategic actions for achieving ecologically sustainable development in NSW.

The NSW *Coastal Protection Act 1979* (the CPA Act) provides guidance on the use, occupation and development of the coastal zone in NSW. The CPA Act was amended in 2002 to better reflect the purpose of the NSW Coastal Policy (1997) and to incorporate the principles of ecologically sustainable development. Key objectives of the CPA Act relevant to this study are: to protect, enhance, maintain and restore the environment of the coastal region; to ensure orderly and balanced utilisation and conservation of the coastal region having regard to the principles of ESD; and to promote public pedestrian access and recognise the public's right to access to the coastal region. The CPA Act applies to the coastal zone of NSW, and this includes the foreshores of the Pindimar Study area as part of Port Stephens estuary.

Under the CPA Act, the public has the right to access foreshore land, even where this is in private land ownership.

The CPA Act provides specific regulation regarding water boundaries that are defined by the mean high water mark, such as along the foreshores of Pindimar and Bundabah. A court, the Registrar General, nor the Minister of Lands does not have power to declare a new boundary that would increase the area of land on the landward side if:

- the perceived trend of accretion is not likely to be sustained indefinitely by natural means, or
- as a consequence of declaring the new boundary, public access to a beach, headland or waterway will or is likely to be restricted or denied.

Thus, illegal land reclamations undertaken along these foreshores (either past or present) have no basis in law to define a new boundary. New boundaries cannot be declared where artificial land reclamation or ongoing artificial nourishment will be required to maintain the boundary This ruling is additional to the other NSW legislation which prohibits land reclamation activities for the purpose of private gain, particularly where public access is further diminished.

APPENDIX C: MEDIA RELEASE BROCHURE & QUESTIONNAIRE

Pindimar, Lower and Upper Pindimar, and Bundabah Foreshore Erosion Study

Information Newsletter *July 2009*

Great Lakes Council has engaged environmental consultants BMT WBM to undertake a study of foreshore erosion at Pindimar, Lower Pindimar, Upper Pindimar and Bundabah. These foreshores have been eroding for many years, resulting in loss of land. A number of artificial walls and other structures have been built to try and stop the erosion.

The study aims to identify causes of foreshore erosion at these locations, and ways to treat the erosion that are friendly to the environment, effective, and easily applied.

This study builds on the Port Stephens Foreshore Management Plan (draft 2009), which stated that erosion at Lower Pindimar, Pindimar and Bundabah was an issue requiring further detailed investigation and treatment.

The Study Area: Upper Pindimar, Pindimar, Lower Pindimar & Bundabah

Example of erosion at Pindimar

As a first step towards understanding the foreshore erosion, we are seeking information from residents about the erosion. Specifically, we are requesting:

- **Photographs** of the foreshore before and / or after erosion (they can be old or new photos)
- **Local knowledge** and stories of erosion events
- **Newspaper clippings**; and
- **Any other records** about erosion events.

If you have any information you feel will be valuable to our study, please forward a copy or contact either:

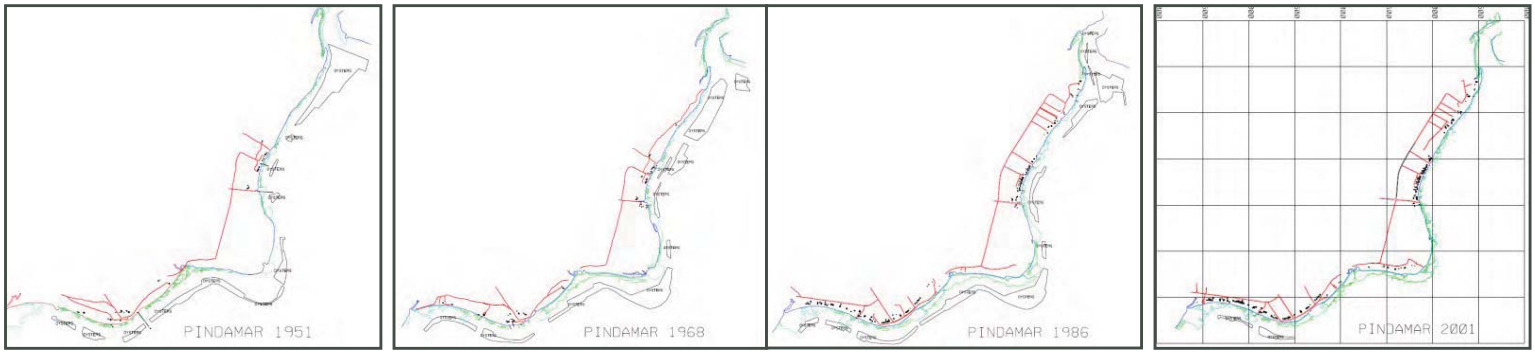
Ms Verity Rollason, BMT WBM
PO Box 266, Broadmeadow NSW 2292 (02) 4940 8882
vrollason@wbmpl.com.au

Ms Prue Tucker
Great Lakes Council
PO Box 450, Forster NSW 2428
(02) 6591 7374
Prue.Tucker@greatlakes.nsw.gov.au

BMT WBM

Great Lakes COUNCIL

What do we know about the erosion so far?



Change in shoreline between 1951 and 2001, showing change in oyster leases (black), seagrass (green) and the shoreline (blue)

A number of studies and plans have been completed over the last 10 years about the Port Stephens / Myall Lakes Estuaries. As part of these studies, erosion on the foreshores of Pindimar, Lower Pindimar and Bundabah has been noted.

Erosion is not only an issue for foreshore residents, but it can also damage the seagrasses, mangroves and saltmarsh habitats that are located around the foreshores and in the shallow water. The erosion is also considered to be visually unappealing, especially from the water.

The studies to date have not fully investigated why erosion is occurring however, they have suggested a number of possible causes, including:

- The **removal of mangroves**, which has exposed the natural sandy and muddy shorelines to waves and currents
- **Wind waves,** which are created by wind blowing across the waterway of Port Stephens
- **Ocean waves,** which during large ocean swells can travel inside and through Port Stephens to the shoreline
- **Currents driven by the tide,** and which change in response to changing sand shoals in the waterway
- **A combination of all these factors**

The studies also described that natural shorelines "evolve" over time – that is, soft shorelines will naturally erode or build up in response to changes in waves, tides and currents.

The Pindimar, Lower and Upper Pindimar and Bundabah Foreshore Erosion Study hopes to answer some of these fundamental questions, and identify practical measures to stop the erosion from impacting on the foreshore.

Your assistance in this process, through providing photos and accounts of erosion, is greatly appreciated.

BMT WBM

Great Lakes COUNCIL

Mangroves provide natural protection to the shoreline

Pindimar, Lower and Upper Pindimar and Bundabah Foreshore Erosion Study

Questionnaire

Overview

Great Lakes Council has appointed environmental consultants BMT WBM to undertake a study of the erosion on Pindimar, Lower Pindimar, Upper Pindimar and Bundabah foreshores. The study aims to identify causes of foreshore erosion at these locations, and ways to treat the erosion that are friendly to the environment, effective, and easily applied.

As a first step towards understanding the foreshore erosion, we are seeking information from residents living on the foreshores. We are particularly interested in what you have noticed over the years in relation to when, where and how much foreshore erosion is occurring. It would be appreciated if you could please take the time to assist us by answering this questionaire and provide responses wherever you can.

If you have any old or recent photos of the foreshore, newspaper clippings or other details, we would greatly appreciate if you would allow us to make copies of these records. The information you provide will be used to inform the technical component of in the study.

A map of the study areas is provided on the back of this questionnaire.

Site Inspection and Invitation

On the 17th and 18th August 2009, we will be conducting a site inspection of the foreshores of Pindimar, Lower Pindimar, Upper Pindimar and Bundabah. During the inspection we will be accessing public and private foreshores to assess erosion and its causes.

As part of this inspection we are offering an invitation to foreshore residents to discuss the erosion issues with us in person. If you would like to meet with us, please fill out your contact details at the end of the questionnaire and we will contact you to arrange a suitable time during our site inspection.

How many years have you lived in the area?

❑ 0-5 years ❑ 5-10 years ❑ 10-20 years

❑ more than 20 years

Have you observed erosion on the foreshore of your property?

❑Yes ❑ No

Have you observed erosion elsewhere on the foreshore near where you live?

❑Yes ❑ No

If yes, please indicate where this erosion is occurring - For example, at the boat ramp, at the public reserve etc. If possible, please provide the address or a street name for this location.

_____

_____

_____

Please draw a sketch of the erosion (either at your property, or elsewhere as indicated above). If known, please draw the location of the shoreline before the erosion, the location of the shoreline now, and the distance between the old and new shoreline (eg, in metres).

Are there any markers (eg, tree, shed, fence post, etc) which show the location of the shoreline before and/or after the erosion? Please describe the markers below, or indicate the markers on the sketch also.

_____

_____

Do you have any photographs of the shoreline before and / or after the erosion?

_____

When did you first notice erosion was occurring (year or more exact date if known)?

_____

Is the erosion occurring **quickly** or **slowly**?

❑ Quick (eg, 1 m per year of foreshore loss) ❑ Slow (eg, a few centimetres per year)

Estimated rate or erosion (approximate) _____ m per year

Has the erosion ever recovered naturally?
For example, has sand/mud been deposited naturally to build the shoreline back out? Please describe when this occurred and any other details (eg how or why this occurred).

_____

_____

_____

_____

_____

Have you noticed any particular **weather conditions** happening when the erosion occurs? For example, strong winds, waves coming into Port Stephens from the ocean, or big tides? Tick if appropriate below, and describe what you have seen.

- ❑ Strong wind?
- ❑ Waves/Seas caused by the wind?
- ❑ Waves coming in from the ocean?
- ❑ Big tides (that is, larger than normal high tide)

Can you describe these conditions, for example, the direction that the wind was coming from? Or the date(s) that this occurred?

In your opinion, what caused the erosion you have observed?

Have you noticed **any changes on the foreshore in recent years** that you feel have **made the erosion worse**? Please describe how you think this change has made the erosion worse.

For example, the removal of mangroves, construction of seawalls, vertical walls of any material, groynes etc. If you wish, you may indicate these changes / features on the attached map.

Please feel free to express here any additional personal comment / opinion about your experience of the foreshore erosion in the Study area including any suggestions for resolving the erosion issues?

As part of the study, we may want to clarify some of the information you have provided, or take measurements of the erosion you have specified.

Please fill in your contact details below and indicate whether you would like us to contact you should we need to discuss issues associated with this study and / or your responses.

I am happy for you to contact me / us to discuss issues associated with this study and to receive further information about this project

❑ Yes ❑ No

Contact Name _____

Contact Phone No. _____

Address: _____

_____

If you would like us to contact you to arrange a meeting during the site inspection (17th & 18th August, 2009) please tick yes to the question below?

❑Yes

For more information regarding this study, please contact:

Ms Prue Tucker
Great Lakes Council
(02) 6591 7374
Prue.Tucker@greatlakes.nsw.gov.au

Ms Verity Rollason
BMT WBM
(02) 4940 8882
vrollason@wbmpl.com.au

Please return completed questionnaire to:

Attention: Verity Rollason

BMT WBM

PO Box 266

BROADMEADOW NSW 2292

Privacy Statement

The information provided in this survey may constitute personal information as defined in the Privacy and Personal Information Protection Act 1998. Council is collecting this information as part of the study indicated. The information may be made available to other parties where such access is in accordance with relevant legislation, regulation or policy to contractors / consultants engaged by Council as part of this study or projects that may arise from the results of this study. The submission of personal information is voluntary. Council is to be regarded as the agency that holds the information, which will ultimately be stored in councils records system. Enquiries concerning matters of privacy can be addressed to Council's Privacy Contact Officer.

Questionnaire Authorised by Great Lakes Council

Title:

Study Area: Upper Pindimar, Pindimar, Lower Pindimar and Bundabah Foreshores

Figure:

Rev:

N

BMT WBM

www.wbmpl.com.au

Filepath :

APPENDIX D: WAVE AND WIND DATA

Table 10.5 Percentage Occurrence Wave Height, Sydney March 1992 to June 2009

H_s (m)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
0 – 0.49	100	100	100	100	100	100	100	100	100	100	100	100	**100**
0.5 – 0.99	99.96	99.99	100	99.9	99.61	99.54	99.71	99.43	99.95	99.84	99.89	99.91	**99.803**
1 – 1.49	89.44	88.99	91.98	87.62	79.15	77.68	79.34	77.75	79.85	85.05	87.56	84.13	**83.784**
1.5 – 1.99	47.28	49.75	52.45	49.23	50.31	49.05	46.83	43.07	41.47	45.35	46.61	44.63	**47.12**
2 – 2.49	18.65	21.05	24.41	25.67	27.42	27.75	26.28	21.73	19.74	18.82	21.45	18.89	**22.777**
2.5 – 2.99	6.43	8.3	10.78	11.82	12.65	15.69	14.53	10.29	9.1	8.15	10.54	7.36	**10.595**
3 – 3.49	2.72	2.94	5.19	6.02	6.48	9.42	7.61	5.47	4.49	4.05	5.69	2.99	**5.349**
3.5 – 3.99	1.03	1.22	2.71	3.14	2.67	5.72	3.96	2.63	1.88	2.15	3.22	1.18	**2.676**
4 – 4.49	0.3	0.51	1.04	1.52	1.16	3.45	2.32	1.56	0.86	1.16	1.59	0.44	**1.361**
4.5 – 4.99	0.07	0.22	0.53	0.67	0.7	1.97	1.38	0.81	0.47	0.43	0.89	0.16	**0.714**
5 – 5.49	0	0.05	0.33	0.25	0.59	1.13	0.62	0.37	0.08	0.12	0.42	0.04	**0.345**
5.5 – 5.99	0	0.01	0.2	0.08	0.37	0.68	0.3	0.13	0.03	0.06	0.18	0	**0.177**
6 – 6.49	0	0	0.08	0.03	0.19	0.27	0.18	0.02	0	0	0.03	0	**0.071**
6.5 – 6.99	0	0	0.01	0	0.15	0.03	0.07	0	0	0	0	0	**0.023**
7 – 7.49	0	0	0	0	0.11	0	0	0	0	0	0	0	**0.01**
7.5 – 7.99	0	0	0	0	0.05	0	0	0	0	0	0	0	**0.004**
8 – 8.49	0	0	0	0	0.04	0	0	0	0	0	0	0	**0.003**
8.5 – 8.99	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Average (m) :	1.57	1.62	1.79	1.63	1.67	1.73	1.66	1.55	1.54	1.58	1.61	1.54	1.63
Maximum (m) :	4.92	5.53	6.61	6.18	8.43	6.87	6.96	6.09	5.78	5.81	6.22	5.49	8.43
Minimum (m):	0.48	0.5	0.59	0.38	0.4	0.39	0.39	0.4	0.45	0.43	0.38	0.46	0.38

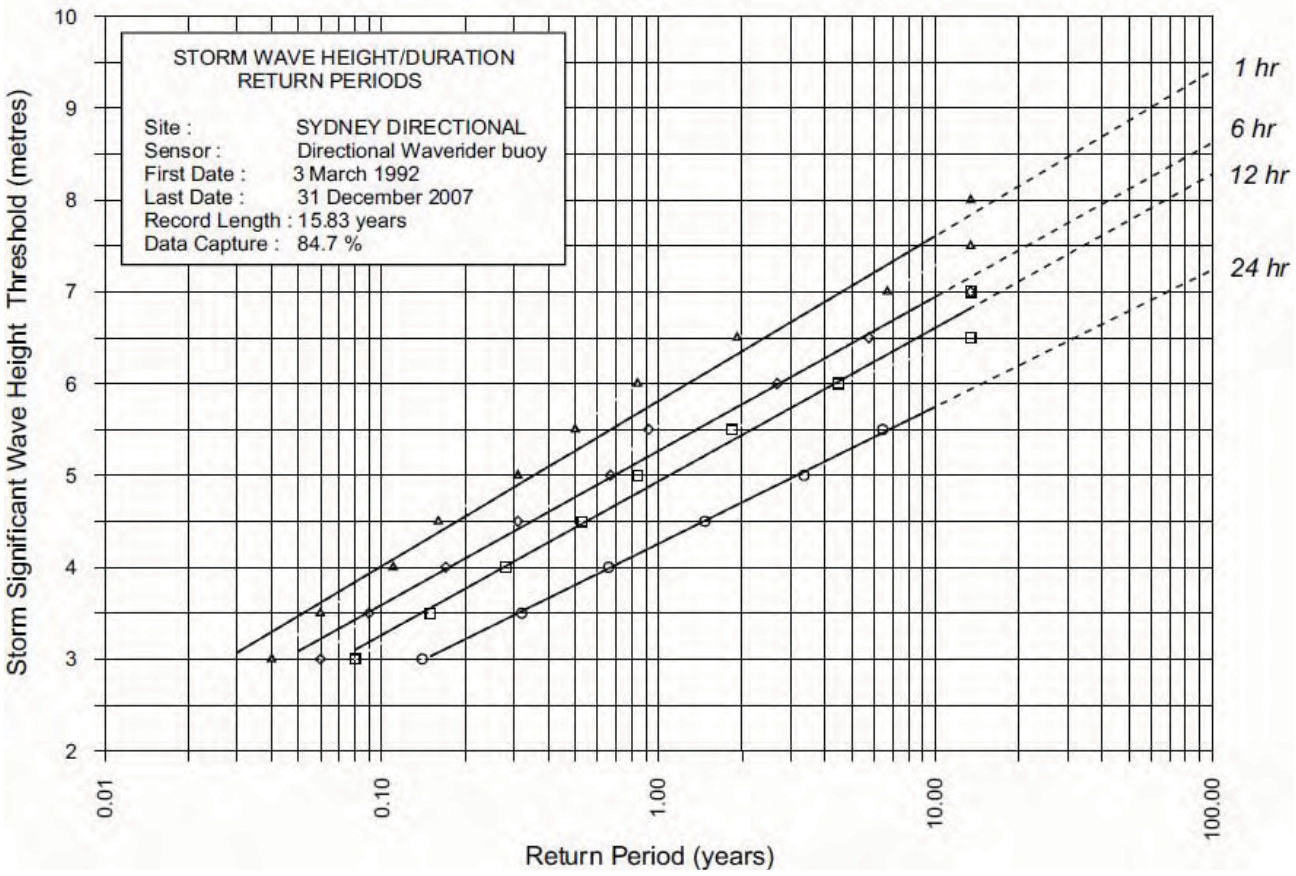


Figure 10-5 Wave Height / Duration Curves for Sydney (MHL, 2009)

Table 10.6 Percentage Occurrence Wave Direction, Sydney, March 1992 – June 2009

DIR'N	DEGREES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
N	*348.75 - 11.24*	0	0	0	0	0	0	0	0	0	0	0	0	**0**
NNE	**11.25 - 33.74**	0.16	0.01	0.06	0.1	0.06	0.05	0.04	0.11	0.09	0.26	0.04	0.09	**0.091**
NE	**33.75 - 56.24**	4.4	2.87	2.66	2.06	1.37	1.07	0.87	1.63	4.94	5.83	4.4	5.15	**3.057**
ENE	**56.25 - 78.74**	16.62	14.07	9.77	6.51	6.33	3.54	3.5	4.7	9.85	11.19	13.77	11.72	**9.033**
E	**78.75 - 101.24**	18.83	17.68	16.74	11.56	9.67	8.6	9.48	5.64	7.66	9.3	9.85	10.56	**11.086**
ESE	**101.25 - 123.74**	11.05	13.32	12.73	13.68	10.25	9.98	12.51	7.46	6.77	7.63	8.66	9.11	**10.227**
SE	**123.75 - 146.24**	11.98	12.16	17.1	18.86	18.22	17.03	19.38	20.21	17.32	13.08	14.18	14.36	**16.312**
SSE	**146.25 - 168.74**	18.82	20.18	24.59	30.03	34.13	40.23	35.74	39.73	32.94	29.35	24.22	24.93	**29.998**
S	**168.75 - 191.24**	16.9	19.07	15.26	16.41	18.91	18.7	16.59	19.09	18.81	21.67	23.02	22.59	**18.884**
SSW	**191.25 - 213.74**	1.22	0.65	1.06	0.64	0.52	0.41	0.76	0.84	0.85	1.41	1.82	1.39	**0.954**
SW	**213.75 - 236.24**	0	0	0.03	0.1	0.11	0.05	0.22	0.03	0.15	0.07	0	0.02	**0.067**
WSW	*236.25 - 258.74*	0	0	0	0	0.03	0.03	0.1	0.05	0.16	0.05	0.03	0.01	**0.04**
W	*258.75 - 281.24*	0.01	0	0	0.04	0.05	0.12	0.27	0.12	0.15	0.05	0.01	0.02	**0.073**
WNW	*281.25 - 303.74*	0	0	0	0	0.1	0.07	0.28	0.1	0.17	0.1	0.01	0.03	**0.077**
NW	*303.75 - 326.24*	0	0	0	0	0.16	0.08	0.15	0.19	0.08	0.02	0	0.02	**0.062**
NNW	326.25 - 348.74	0	0	0	0	0.06	0.03	0.08	0.08	0.01	0	0	0.01	0.024
	Average :	120.37	123.6	128.12	135.53	138.79	144.56	142.69	144.96	136.64	134.06	132.3	133.07	134.87
	Maximum :	277	208	221	281	351	357	358	355	356	325	297	330	358
	Minimum :	21	33	21	3	20	10	23	15	0	20	33	7	0

Table 10.7 Percentage Occurrence Wave Period, Sydney March 1992 to June 2009

T_P (s)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
0.00 - 1.99	0	0	0	0	0	0	0	0	0	0	0	0	0
2.00 - 3.99	0.08	0.05	0.06	0.17	0.46	0.51	0.72	0.66	0.59	0.35	0.14	0.27	0.353
4.00 - 5.99	8.56	7.44	4.03	5.38	3.13	2.34	3.2	4.21	6.05	9.1	9.59	9.88	5.962
6.00 - 7.99	27.13	23.32	13.87	10.85	8.37	8.43	6.37	10.75	15.04	20.56	25.38	25.23	15.848
8.00 - 9.99	31.15	28.89	30.23	26.01	26.74	21.43	22.33	22.32	27.76	26.59	29.9	26.91	26.513
10.00 - 11.99	26.1	25.68	32.01	34.01	38.84	37.5	41.89	37.33	33.76	29.16	27.3	26.91	32.884
12.00 - 13.99	6.13	12.71	16.82	19.13	17.68	23.36	20.06	18.92	12.53	10.28	7.08	9.48	14.759
14.00 - 15.99	0.71	1.72	2.72	3.64	3.96	5.31	4.84	4.7	3.5	2.76	0.61	1.24	3.067
16.00 - 17.99	0.14	0.19	0.24	0.7	0.74	1.09	0.54	1.08	0.68	1.01	0.01	0.06	0.56
18.00 - 19.99	0	0	0.02	0.09	0.07	0.04	0.05	0.03	0.11	0.14	0	0.02	0.049
20.00 - 21.99	0	0	0	0.02	0	0	0	0	0	0.05	0	0	0.006
Average (s) :	8.81	9.29	10.03	10.28	10.32	10.81	10.56	10.33	9.77	9.38	8.88	9.04	9.78
Maximum (s) :	17.1	17.1	19.7	20	19.7	19.7	18.18	18.18	19.7	20	17.1	19.7	20
Minimum (s):	3.33	3.8	3	2.8	2.77	2.8	2.85	2.77	3	2.6	3.4	2.6	2.6

Table 10.8 Maximum Yearly Wind Speeds for Wind Direction Octants (Williamtown)

Year	NN	NE	EE	SE	SS	SW	WW	NW
1989	31	39	48	46	48	55	50	55
1990	26	44	48	52	59	46	63	65
1991	30	44	46	42	50	48	67	65
1992	33	42	44	50	54	52	65	61
1993	41	37	39	46	50	48	63	63
1994	37	46	44	57	57	41	70	65
1995	37	39	41	48	55	54	57	55
1996	35	44	37	55	55	37	55	59
1997	28	39	48	39	55	44	55	46
1998	22	35	33	44	48	52	63	74
1999	18	33	35	42	46	59	59	57
2000	26	37	39	44	46	41	59	50
2001	30	39	41	48	57	41	50	61
2002	24	37	42	39	44	41	50	59
2003	35	39	39	41	50	46	57	72
2004	35	35	37	44	46	48	57	63
2005	28	33	39	46	54	52	65	54
2006	28	35	52	52	50	52	52	44
2007	28	33	39	67	42	37	57	55
2008	28	31	37	44	48	52	59	57
2009	33	33	41	46	50	39	63	65
MAX	**41**	**46**	**52**	**67**	**59**	**59**	**70**	**74**

APPENDIX E: WAVE MODEL OUTPUTS

Table 10.9 Modelled Swell Wave Heights at Shoreline Sections in the Study Area, 0.98 m WL

Water Level: 0.98 m			Lower Pindimar				Pindimar					Upper Pindimar					Bundabah	
		Shoreline Section	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Direction	H_s (m)	T_p	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)
NE	3.5	11	0.20	0.13	0.12	0.07	0.15	0.27	0.21	0.23	0.13	0.05	0.02	0.06	0.04	0.02	0.00	0.00
NE	4.5	11	0.24	0.15	0.14	0.08	0.18	0.33	0.25	0.27	0.15	0.06	0.02	0.07	0.05	0.03	0.00	0.00
ENE	3.5	11	0.25	0.15	0.14	0.09	0.20	0.36	0.28	0.30	0.16	0.07	0.02	0.08	0.06	0.03	0.00	0.00
ENE	4.5	11	0.30	0.18	0.17	0.10	0.24	0.43	0.33	0.35	0.19	0.08	0.03	0.09	0.07	0.04	0.00	0.00
ENE	5.5	13	0.33	0.21	0.20	0.12	0.26	0.46	0.35	0.37	0.21	0.09	0.03	0.10	0.07	0.04	0.00	0.00
E	3.5	11	0.31	0.20	0.19	0.12	0.25	0.42	0.33	0.33	0.20	0.08	0.03	0.10	0.07	0.04	0.00	0.00
E	4.5	11	0.35	0.23	0.22	0.14	0.29	0.49	0.37	0.37	0.23	0.09	0.03	0.11	0.08	0.04	0.00	0.00
E	5.5	13	0.39	0.27	0.27	0.21	0.31	0.54	0.41	0.40	0.25	0.11	0.03	0.12	0.09	0.05	0.00	0.00
E	6.5	13	0.41	0.29	0.28	0.22	0.33	0.57	0.43	0.42	0.26	0.11	0.04	0.13	0.09	0.05	0.00	0.00
ESE	3.5	11	0.36	0.24	0.23	0.20	0.30	0.52	0.39	0.38	0.25	0.11	0.05	0.13	0.09	0.05	0.00	0.00
ESE	4.5	11	0.39	0.26	0.25	0.21	0.32	0.55	0.42	0.40	0.27	0.12	0.05	0.14	0.10	0.06	0.00	0.00
ESE	5.5	13	0.41	0.29	0.28	0.22	0.34	0.58	0.43	0.42	0.28	0.12	0.05	0.14	0.10	0.06	0.00	0.00
ESE	6.5	13	0.43	0.30	0.29	0.23	0.35	0.60	0.45	0.44	0.28	0.13	0.05	0.15	0.11	0.06	0.00	0.00
SE	3.5	11	0.38	0.26	0.26	0.20	0.29	0.50	0.38	0.36	0.25	0.10	0.03	0.12	0.08	0.05	0.00	0.00
SE	4.5	11	0.40	0.28	0.27	0.21	0.31	0.54	0.40	0.38	0.26	0.11	0.04	0.13	0.09	0.05	0.00	0.00
SE	5.5	13	0.43	0.31	0.30	0.23	0.33	0.58	0.43	0.41	0.27	0.12	0.04	0.14	0.10	0.05	0.00	0.00
SE	6.5	13	0.44	0.32	0.31	0.23	0.34	0.60	0.44	0.42	0.28	0.13	0.04	0.14	0.10	0.06	0.00	0.00
SE	7.5	13	0.45	0.32	0.31	0.24	0.35	0.62	0.45	0.43	0.29	0.14	0.04	0.15	0.11	0.06	0.00	0.00
SSE	3.5	11	0.29	0.21	0.21	0.12	0.21	0.34	0.27	0.25	0.19	0.08	0.02	0.08	0.06	0.03	0.00	0.00
SSE	4.5	11	0.34	0.25	0.25	0.14	0.25	0.40	0.32	0.29	0.22	0.09	0.03	0.09	0.07	0.04	0.00	0.00
SSE	5.5	13	0.41	0.31	0.31	0.24	0.31	0.50	0.39	0.35	0.27	0.11	0.03	0.11	0.08	0.04	0.00	0.00
SSE	6.5	13	0.42	0.32	0.32	0.25	0.32	0.53	0.40	0.36	0.28	0.12	0.03	0.12	0.09	0.05	0.00	0.00
SSE	7.5	13	0.43	0.33	0.33	0.25	0.33	0.53	0.41	0.37	0.28	0.12	0.04	0.12	0.09	0.05	0.00	0.00
S	3.5	11	0.11	0.08	0.08	0.05	0.08	0.13	0.11	0.10	0.08	0.03	0.01	0.03	0.02	0.01	0.00	0.00
S	4.5	11	0.13	0.10	0.10	0.06	0.10	0.16	0.13	0.12	0.09	0.04	0.01	0.04	0.03	0.01	0.00	0.00

S	5.5	13	0.22	0.17	0.17	0.10	0.17	0.26	0.21	0.19	0.15	0.06	0.02	0.06	0.04	0.02	0.00	0.00
S	6.5	13	0.25	0.19	0.19	0.11	0.19	0.29	0.24	0.22	0.17	0.07	0.02	0.07	0.05	0.02	0.00	0.00
S	7.5	13	0.27	0.21	0.21	0.12	0.21	0.32	0.26	0.24	0.19	0.08	0.02	0.07	0.05	0.03	0.00	0.00
SSW	3.5	11	0.06	0.04	0.04	0.02	0.04	0.07	0.06	0.06	0.04	0.02	0.00	0.02	0.01	0.01	0.00	0.00
SSW	4.5	11	0.07	0.05	0.05	0.03	0.05	0.09	0.07	0.07	0.05	0.02	0.01	0.02	0.02	0.01	0.00	0.00
SSW	5.5	13	0.12	0.08	0.09	0.05	0.09	0.14	0.11	0.11	0.08	0.03	0.01	0.03	0.02	0.01	0.00	0.00
126	1.6	9.0	0.22	0.14	0.13	0.08	0.17	0.30	0.23	0.23	0.15	0.06	0.03	0.09	0.06	0.03	0.00	0.00
134	1.7	10.2	0.25	0.16	0.16	0.09	0.18	0.31	0.24	0.24	0.16	0.07	0.02	0.08	0.05	0.03	0.00	0.00
144	1.6	10.6	0.24	0.16	0.16	0.10	0.17	0.28	0.23	0.22	0.16	0.06	0.02	0.07	0.05	0.03	0.00	0.00
134	1.6	9.3	0.22	0.14	0.13	0.08	0.17	0.28	0.22	0.22	0.15	0.06	0.02	0.07	0.05	0.03	0.00	0.00
		MAX	**0.45**	**0.33**	**0.33**	**0.25**	**0.35**	**0.62**	**0.45**	**0.44**	**0.29**	**0.14**	**0.05**	**0.15**	**0.11**	**0.06**	**0.00**	**0.00**

Table 10.10 Modelled Swell Wave Heights at Shoreline Sections in the Study Area, 1.38 m WL

Water Level: 1.38 m			Lower Pindimar				Pindimar					Upper Pindimar					Bundabah	
		Shoreline Section	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Direction	H_s (m)	T_p	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)
NE	3.5	11	0.20	0.13	0.11	0.09	0.16	0.29	0.22	0.23	0.12	0.06	0.02	0.08	0.05	0.04	0.00	0.00
NE	4.5	11	0.25	0.15	0.14	0.11	0.20	0.35	0.27	0.28	0.15	0.07	0.02	0.09	0.07	0.04	0.00	0.00
ENE	3.5	11	0.26	0.15	0.13	0.11	0.22	0.39	0.30	0.31	0.16	0.08	0.03	0.10	0.08	0.05	0.00	0.00
ENE	4.5	11	0.31	0.18	0.16	0.13	0.27	0.47	0.36	0.37	0.20	0.09	0.03	0.12	0.09	0.05	0.00	0.00
ENE	5.5	13	0.35	0.22	0.20	0.16	0.29	0.51	0.39	0.39	0.22	0.11	0.03	0.13	0.10	0.06	0.00	0.00
E	3.5	11	0.33	0.21	0.19	0.17	0.27	0.46	0.35	0.34	0.21	0.10	0.03	0.13	0.09	0.06	0.00	0.00
E	4.5	11	0.38	0.24	0.22	0.20	0.32	0.54	0.41	0.40	0.24	0.12	0.04	0.15	0.11	0.07	0.00	0.00
E	5.5	13	0.44	0.30	0.28	0.23	0.35	0.61	0.45	0.44	0.27	0.14	0.04	0.16	0.12	0.07	0.00	0.00
E	6.5	13	0.46	0.31	0.29	0.24	0.38	0.65	0.48	0.47	0.29	0.15	0.05	0.17	0.13	0.08	0.00	0.00

ESE	3.5	11	0.40	0.26	0.23	0.22	0.34	0.58	0.43	0.41	0.28	0.14	0.07	0.18	0.13	0.08	0.00	0.00
ESE	4.5	11	0.43	0.28	0.26	0.23	0.38	0.64	0.47	0.45	0.30	0.15	0.07	0.20	0.15	0.08	0.00	0.00
ESE	5.5	13	0.46	0.32	0.29	0.24	0.39	0.67	0.49	0.47	0.31	0.16	0.07	0.20	0.15	0.08	0.00	0.00
ESE	6.5	13	0.48	0.32	0.30	0.24	0.40	0.69	0.51	0.49	0.31	0.17	0.07	0.20	0.15	0.09	0.00	0.00
SE	3.5	11	0.41	0.28	0.26	0.20	0.32	0.55	0.41	0.38	0.26	0.13	0.05	0.16	0.12	0.07	0.00	0.00
SE	4.5	11	0.44	0.30	0.28	0.22	0.35	0.61	0.45	0.42	0.28	0.15	0.05	0.18	0.13	0.08	0.00	0.00
SE	5.5	13	0.47	0.34	0.32	0.24	0.38	0.66	0.48	0.45	0.30	0.16	0.05	0.19	0.14	0.08	0.00	0.00
SE	6.5	13	0.48	0.34	0.32	0.24	0.39	0.68	0.49	0.46	0.30	0.16	0.06	0.20	0.15	0.09	0.00	0.00
SE	7.5	13	0.50	0.35	0.33	0.25	0.40	0.70	0.51	0.48	0.31	0.17	0.06	0.21	0.16	0.10	0.00	0.00
SSE	3.5	11	0.30	0.21	0.20	0.16	0.21	0.35	0.28	0.26	0.19	0.10	0.03	0.10	0.07	0.04	0.00	0.00
SSE	4.5	11	0.35	0.25	0.24	0.19	0.25	0.42	0.32	0.30	0.22	0.11	0.03	0.11	0.08	0.05	0.00	0.00
SSE	5.5	13	0.44	0.33	0.32	0.25	0.33	0.55	0.42	0.38	0.28	0.15	0.04	0.15	0.11	0.07	0.00	0.00
SSE	6.5	13	0.46	0.35	0.34	0.26	0.35	0.58	0.44	0.40	0.30	0.16	0.05	0.16	0.12	0.07	0.00	0.00
SSE	7.5	13	0.47	0.35	0.35	0.27	0.37	0.61	0.45	0.41	0.31	0.16	0.05	0.16	0.12	0.07	0.00	0.00
S	3.5	11	0.11	0.07	0.07	0.06	0.08	0.13	0.10	0.10	0.07	0.04	0.01	0.04	0.03	0.02	0.00	0.00
S	4.5	11	0.13	0.09	0.09	0.07	0.10	0.16	0.13	0.12	0.09	0.05	0.01	0.05	0.03	0.02	0.00	0.00
S	5.5	13	0.22	0.16	0.16	0.13	0.16	0.26	0.21	0.19	0.15	0.08	0.02	0.07	0.05	0.03	0.00	0.00
S	6.5	13	0.25	0.18	0.18	0.14	0.18	0.30	0.24	0.22	0.16	0.08	0.02	0.08	0.06	0.04	0.00	0.00
S	7.5	13	0.28	0.20	0.20	0.16	0.20	0.33	0.26	0.24	0.18	0.09	0.03	0.09	0.06	0.04	0.00	0.00
SSW	3.5	11	0.06	0.04	0.04	0.03	0.04	0.07	0.06	0.05	0.04	0.02	0.01	0.02	0.02	0.01	0.00	0.00
SSW	4.5	11	0.07	0.05	0.05	0.04	0.05	0.09	0.07	0.07	0.05	0.02	0.01	0.03	0.02	0.02	0.00	0.00
SSW	5.5	13	0.11	0.08	0.08	0.06	0.08	0.14	0.11	0.10	0.07	0.04	0.01	0.04	0.03	0.02	0.00	0.00
SSE	8.2	13	0.48	0.36	0.35	0.27	0.37	0.62	0.46	0.42	0.31	0.16	0.05	0.17	0.13	0.08	0.00	0.00
E	8.2	13	0.48	0.33	0.30	0.24	0.40	0.70	0.51	0.50	0.30	0.16	0.05	0.19	0.14	0.09	0.00	0.00
SSE	8.9	13	0.49	0.36	0.35	0.27	0.37	0.63	0.47	0.42	0.31	0.17	0.05	0.18	0.14	0.08	0.00	0.00
E	8.9	13	0.49	0.33	0.31	0.25	0.41	0.71	0.52	0.51	0.30	0.16	0.05	0.20	0.15	0.09	0.00	0.00
126	1.6	9.0	0.22	0.13	0.12	0.10	0.18	0.32	0.24	0.23	0.15	0.08	0.03	0.11	0.08	0.05	0.00	0.00
134	1.7	10.2	0.25	0.16	0.15	0.12	0.19	0.33	0.25	0.24	0.16	0.08	0.03	0.10	0.07	0.05	0.00	0.00
144	1.6	10.6	0.24	0.16	0.15	0.12	0.17	0.29	0.23	0.22	0.15	0.08	0.02	0.09	0.06	0.04	0.00	0.00
134	1.6	9.3	0.22	0.14	0.13	0.10	0.17	0.30	0.22	0.21	0.14	0.07	0.03	0.10	0.07	0.04	0.00	0.00
			0.50	**0.36**	**0.35**	**0.27**	**0.41**	**0.71**	**0.52**	**0.51**	**0.31**	**0.17**	**0.07**	**0.21**	**0.16**	**0.10**	**0.00**	**0.00**

Table 10.11 Modelled Swell Wave Heights at Shoreline Sections in the Study Area, 1.42 m WL

Water Level: 1.42 m			Lower Pindimar				Pindimar					Upper Pindimar					Bundabah	
		Shoreline Section	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Direction	H_s (m)	T_p	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)
SSE	8.2	13	0.49	0.36	0.35	0.27	0.37	0.62	0.46	0.42	0.31	0.17	0.05	0.18	0.13	0.08	0.00	0.00
E	8.2	13	0.49	0.33	0.31	0.24	0.41	0.70	0.52	0.50	0.30	0.16	0.06	0.20	0.15	0.09	0.00	0.00
SSE	8.9	13	0.49	0.37	0.35	0.27	0.38	0.64	0.47	0.43	0.31	0.17	0.05	0.19	0.14	0.09	0.00	0.00
E	8.9	13	0.50	0.34	0.31	0.25	0.41	0.72	0.53	0.51	0.31	0.17	0.06	0.20	0.15	0.09	0.00	0.00
		MAX	**0.50**	**0.37**	**0.35**	**0.27**	**0.41**	**0.72**	**0.53**	**0.51**	**0.31**	**0.17**	**0.06**	**0.20**	**0.15**	**0.09**	**0.00**	**0.00**

Table 10.12 Modelled Swell Wave Heights at Shoreline Sections in the Study Area, 1.78 m WL

Water Level: 1.78 m			Lower Pindimar				Pindimar					Upper Pindimar					Bundabah	
		Shoreline Section	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Direction	H_s (m)	T_p	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)
NE	3.5	11	0.20	0.12	0.11	0.08	0.17	0.31	0.23	0.23	0.13	0.07	0.03	0.12	0.08	0.06	0.00	0.00
NE	4.5	11	0.25	0.15	0.13	0.10	0.21	0.38	0.28	0.28	0.15	0.09	0.04	0.14	0.10	0.07	0.00	0.00
ENE	3.5	11	0.26	0.15	0.13	0.11	0.24	0.42	0.32	0.32	0.16	0.09	0.04	0.15	0.11	0.08	0.00	0.00
ENE	4.5	11	0.32	0.18	0.15	0.13	0.29	0.51	0.38	0.38	0.20	0.11	0.05	0.17	0.13	0.09	0.00	0.00
ENE	5.5	13	0.37	0.23	0.20	0.16	0.32	0.55	0.41	0.41	0.22	0.12	0.05	0.18	0.14	0.09	0.00	0.00
E	3.5	11	0.34	0.21	0.18	0.18	0.29	0.49	0.37	0.35	0.21	0.12	0.05	0.18	0.13	0.09	0.00	0.00
E	4.5	11	0.40	0.25	0.22	0.22	0.35	0.59	0.44	0.42	0.25	0.14	0.06	0.21	0.16	0.10	0.00	0.00
E	5.5	13	0.47	0.31	0.28	0.24	0.40	0.67	0.49	0.47	0.28	0.16	0.06	0.23	0.17	0.11	0.00	0.00
E	6.5	13	0.50	0.33	0.30	0.25	0.43	0.72	0.53	0.50	0.30	0.18	0.07	0.24	0.18	0.12	0.00	0.00
ESE	3.5	11	0.42	0.27	0.23	0.24	0.38	0.63	0.46	0.43	0.31	0.18	0.10	0.25	0.19	0.12	0.00	0.00
ESE	4.5	11	0.47	0.30	0.26	0.27	0.43	0.71	0.52	0.48	0.34	0.20	0.11	0.27	0.20	0.13	0.00	0.00
ESE	5.5	13	0.51	0.34	0.30	0.27	0.44	0.75	0.54	0.51	0.34	0.20	0.10	0.27	0.21	0.13	0.00	0.00

ESE	6.5	13	0.52	0.34	0.31	0.27	0.46	0.77	0.56	0.53	0.35	0.21	0.10	0.28	0.21	0.13	0.00	0.00
SE	3.5	11	0.44	0.28	0.25	0.20	0.34	0.59	0.43	0.40	0.27	0.16	0.07	0.23	0.17	0.11	0.00	0.00
SE	4.5	11	0.48	0.31	0.28	0.23	0.39	0.67	0.48	0.45	0.30	0.18	0.07	0.25	0.19	0.12	0.00	0.00
SE	5.5	13	0.52	0.36	0.33	0.25	0.43	0.73	0.53	0.49	0.32	0.20	0.08	0.27	0.20	0.13	0.00	0.00
SE	6.5	13	0.53	0.36	0.33	0.25	0.44	0.75	0.54	0.50	0.33	0.20	0.08	0.27	0.21	0.13	0.00	0.00
SE	7.5	13	0.54	0.37	0.33	0.25	0.44	0.76	0.55	0.51	0.33	0.20	0.08	0.29	0.21	0.14	0.00	0.00
SSE	3.5	11	0.30	0.20	0.19	0.15	0.21	0.36	0.27	0.25	0.18	0.11	0.04	0.13	0.10	0.07	0.00	0.00
SSE	4.5	11	0.35	0.25	0.23	0.18	0.26	0.43	0.32	0.30	0.22	0.13	0.05	0.16	0.12	0.08	0.00	0.00
SSE	5.5	13	0.47	0.34	0.32	0.25	0.35	0.58	0.43	0.40	0.29	0.17	0.06	0.20	0.15	0.10	0.00	0.00
SSE	6.5	13	0.50	0.37	0.35	0.27	0.37	0.63	0.46	0.42	0.31	0.19	0.07	0.22	0.17	0.11	0.00	0.00
SSE	7.5	13	0.51	0.37	0.35	0.28	0.38	0.65	0.47	0.44	0.31	0.18	0.07	0.23	0.17	0.11	0.00	0.00
S	3.5	11	0.10	0.07	0.07	0.05	0.08	0.12	0.10	0.09	0.07	0.04	0.02	0.05	0.04	0.03	0.00	0.00
S	4.5	11	0.13	0.09	0.08	0.07	0.09	0.15	0.12	0.11	0.08	0.05	0.02	0.06	0.04	0.03	0.00	0.00
S	5.5	13	0.22	0.16	0.15	0.12	0.16	0.26	0.20	0.19	0.14	0.08	0.03	0.10	0.07	0.05	0.00	0.00
S	6.5	13	0.25	0.18	0.17	0.13	0.18	0.30	0.23	0.21	0.16	0.10	0.03	0.11	0.08	0.06	0.00	0.00
S	7.5	13	0.27	0.20	0.19	0.15	0.20	0.33	0.26	0.24	0.18	0.11	0.04	0.12	0.09	0.06	0.00	0.00
SSW	3.5	11	0.05	0.04	0.03	0.03	0.04	0.07	0.05	0.05	0.04	0.03	0.01	0.03	0.02	0.02	0.00	0.00
SSW	4.5	11	0.07	0.05	0.04	0.03	0.05	0.09	0.07	0.07	0.05	0.03	0.01	0.04	0.03	0.02	0.00	0.00
SSW	5.5	13	0.11	0.08	0.07	0.06	0.08	0.14	0.11	0.10	0.07	0.05	0.02	0.06	0.04	0.03	0.00	0.00
SSE	8.2	13	0.53	0.38	0.36	0.28	0.40	0.67	0.49	0.45	0.33	0.20	0.07	0.25	0.19	0.12	0.00	0.00
E	8.2	13	0.53	0.35	0.31	0.27	0.46	0.78	0.57	0.54	0.32	0.19	0.08	0.27	0.20	0.13	0.00	0.00
SSE	8.9	13	0.53	0.39	0.36	0.28	0.41	0.69	0.50	0.45	0.33	0.20	0.08	0.26	0.19	0.13	0.00	0.00
E	8.9	13	0.54	0.36	0.32	0.27	0.47	0.80	0.58	0.55	0.33	0.20	0.08	0.28	0.21	0.14	0.00	0.00
126	1.6	9.0	0.22	0.13	0.11	0.11	0.19	0.33	0.24	0.22	0.16	0.10	0.05	0.16	0.12	0.08	0.00	0.00
134	1.7	10.2	0.25	0.16	0.14	0.12	0.20	0.34	0.25	0.23	0.16	0.10	0.04	0.15	0.11	0.07	0.00	0.00
144	1.6	10.6	0.24	0.15	0.14	0.11	0.18	0.30	0.22	0.21	0.15	0.09	0.04	0.13	0.09	0.06	0.00	0.00
134	1.6	9.3	0.22	0.13	0.12	0.10	0.18	0.30	0.22	0.21	0.15	0.09	0.04	0.14	0.10	0.07	0.00	0.00
		MAX	**0.50**	**0.36**	**0.35**	**0.27**	**0.41**	**0.71**	**0.52**	**0.51**	**0.31**	**0.17**	**0.07**	**0.21**	**0.16**	**0.10**	**0.00**	**0.00**

Table 10.13 Modelled Swell Wave Heights at Shoreline Sections in the Study Area, 2.32 m WL

Water Level: 2.32 m			Lower Pindimar				Pindimar					Upper Pindimar					Bundabah	
		Shoreline Section	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Direction	H_s (m)	T_p	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)
SSE	8.2	13	0.58	0.40	0.36	0.29	0.44	0.73	0.52	0.48	0.37	0.26	0.13	0.37	0.28	0.18	0.00	0.00
E	8.2	13	0.60	0.38	0.32	0.32	0.55	0.89	0.63	0.58	0.38	0.27	0.14	0.42	0.32	0.21	0.00	0.00
SSE	8.9	13	0.59	0.41	0.36	0.29	0.45	0.75	0.53	0.49	0.38	0.27	0.13	0.38	0.29	0.19	0.00	0.00
E	8.9	13	0.61	0.38	0.32	0.32	0.56	0.91	0.65	0.60	0.38	0.28	0.15	0.44	0.33	0.22	0.00	0.00
		MAX	**0.61**	**0.41**	**0.36**	**0.32**	**0.56**	**0.91**	**0.65**	**0.60**	**0.38**	**0.28**	**0.15**	**0.44**	**0.33**	**0.22**	**0.00**	**0.00**

Table 10.14 Modelled Wind Wave Heights at Shoreline Sections in the Study Area, 0.98 m WL

Water Level: 0.98 m			Lower Pindimar				Pindimar					Upper Pindimar					Bundabah	
		Shoreline Section	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Direction	Speed (m/s)	ARI	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)
NN	7.8	1 yr	0.09	0.08	0.06	0.06	0.13	0.12	0.12	0.12	0.18	0.17	0.12	0.12	0.12	0.12	0.17	0.07
NN	9.8	5 yr	0.12	0.10	0.08	0.08	0.16	0.16	0.15	0.15	0.22	0.21	0.15	0.15	0.14	0.14	0.21	0.10
NN	10.4	10 yr	0.13	0.11	0.08	0.08	0.17	0.17	0.16	0.17	0.23	0.23	0.16	0.16	0.16	0.15	0.22	0.10
NE	10.0	1 yr	0.26	0.22	0.17	0.16	0.27	0.28	0.26	0.22	0.27	0.25	0.20	0.19	0.18	0.15	0.17	0.08
NE	11.6	5 yr	0.32	0.27	0.22	0.20	0.33	0.35	0.32	0.27	0.31	0.29	0.23	0.23	0.22	0.17	0.19	0.09
NE	12.2	10 yr	0.34	0.29	0.23	0.22	0.35	0.37	0.34	0.28	0.33	0.31	0.24	0.24	0.23	0.18	0.20	0.09
EE	10.9	1 yr	0.44	0.40	0.34	0.31	0.45	0.48	0.45	0.37	0.40	0.34	0.30	0.30	0.28	0.22	0.13	0.07
EE	12.7	5 yr	0.50	0.46	0.39	0.34	0.50	0.55	0.52	0.43	0.44	0.39	0.34	0.36	0.33	0.27	0.13	0.08
EE	13.4	10 yr	0.52	0.48	0.41	0.35	0.52	0.58	0.55	0.45	0.45	0.41	0.35	0.38	0.36	0.28	0.13	0.09
SE	12.2	1 yr	0.52	0.48	0.43	0.36	0.53	0.57	0.55	0.47	0.46	0.41	0.37	0.43	0.41	0.34	0.11	0.10
SE	14.4	5 yr	0.55	0.54	0.47	0.38	0.57	0.64	0.62	0.54	0.47	0.47	0.41	0.51	0.49	0.41	0.13	0.12
SE	15.6	10 yr	0.57	0.57	0.49	0.38	0.58	0.66	0.64	0.57	0.48	0.50	0.43	0.53	0.52	0.43	0.15	0.13
SS	13.6	1 yr	0.54	0.53	0.48	0.38	0.56	0.58	0.59	0.53	0.48	0.38	0.37	0.49	0.48	0.43	0.25	0.21
SS	15.3	5 yr	0.55	0.55	0.49	0.38	0.57	0.59	0.60	0.55	0.48	0.41	0.38	0.52	0.51	0.46	0.30	0.25
SS	15.9	10 yr	0.55	0.56	0.49	0.38	0.58	0.59	0.60	0.55	0.48	0.42	0.39	0.53	0.52	0.46	0.31	0.26
SW	12.4	1 yr	0.46	0.44	0.45	0.36	0.51	0.48	0.47	0.47	0.47	0.29	0.28	0.40	0.41	0.37	0.31	0.25
SW	14.7	5 yr	0.46	0.45	0.45	0.36	0.52	0.50	0.50	0.51	0.47	0.30	0.27	0.39	0.41	0.39	0.37	0.30
SW	15.4	10 yr	0.47	0.46	0.46	0.36	0.53	0.51	0.51	0.52	0.48	0.31	0.26	0.39	0.42	0.40	0.39	0.32
WW	15.8	1 yr	0.42	0.38	0.40	0.34	0.51	0.49	0.42	0.49	0.47	0.25	0.18	0.28	0.30	0.30	0.38	0.28
WW	17.9	5 yr	0.45	0.42	0.42	0.36	0.54	0.54	0.46	0.53	0.48	0.27	0.18	0.26	0.29	0.29	0.42	0.31

WW	18.6	10 yr	0.46	0.43	0.42	0.36	0.54	0.55	0.47	0.54	0.48	0.27	0.18	0.26	0.29	0.29	0.43	0.32
NW	15.8	1 yr	0.33	0.29	0.31	0.29	0.43	0.39	0.33	0.41	0.43	0.27	0.14	0.18	0.21	0.21	0.39	0.24
NW	18.5	5 yr	0.35	0.30	0.29	0.28	0.43	0.38	0.32	0.39	0.42	0.28	0.15	0.19	0.20	0.21	0.41	0.24
NW	19.2	10 yr	0.36	0.31	0.29	0.28	0.43	0.39	0.33	0.38	0.42	0.29	0.16	0.19	0.20	0.22	0.42	0.25
		MAX	**0.57**	**0.57**	**0.49**	**0.38**	**0.58**	**0.66**	**0.64**	**0.57**	**0.48**	**0.50**	**0.43**	**0.53**	**0.52**	**0.46**	**0.43**	**0.32**

Table 10.15 Modelled Wind Wave Heights at Shoreline Sections in the Study Area, 1.38 m WL

Water Level: 1.38 m			Lower Pindimar				Pindimar					Upper Pindimar					Bundabah	
		Shoreline Section	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Direction	Speed (m/s)	ARI	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)
NN	7.8	1 yr	0.10	0.09	0.08	0.09	0.14	0.13	0.13	0.14	0.19	0.18	0.13	0.13	0.13	0.13	0.18	0.08
NN	9.8	5 yr	0.13	0.11	0.09	0.11	0.17	0.17	0.17	0.17	0.24	0.22	0.16	0.16	0.16	0.16	0.22	0.10
NN	10.4	10 yr	0.14	0.12	0.10	0.12	0.18	0.18	0.18	0.18	0.26	0.24	0.17	0.17	0.17	0.17	0.24	0.11
NN	11.1	25 yr	0.15	0.13	0.11	0.13	0.19	0.19	0.19	0.20	0.28	0.26	0.19	0.19	0.18	0.18	0.25	0.12
NE	10.0	1 yr	0.28	0.24	0.19	0.23	0.30	0.30	0.27	0.24	0.29	0.26	0.22	0.21	0.20	0.17	0.19	0.08
NE	11.6	5 yr	0.35	0.30	0.25	0.29	0.36	0.37	0.34	0.29	0.34	0.31	0.26	0.25	0.24	0.20	0.21	0.10
NE	12.2	10 yr	0.37	0.31	0.26	0.31	0.38	0.39	0.36	0.31	0.36	0.33	0.28	0.26	0.25	0.21	0.22	0.10
NE	12.8	20 yr	0.39	0.33	0.28	0.33	0.40	0.41	0.38	0.33	0.38	0.35	0.29	0.28	0.26	0.22	0.23	0.11
EE	10.9	1 yr	0.48	0.43	0.37	0.45	0.50	0.52	0.48	0.42	0.45	0.37	0.34	0.33	0.31	0.25	0.14	0.08
EE	12.7	5 yr	0.55	0.49	0.43	0.51	0.57	0.60	0.56	0.48	0.52	0.43	0.39	0.39	0.36	0.30	0.14	0.08
EE	13.4	10 yr	0.58	0.51	0.45	0.54	0.59	0.63	0.59	0.50	0.54	0.45	0.41	0.41	0.38	0.31	0.15	0.09
EE	14.3	25 yr	0.61	0.55	0.48	0.56	0.63	0.67	0.63	0.54	0.57	0.48	0.44	0.44	0.41	0.34	0.16	0.10
SE	12.2	1 yr	0.57	0.52	0.48	0.55	0.60	0.63	0.59	0.51	0.56	0.45	0.43	0.47	0.44	0.38	0.12	0.10
SE	14.4	5 yr	0.63	0.59	0.55	0.61	0.67	0.72	0.68	0.60	0.61	0.52	0.49	0.56	0.54	0.46	0.15	0.12
SE	15.6	10 yr	0.66	0.63	0.58	0.63	0.70	0.76	0.72	0.65	0.62	0.55	0.51	0.61	0.58	0.49	0.16	0.14
SE	17.2	25 yr	0.70	0.67	0.62	0.65	0.73	0.80	0.77	0.70	0.64	0.60	0.55	0.65	0.63	0.53	0.18	0.15
SE	18.6	50 yr	0.73	0.71	0.64	0.66	0.75	0.84	0.80	0.73	0.65	0.64	0.58	0.69	0.67	0.56	0.19	0.17
SS	13.6	1 yr	0.65	0.60	0.58	0.63	0.69	0.70	0.69	0.63	0.63	0.46	0.45	0.56	0.54	0.49	0.27	0.21

SS	15.3	5 yr	0.65	0.62	0.59	0.63	0.70	0.70	0.69	0.63	0.63	0.48	0.45	0.58	0.58	0.52	0.32	0.25
SS	15.9	10 yr	0.65	0.62	0.60	0.63	0.70	0.69	0.69	0.64	0.64	0.49	0.45	0.59	0.59	0.53	0.34	0.26
SS	16.3	20 yr	0.66	0.63	0.61	0.63	0.70	0.69	0.70	0.64	0.64	0.50	0.46	0.60	0.60	0.55	0.35	0.27
SW	12.4	1 yr	0.52	0.48	0.50	0.54	0.57	0.52	0.51	0.51	0.58	0.35	0.32	0.43	0.44	0.41	0.33	0.26
SW	14.7	5 yr	0.53	0.50	0.50	0.53	0.58	0.54	0.53	0.55	0.60	0.38	0.30	0.42	0.44	0.44	0.39	0.31
SW	15.4	10 yr	0.54	0.51	0.51	0.54	0.60	0.56	0.54	0.57	0.61	0.39	0.30	0.42	0.45	0.45	0.41	0.33
SW	16.2	25 yr	0.56	0.53	0.52	0.56	0.62	0.58	0.56	0.59	0.62	0.40	0.31	0.43	0.47	0.47	0.43	0.34
WW	15.8	1 yr	0.50	0.45	0.43	0.50	0.58	0.54	0.46	0.53	0.57	0.35	0.22	0.30	0.33	0.34	0.42	0.29
WW	17.9	5 yr	0.55	0.49	0.45	0.54	0.63	0.61	0.51	0.59	0.61	0.37	0.22	0.30	0.32	0.33	0.46	0.32
WW	18.6	10 yr	0.56	0.50	0.46	0.55	0.64	0.62	0.52	0.60	0.62	0.38	0.22	0.30	0.33	0.33	0.47	0.33
WW	19.3	25 yr	0.57	0.52	0.47	0.56	0.66	0.65	0.54	0.63	0.63	0.39	0.23	0.30	0.33	0.34	0.49	0.34
NW	15.8	1 yr	0.39	0.34	0.30	0.41	0.47	0.43	0.37	0.45	0.48	0.34	0.18	0.22	0.24	0.23	0.42	0.24
NW	18.5	5 yr	0.41	0.36	0.30	0.40	0.47	0.42	0.36	0.42	0.48	0.34	0.19	0.22	0.23	0.23	0.44	0.25
NW	19.2	10 yr	0.42	0.37	0.31	0.40	0.47	0.43	0.37	0.42	0.48	0.35	0.19	0.22	0.23	0.24	0.45	0.26
NW	20.0	25 yr	0.44	0.38	0.32	0.40	0.48	0.45	0.38	0.43	0.49	0.36	0.20	0.23	0.23	0.25	0.47	0.26
NW	20.4	50 yr	0.45	0.39	0.32	0.40	0.49	0.45	0.39	0.43	0.50	0.36	0.20	0.23	0.24	0.26	0.48	0.27
		MAX	**0.73**	**0.71**	**0.64**	**0.66**	**0.75**	**0.84**	**0.80**	**0.73**	**0.65**	**0.64**	**0.58**	**0.69**	**0.67**	**0.56**	**0.49**	**0.34**

Table 10.16 Modelled Wind Wave Heights at Shoreline Sections in the Study Area, 1.42 m WL

Water Level: 1.42 m			Lower Pindimar				Pindimar					Upper Pindimar					Bundabah	
		Shoreline Section	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Direction	Speed (m/s)	ARI	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)
NN	11.1	25 yr	0.16	0.14	0.12	0.14	0.20	0.20	0.19	0.20	0.28	0.26	0.19	0.19	0.18	0.18	0.26	0.12
NE	12.8	20 yr	0.33	0.29	0.24	0.28	0.36	0.38	0.35	0.31	0.37	0.34	0.28	0.27	0.25	0.21	0.24	0.11
EE	14.3	25 yr	0.56	0.52	0.45	0.53	0.58	0.62	0.58	0.53	0.55	0.46	0.40	0.40	0.37	0.30	0.17	0.09
SE	17.2	25 yr	0.70	0.67	0.61	0.65	0.73	0.80	0.76	0.70	0.64	0.59	0.53	0.61	0.59	0.49	0.16	0.12
SE	18.6	50 yr	0.77	0.75	0.66	0.68	0.78	0.88	0.84	0.77	0.67	0.65	0.59	0.71	0.69	0.58	0.20	0.17
SS	16.3	20 yr	0.72	0.68	0.63	0.67	0.75	0.78	0.76	0.70	0.66	0.52	0.49	0.64	0.63	0.57	0.32	0.26

SW	16.2	25 yr	0.63	0.58	0.58	0.63	0.68	0.67	0.65	0.63	0.65	0.41	0.37	0.50	0.51	0.48	0.43	0.33
WW	19.3	25 yr	0.60	0.53	0.53	0.59	0.66	0.63	0.56	0.61	0.64	0.36	0.27	0.38	0.39	0.37	0.47	0.34
NW	20.0	25 yr	0.46	0.38	0.39	0.45	0.52	0.46	0.40	0.46	0.53	0.34	0.19	0.25	0.26	0.27	0.47	0.28
NW	20.4	50 yr	0.46	0.39	0.37	0.43	0.51	0.46	0.39	0.45	0.51	0.35	0.20	0.24	0.25	0.26	0.49	0.28
		MAX	**0.77**	**0.75**	**0.66**	**0.68**	**0.78**	**0.88**	**0.84**	**0.77**	**0.67**	**0.65**	**0.59**	**0.71**	**0.69**	**0.58**	**0.49**	**0.34**

Table 10.17 Modelled Wind Wave Heights at Shoreline Sections in the Study Area, 1.78 m WL

Water Level: 1.78 m			Lower Pindimar				Pindimar					Upper Pindimar					Bundabah	
		Shoreline Section	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Direction	Speed (m/s)	ARI	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)
NN	7.8	1 yr	0.12	0.11	0.09	0.10	0.15	0.15	0.15	0.15	0.21	0.19	0.14	0.14	0.14	0.15	0.19	0.08
NN	9.8	5 yr	0.15	0.13	0.11	0.12	0.18	0.19	0.19	0.19	0.26	0.24	0.18	0.17	0.17	0.18	0.23	0.10
NN	10.4	10 yr	0.16	0.14	0.12	0.13	0.19	0.20	0.20	0.20	0.28	0.25	0.19	0.18	0.18	0.19	0.25	0.11
NN	11.1	25 yr	0.17	0.15	0.13	0.14	0.21	0.22	0.21	0.22	0.30	0.27	0.21	0.20	0.19	0.20	0.26	0.12
NE	10.0	1 yr	0.30	0.26	0.22	0.24	0.31	0.31	0.29	0.27	0.31	0.28	0.25	0.23	0.22	0.19	0.19	0.08
NE	11.6	5 yr	0.37	0.32	0.27	0.31	0.38	0.39	0.36	0.32	0.37	0.34	0.29	0.27	0.26	0.22	0.22	0.10
NE	12.2	10 yr	0.39	0.34	0.29	0.33	0.41	0.41	0.38	0.34	0.39	0.36	0.30	0.29	0.27	0.24	0.23	0.10
NE	12.8	20 yr	0.41	0.35	0.30	0.35	0.43	0.43	0.40	0.36	0.41	0.38	0.32	0.30	0.29	0.25	0.24	0.11
EE	10.9	1 yr	0.50	0.45	0.41	0.48	0.52	0.54	0.50	0.45	0.48	0.41	0.38	0.37	0.35	0.29	0.14	0.08
EE	12.7	5 yr	0.58	0.52	0.47	0.56	0.60	0.63	0.59	0.52	0.56	0.47	0.44	0.44	0.41	0.34	0.14	0.09
EE	13.4	10 yr	0.62	0.54	0.49	0.60	0.64	0.67	0.62	0.55	0.60	0.50	0.46	0.46	0.43	0.36	0.15	0.09
EE	14.3	25 yr	0.66	0.58	0.53	0.64	0.68	0.72	0.67	0.59	0.64	0.53	0.49	0.49	0.46	0.38	0.16	0.10
SE	12.2	1 yr	0.59	0.54	0.52	0.60	0.63	0.65	0.61	0.55	0.59	0.49	0.47	0.51	0.49	0.42	0.13	0.10
SE	14.4	5 yr	0.67	0.63	0.60	0.69	0.72	0.75	0.70	0.65	0.68	0.57	0.54	0.61	0.58	0.51	0.15	0.13
SE	15.6	10 yr	0.71	0.67	0.64	0.73	0.77	0.81	0.75	0.69	0.72	0.61	0.58	0.66	0.63	0.54	0.17	0.14
SE	17.2	25 yr	0.77	0.72	0.69	0.76	0.82	0.88	0.82	0.76	0.76	0.66	0.62	0.72	0.69	0.59	0.19	0.16

SE	18.6	50 yr	0.81	0.76	0.72	0.79	0.86	0.92	0.87	0.80	0.78	0.70	0.65	0.77	0.74	0.63	0.20	0.17
SS	13.6	1 yr	0.69	0.64	0.63	0.71	0.74	0.74	0.71	0.65	0.72	0.52	0.50	0.59	0.58	0.53	0.28	0.21
SS	15.3	5 yr	0.69	0.65	0.64	0.71	0.75	0.73	0.71	0.66	0.74	0.54	0.50	0.61	0.61	0.57	0.34	0.25
SS	15.9	10 yr	0.70	0.66	0.65	0.71	0.75	0.73	0.72	0.67	0.74	0.55	0.50	0.62	0.62	0.58	0.35	0.26
SS	16.3	20 yr	0.70	0.67	0.66	0.71	0.76	0.73	0.72	0.68	0.75	0.56	0.51	0.63	0.64	0.60	0.36	0.28
SW	12.4	1 yr	0.54	0.50	0.52	0.54	0.57	0.53	0.51	0.52	0.60	0.40	0.34	0.43	0.45	0.44	0.34	0.26
SW	14.7	5 yr	0.57	0.54	0.53	0.56	0.60	0.57	0.55	0.57	0.64	0.44	0.34	0.44	0.47	0.47	0.41	0.32
SW	15.4	10 yr	0.59	0.57	0.54	0.58	0.62	0.59	0.57	0.60	0.66	0.46	0.35	0.45	0.48	0.49	0.43	0.33
SW	16.2	25 yr	0.61	0.59	0.56	0.60	0.65	0.62	0.60	0.62	0.68	0.48	0.36	0.46	0.50	0.51	0.45	0.35
WW	15.8	1 yr	0.55	0.51	0.46	0.53	0.61	0.58	0.50	0.56	0.61	0.41	0.26	0.33	0.35	0.35	0.43	0.29
WW	17.9	5 yr	0.62	0.57	0.50	0.58	0.68	0.66	0.56	0.63	0.68	0.45	0.27	0.34	0.36	0.36	0.48	0.33
WW	18.6	10 yr	0.63	0.58	0.51	0.59	0.70	0.68	0.57	0.65	0.70	0.46	0.28	0.34	0.37	0.36	0.49	0.34
WW	19.3	25 yr	0.65	0.60	0.52	0.61	0.72	0.70	0.59	0.67	0.72	0.47	0.28	0.35	0.38	0.37	0.51	0.35
NW	15.8	1 yr	0.43	0.40	0.34	0.43	0.48	0.46	0.40	0.46	0.51	0.37	0.21	0.24	0.25	0.26	0.43	0.24
NW	18.5	5 yr	0.45	0.42	0.35	0.42	0.48	0.45	0.40	0.44	0.51	0.37	0.21	0.23	0.23	0.26	0.46	0.26
NW	19.2	10 yr	0.47	0.43	0.35	0.42	0.49	0.46	0.41	0.44	0.51	0.38	0.22	0.24	0.24	0.27	0.48	0.26
NW	20.0	25 yr	0.49	0.45	0.37	0.43	0.50	0.48	0.42	0.45	0.52	0.39	0.22	0.24	0.24	0.28	0.50	0.27
NW	20.4	50 yr	0.50	0.45	0.37	0.43	0.51	0.49	0.43	0.46	0.53	0.40	0.23	0.25	0.25	0.28	0.51	0.28
		MAX	**0.81**	**0.76**	**0.72**	**0.79**	**0.86**	**0.92**	**0.87**	**0.80**	**0.78**	**0.70**	**0.65**	**0.77**	**0.74**	**0.63**	**0.51**	**0.35**

Table 10.18 Modelled Wind Wave Heights at Shoreline Sections in the Study Area, 2.32 m WL

Water Level: 2.32 m			Lower Pindimar				Pindimar					Upper Pindimar					Bundabah	
		Shoreline Section	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Direction	Speed (m/s)	ARI	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)	H_s (m)
NN	11.1	25 yr	0.21	0.19	0.18	0.21	0.27	0.27	0.27	0.29	0.33	0.29	0.23	0.22	0.22	0.23	0.28	0.13
NE	12.8	20 yr	0.41	0.37	0.35	0.37	0.44	0.44	0.42	0.40	0.43	0.40	0.35	0.33	0.32	0.28	0.26	0.11
EE	14.3	25 yr	0.66	0.60	0.56	0.64	0.67	0.70	0.66	0.63	0.64	0.57	0.53	0.54	0.51	0.42	0.19	0.10
SE	17.2	25 yr	0.83	0.78	0.76	0.87	0.88	0.93	0.87	0.83	0.83	0.72	0.67	0.77	0.73	0.63	0.17	0.13

SE	18.6	50 yr	0.93	0.85	0.84	0.96	1.00	1.06	0.98	0.92	0.94	0.80	0.76	0.89	0.84	0.73	0.22	0.18
SS	16.3	20 yr	0.82	0.76	0.76	0.86	0.88	0.88	0.83	0.78	0.86	0.66	0.61	0.74	0.72	0.68	0.35	0.26
SW	16.2	25 yr	0.70	0.66	0.66	0.72	0.74	0.71	0.68	0.68	0.76	0.56	0.45	0.55	0.57	0.57	0.47	0.35
WW	19.3	25 yr	0.71	0.68	0.63	0.67	0.74	0.72	0.64	0.69	0.76	0.54	0.34	0.42	0.44	0.44	0.52	0.36
NW	20.0	25 yr	0.53	0.50	0.44	0.50	0.56	0.54	0.49	0.52	0.57	0.42	0.25	0.29	0.30	0.32	0.51	0.29
NW	20.4	50 yr	0.55	0.52	0.45	0.50	0.57	0.56	0.50	0.51	0.57	0.43	0.25	0.28	0.29	0.32	0.54	0.29
		MAX	**0.93**	**0.85**	**0.84**	**0.96**	**1.00**	**1.06**	**0.98**	**0.92**	**0.94**	**0.80**	**0.76**	**0.89**	**0.84**	**0.73**	**0.54**	**0.36**

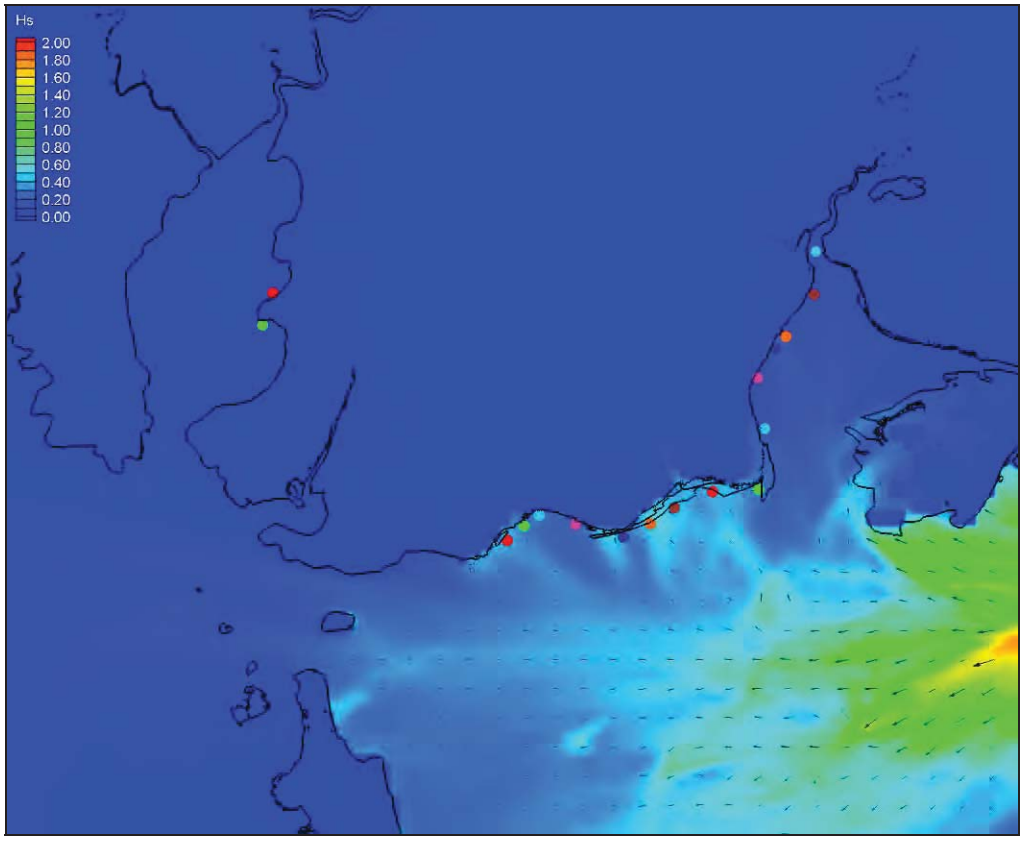


Figure 10-6 Modelled waves at Shoreline for input parameters: Hs 3.5 m ESE 0.98 m WL

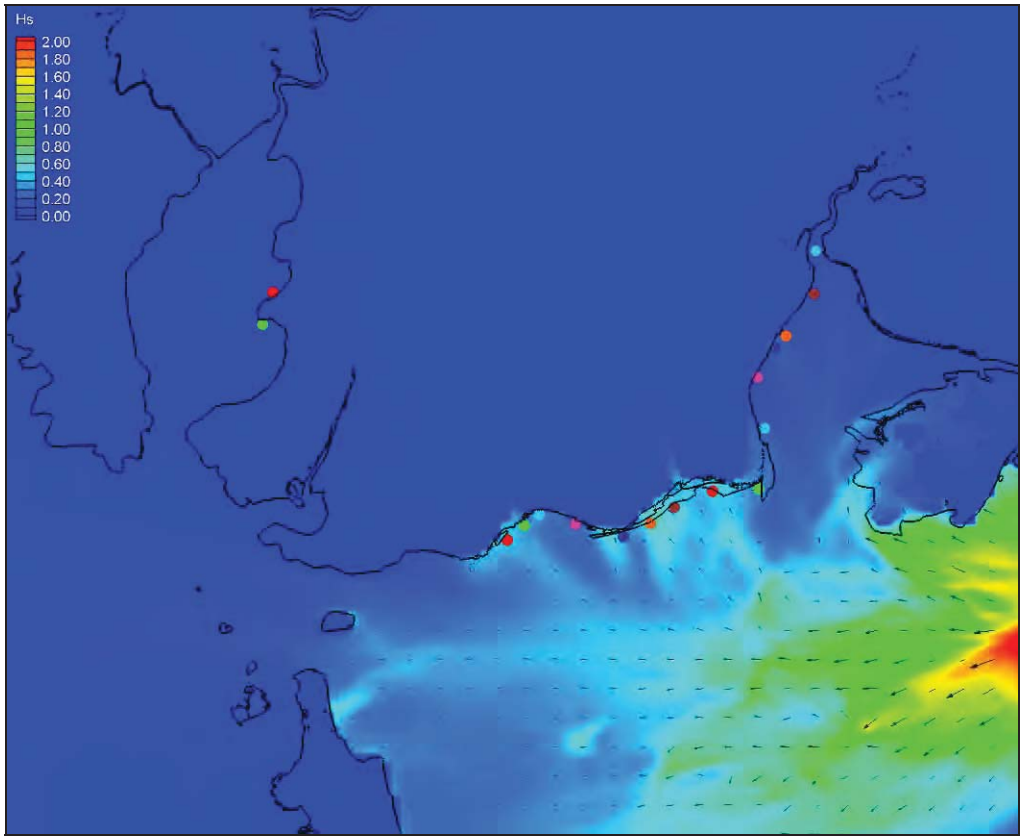


Figure 10-7 Modelled waves at Shoreline for input parameters: Hs 6.5 m ESE 0.98 m WL

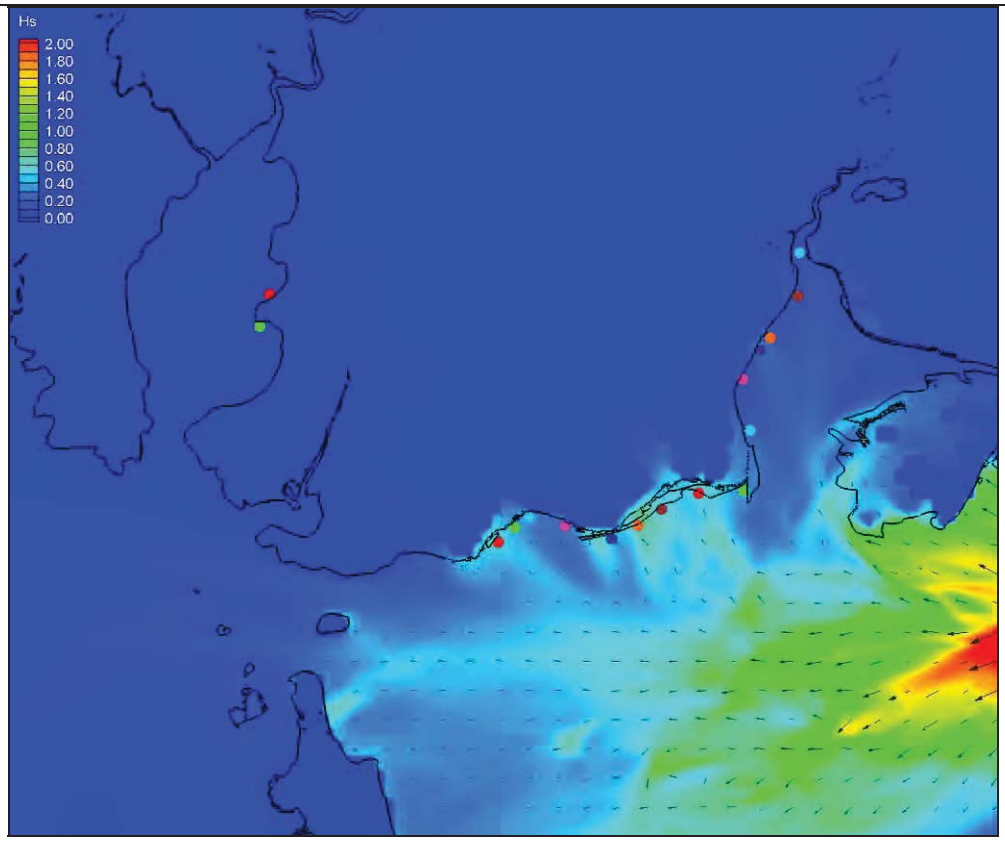


Figure 10-8 Modelled waves at Shoreline for input parameters: Hs 6.5 m ESE 1.38 m WL

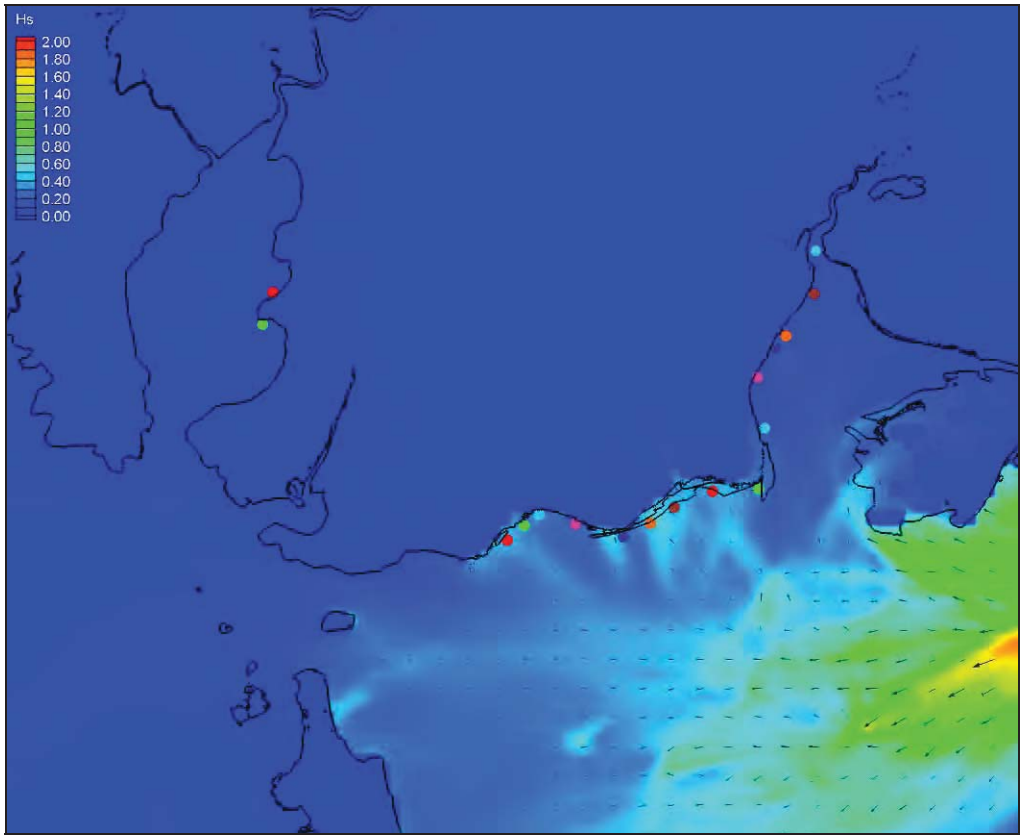


Figure 10-9 Modelled waves at Shoreline for input parameters: Hs 3.5 m SE 0.98 m WL

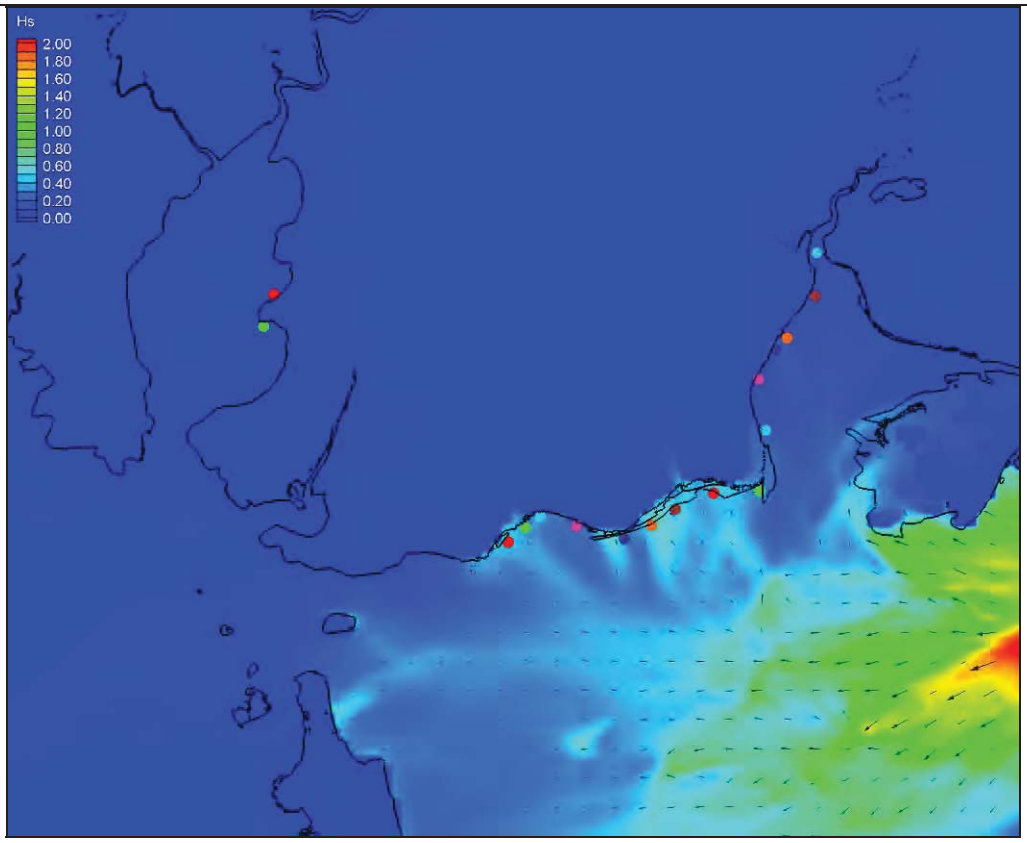


Figure 10-10 Modelled waves at Shoreline for input parameters: Hs 6.5 m SE 0.98 m WL

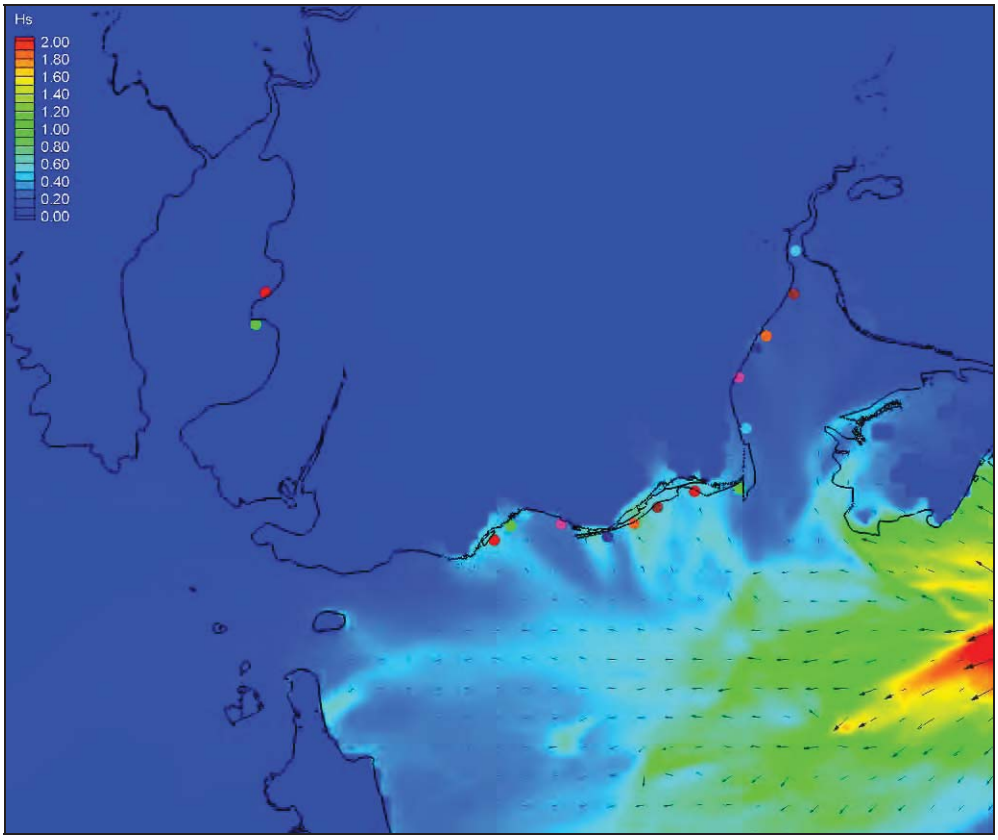


Figure 10-11 Modelled waves at Shoreline for input parameters: Hs 6.5 m SE 1.38 m WL

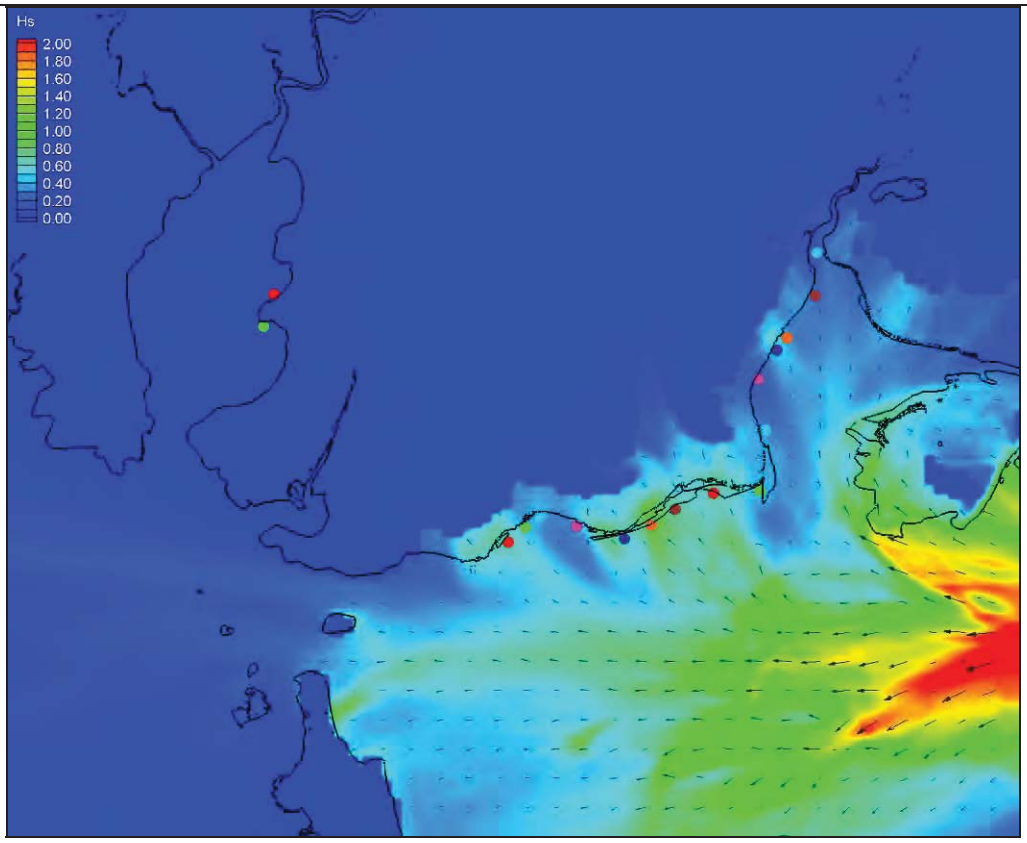


Figure 10-12 Modelled waves at Shoreline for input parameters: Hs 8.9 m E 2.32 m WL

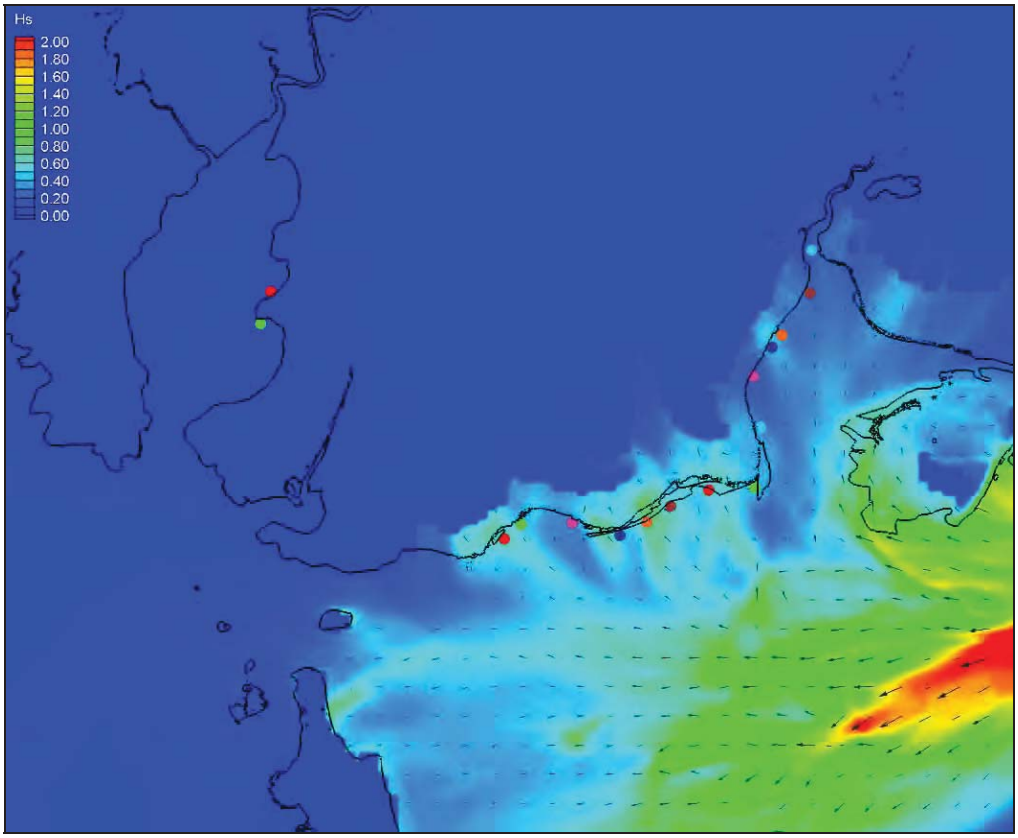


Figure 10-13 Modelled waves at Shoreline for input parameters: Hs 8.9 m SSE 2.32 m WL

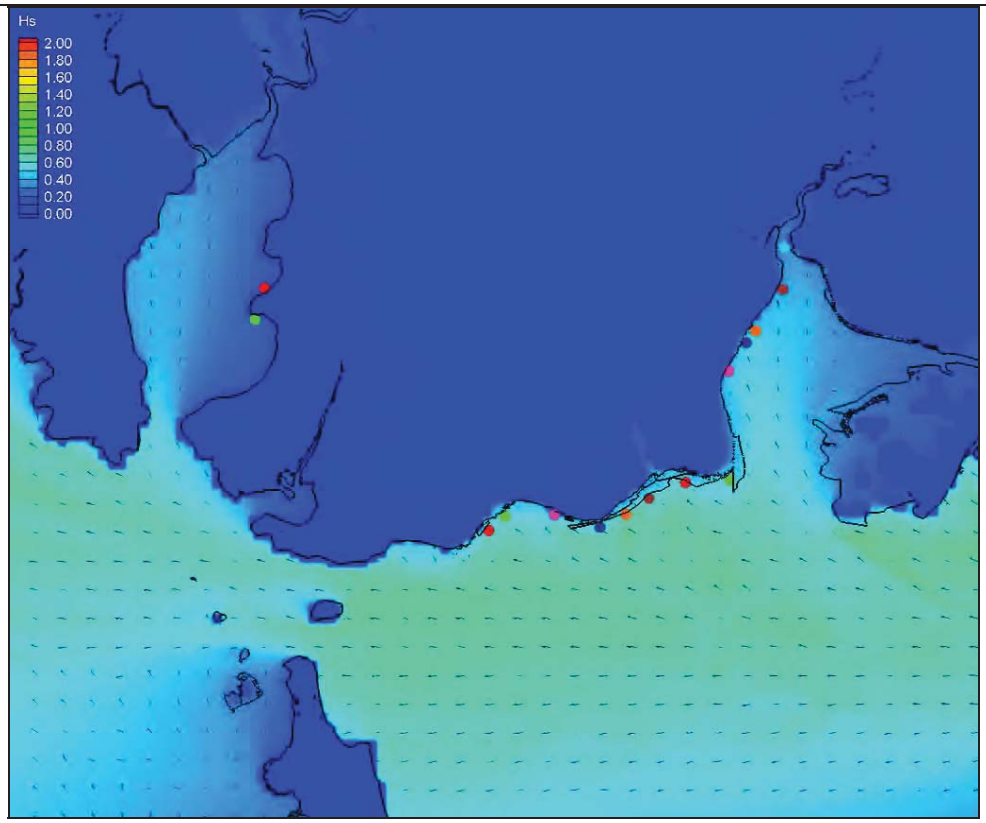


Figure 10-14 Modelled waves at Shoreline for input parameters: Wind 1 yr ARI SE 0.98 m WL

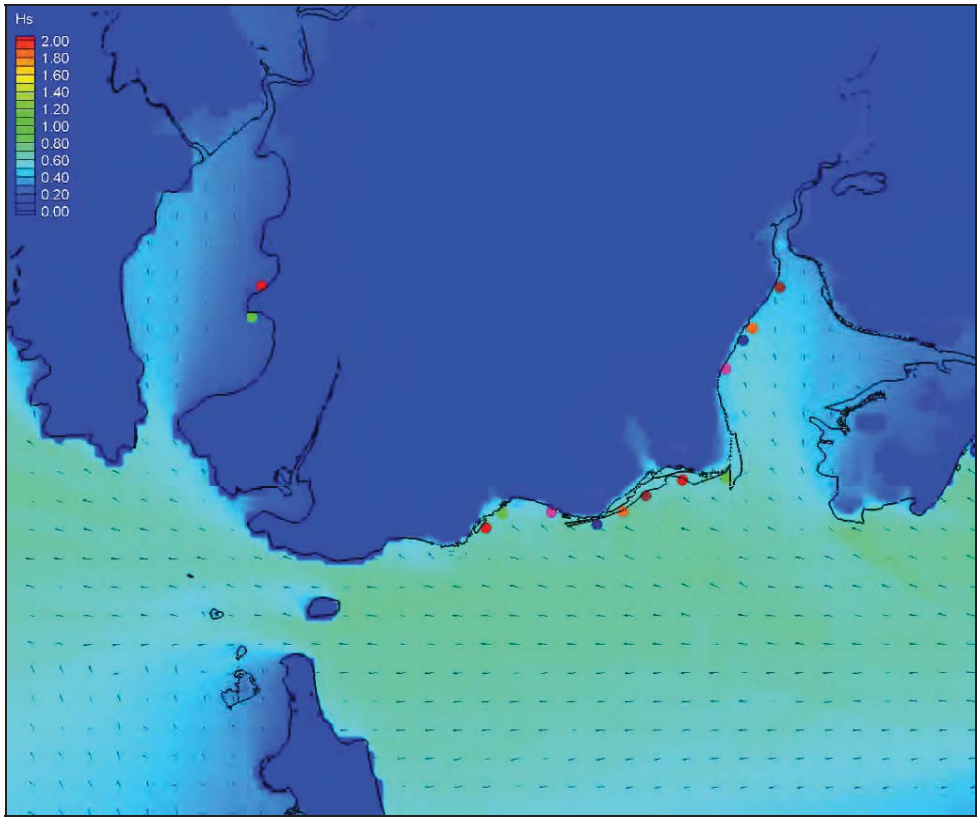


Figure 10-15 Modelled waves at Shoreline for input parameters: Wind 1 yr ARI SE 1.38 m WL

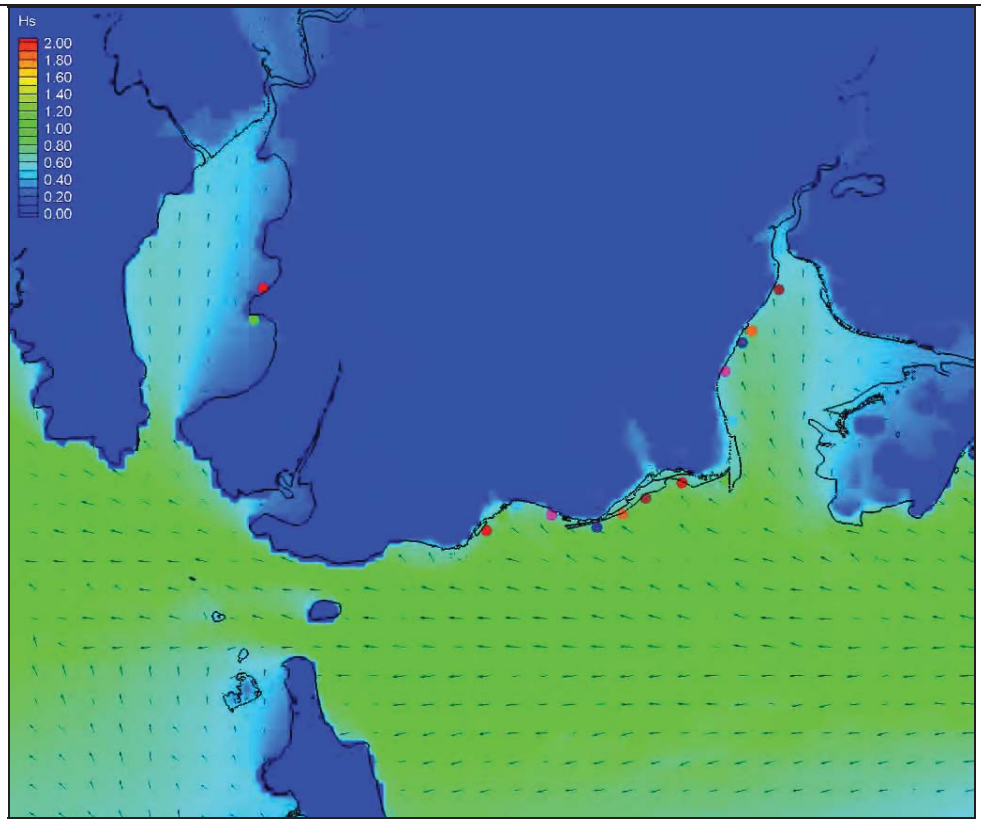


Figure 10-16 Modelled waves at Shoreline for input parameters: Wind 25 yr ARI SE 1.38 m WL

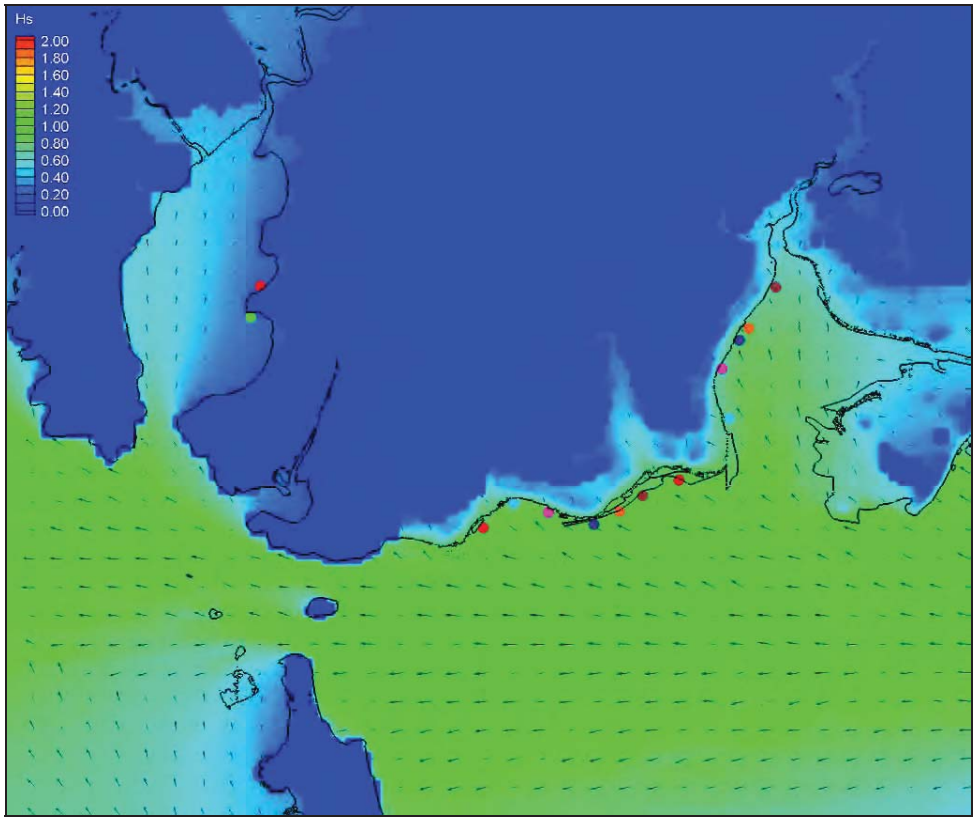


Figure 10-17 Modelled waves at Shoreline for input parameters: Wind 25 yr ARI SE 2.32 m WL

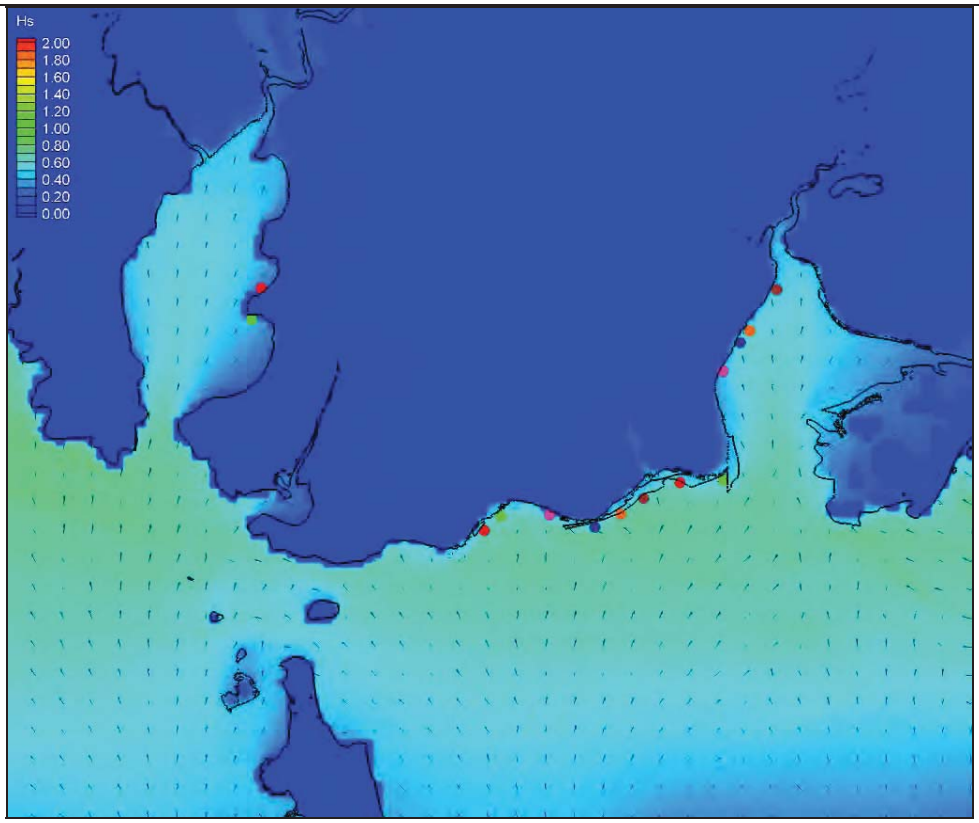


Figure 10-18 Modelled waves at Shoreline for input parameters: Wind 1 yr ARI S 0.98 m WL

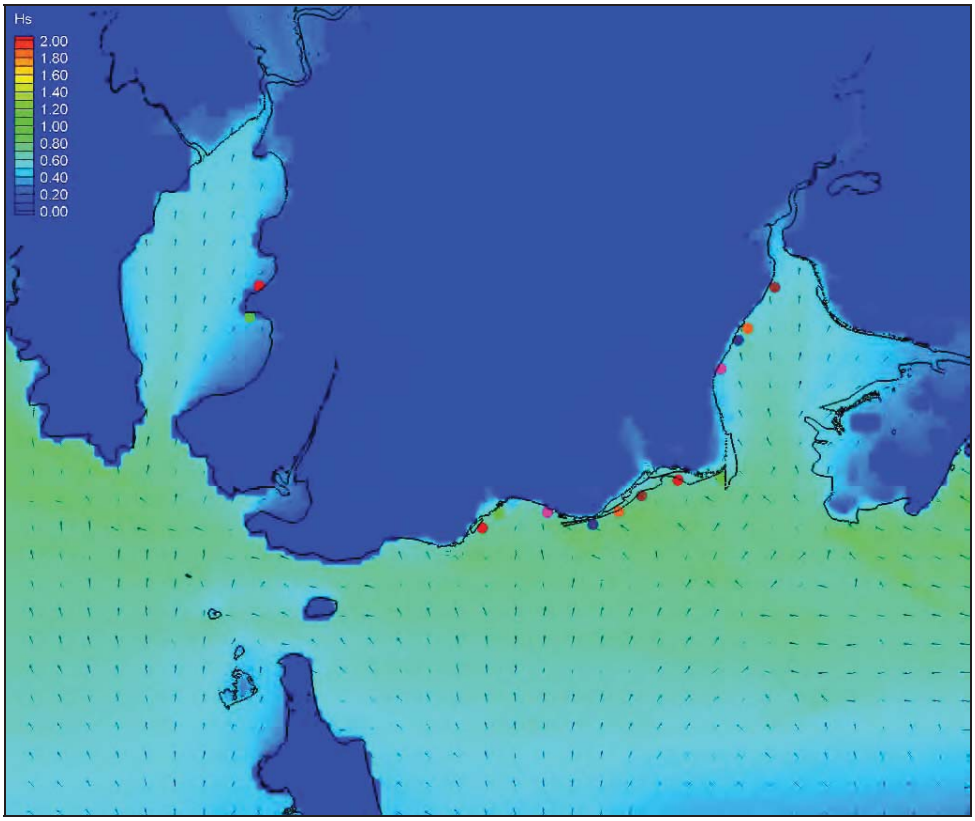


Figure 10-19 Modelled waves at Shoreline for input parameters: Wind 1 yr ARI S 1.38 m WL

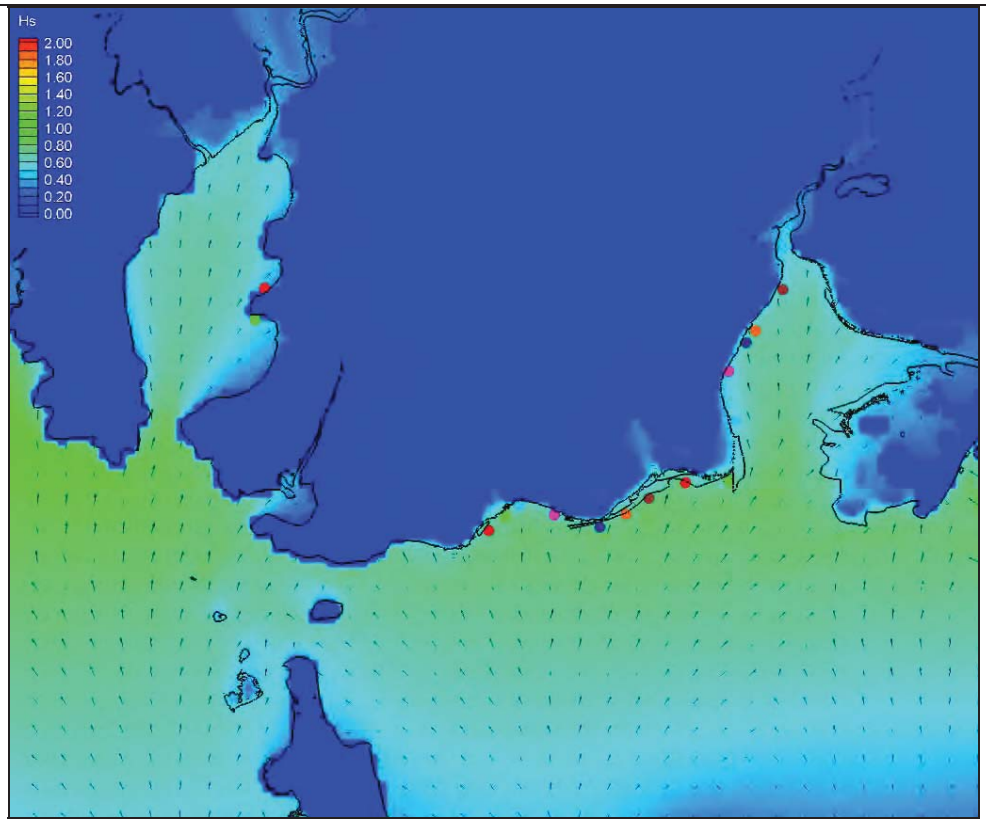


Figure 10-20 Modelled waves at Shoreline for input parameters: Wind 20 yr ARI S 1.38 m WL

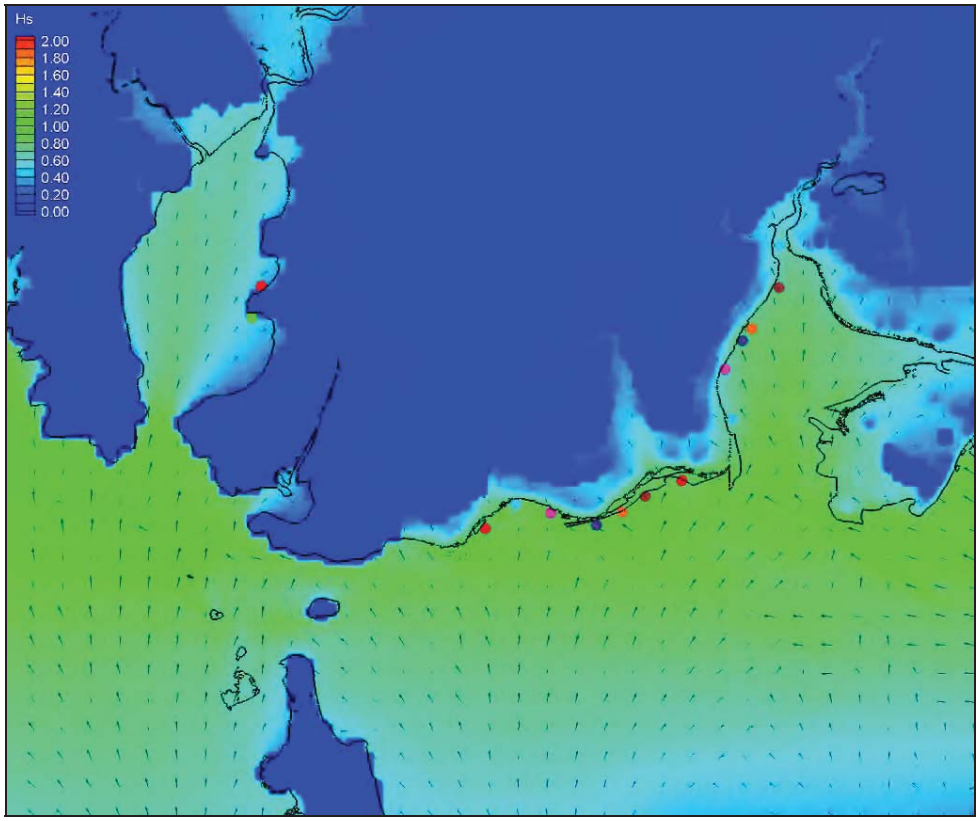


Figure 10-21 Modelled waves at Shoreline for input parameters: Wind 20 yr ARI S 2.32 m WL

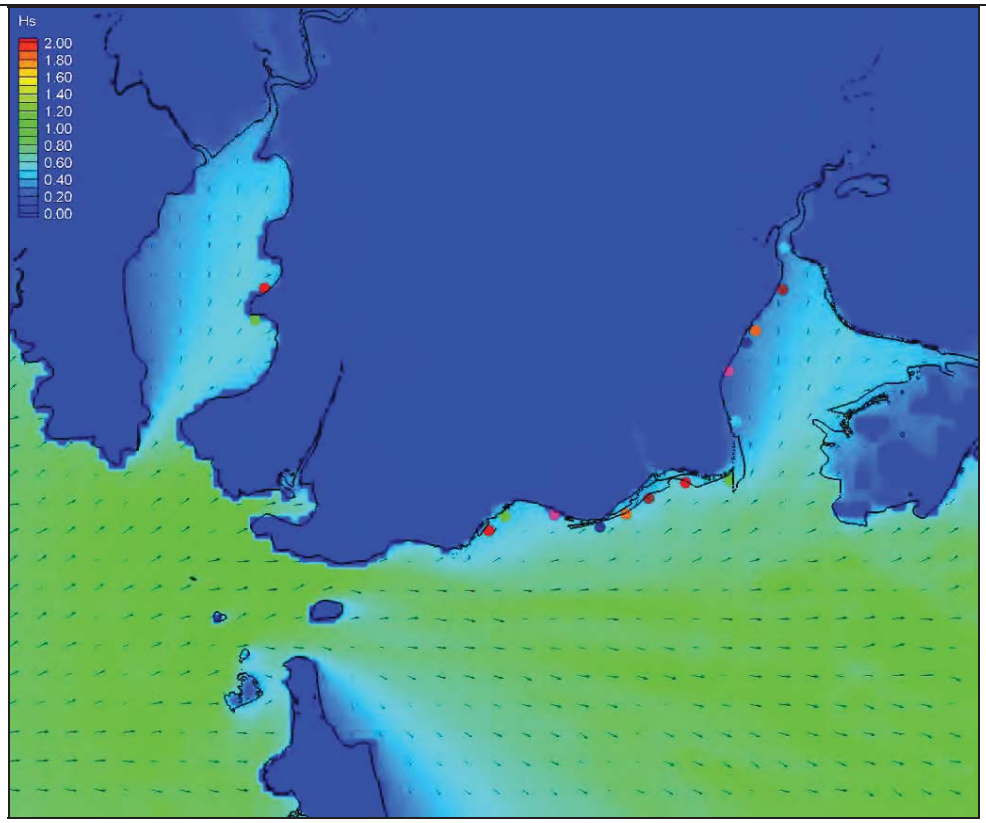


Figure 10-22 Modelled waves at Shoreline for input parameters: Wind 1 yr ARI W 0.98 m WL

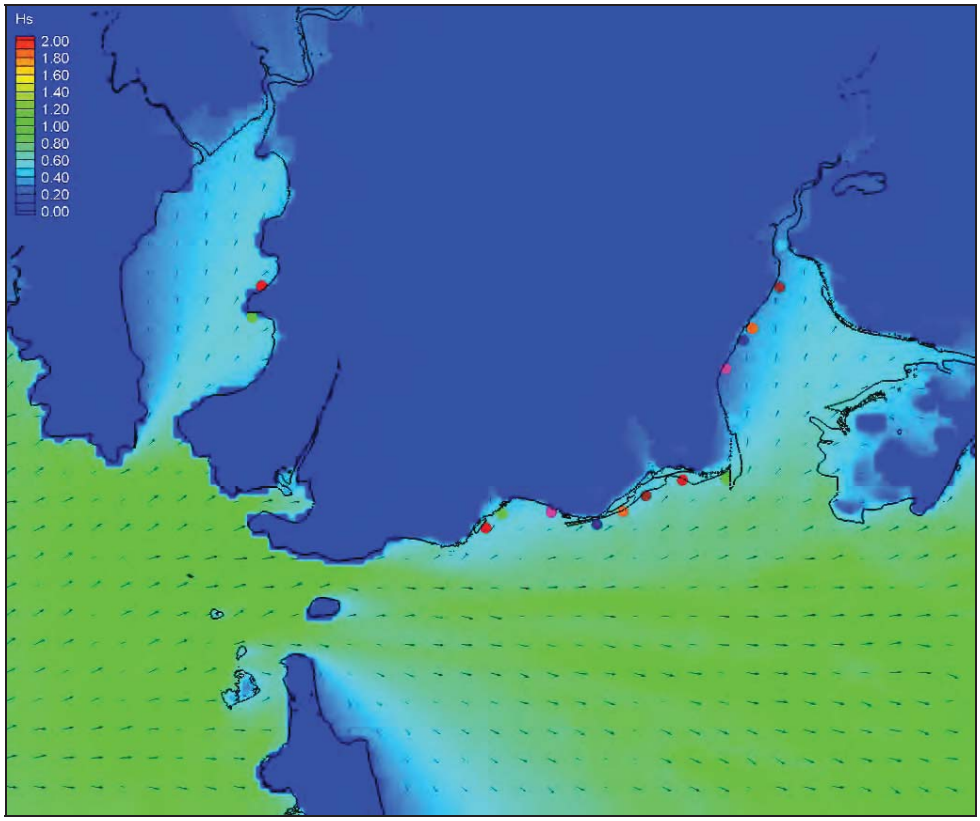


Figure 10-23 Modelled waves at Shoreline for input parameters: Wind 1 yr ARI W 1.38 m WL

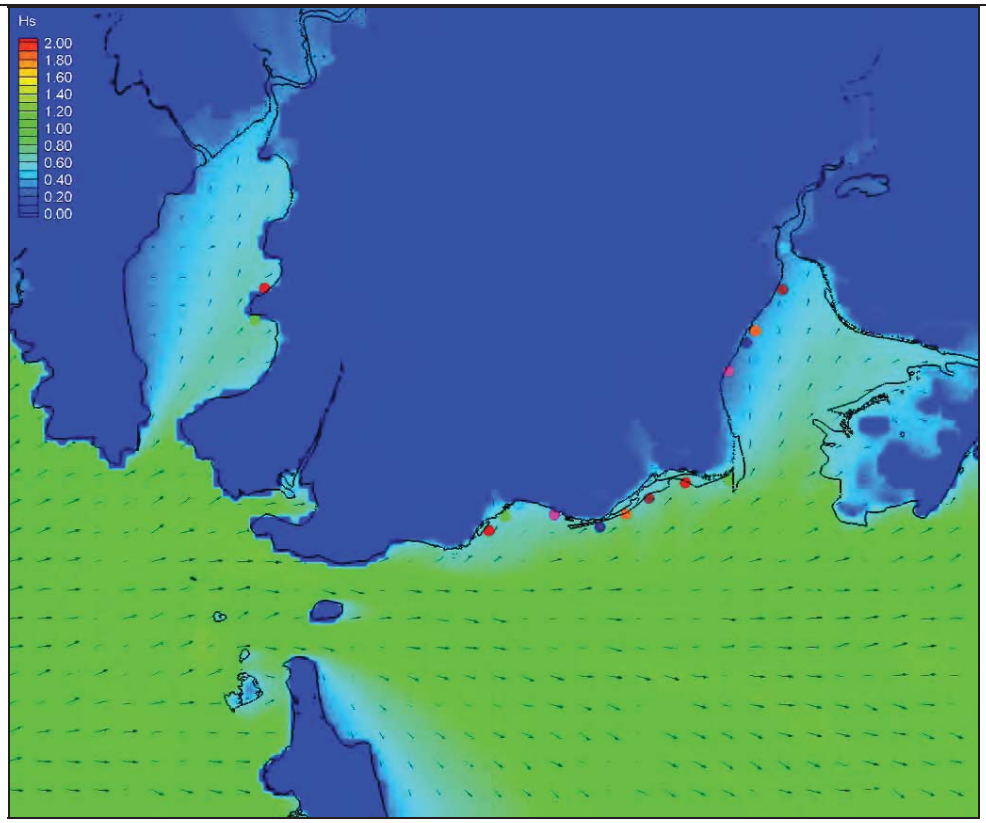


Figure 10-24 Modelled waves at Shoreline for input parameters: Wind 25 yr ARI W 1.38 m WL

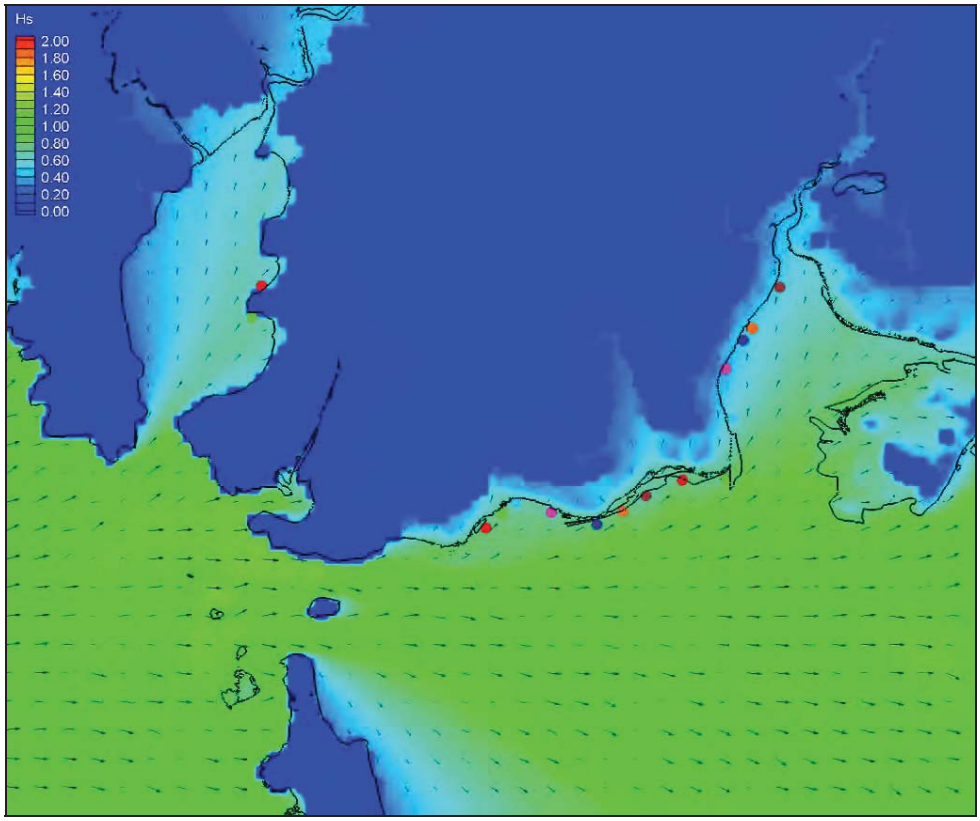


Figure 10-25 Modelled waves at Shoreline for input parameters: Wind 25 yr ARI W 2.32 m WL

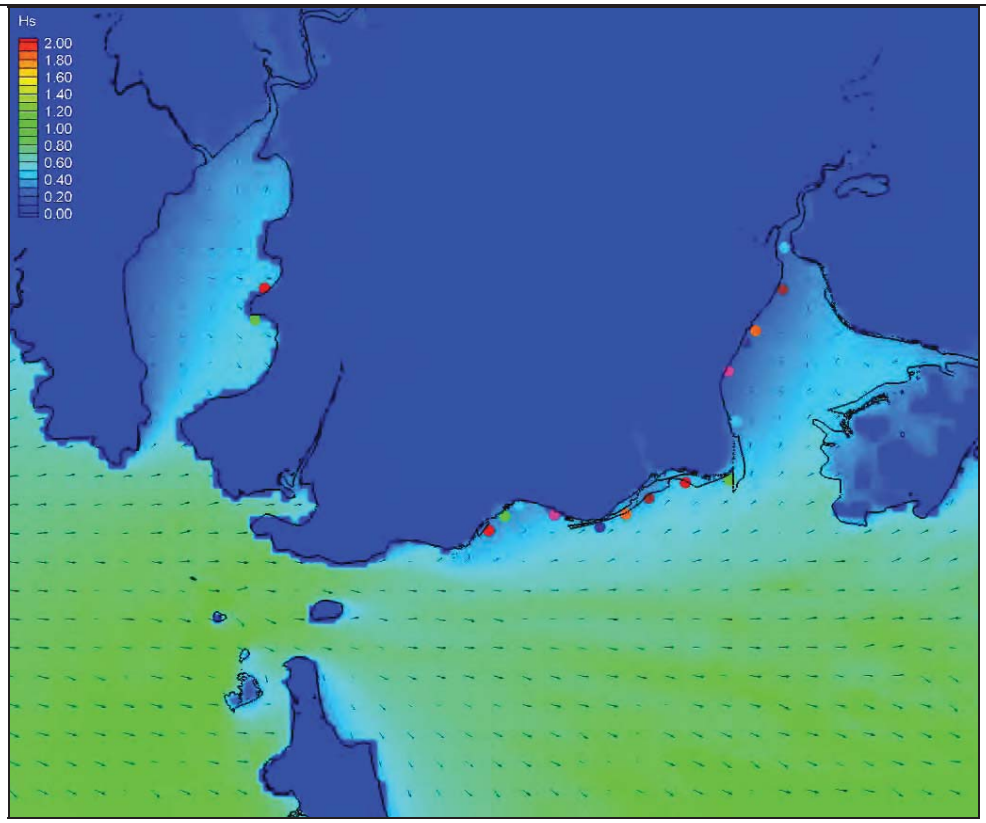


Figure 10-26 Modelled waves at Shoreline for input parameters: Wind 1 yr ARI NW 0.98 m WL

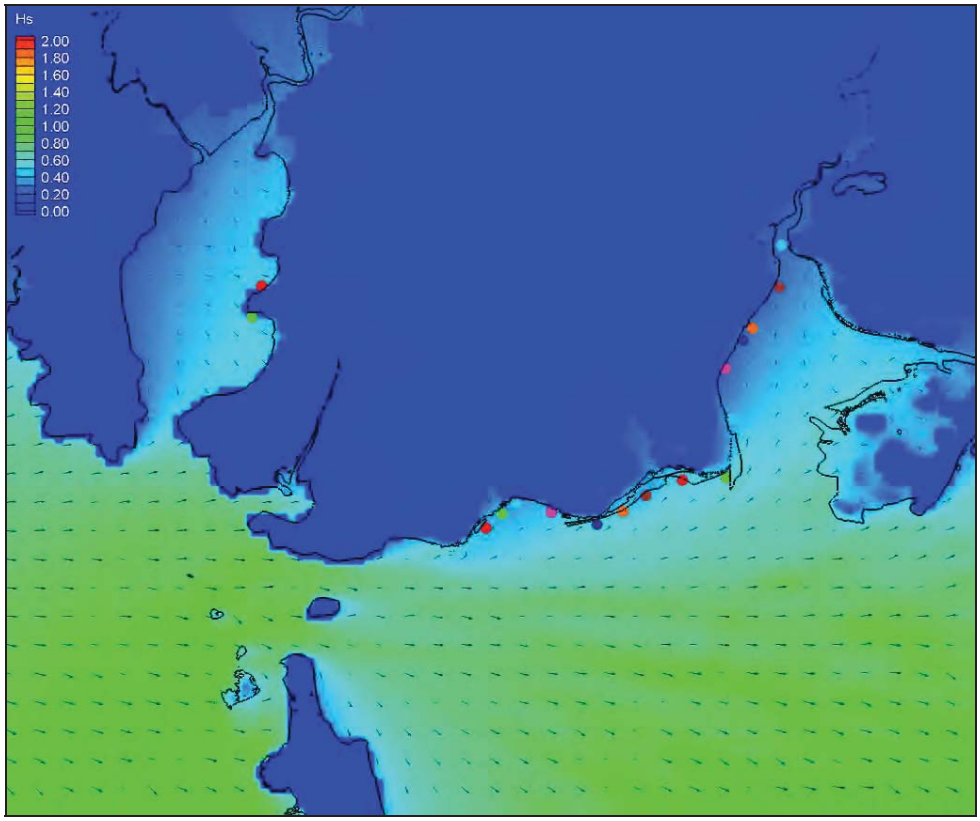


Figure 10-27 Modelled waves at Shoreline for input parameters: Wind 1 yr ARI NW 1.38 m WL

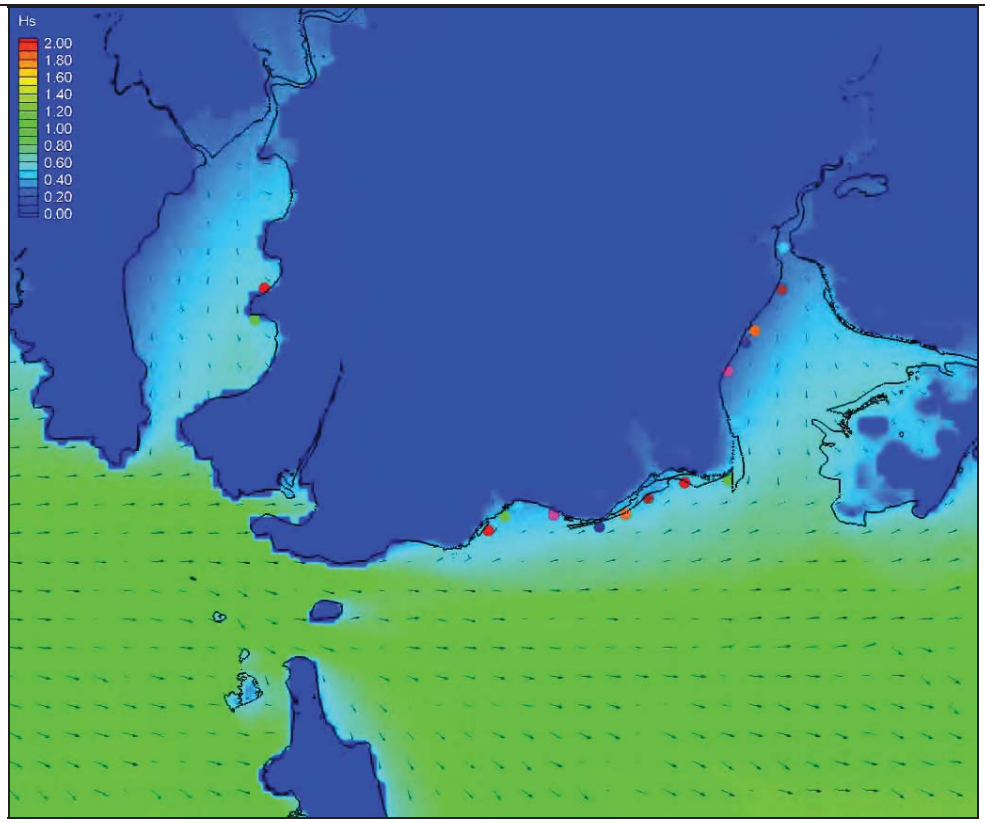


Figure 10-28 Modelled waves at Shoreline for input parameters: Wind 25 yr ARI NW 1.38 m WL

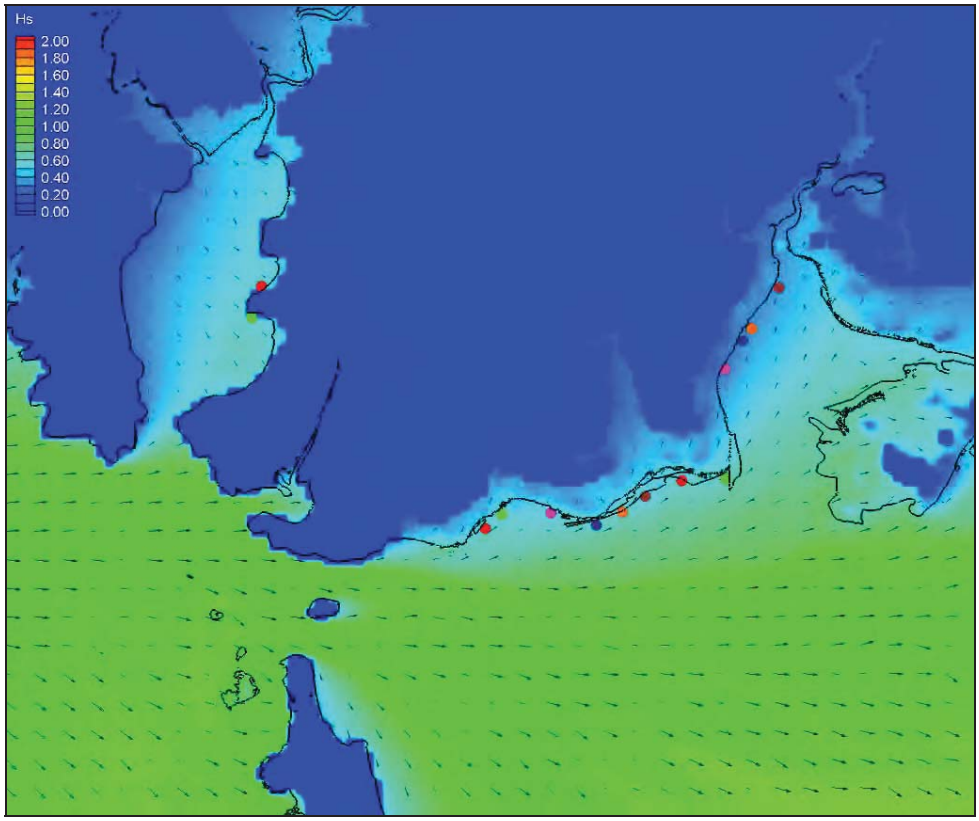


Figure 10-29 Modelled waves at Shoreline for input parameters: Wind 25 yr ARI W 2.32 m WL

APPENDIX F: DECISION MATRIX

Table 10.19 Decision Matrix for Recommended Strategies

Strategy	Location(s) (SS = shoreline section)	1	2	3	4	5	6	7	8a	8b	8c	8d	8e	8f
Provide a 'Natural Foreshore Protection Guideline' (Appendix G) to landholders and residents along the foreshore	SS1, SS2, SS3, SS7, SS8, SS9, SS10, SS12	Natural	NA	SEPP 14, saltmarsh, mangroves	Wider community = high It may be less acceptable for the few properties with structures, prior to education	Waves, wind waves, tides, historical recession now stabilised. SS1 - SS3, SS12 = Natural foreshore vegetation enhancement is sufficient; SS7 - SS10 already existing good vegetation, enhancement will be sufficient	Low	Benefit to community and the environment will be realised prior to SLR impacts	NA					
Undertake community education for local landholders and residents to promote the 'Natural Foreshore Protection Guideline'.	All sections, but especially SS1, SS2, SS3, SS7, SS8, SS9, SS10, SS12	Natural	NA	SEPP 14, saltmarsh, mangroves	High	As above	Low - Medium	Benefit to community and the environment will be realised prior to SLR impacts	NA					
Provide an 'Existing Structures Maintenance Guideline' (Appendix G) to landholders and residents along the foreshore.	SS4, SS11, SS13, SS14	Modified	NA	Mangroves	Medium - High	Waves, wind waves, tides, little historical recession. SS4 = insufficient natural foreshore vegetation, vertical walls causing decay of wrack in intertidal zone; SS11, SS13, SS14, little existing vegetation, groynes enhance erosion updrift, need to reduce slopes of existing structures and re-introduce vegetation.	Low	Benefit to community and the environment will be realised prior to SLR impacts	NA					
Provide an 'Natural Foreshore Protection Guideline' (Appendix G) to landholders and residents along the foreshore - Bundabah specific	SS15, SS16	Natural	NA	Mangroves	Medium	Tides, minor wind wave impacts at high tides. Existing approaches insufficient to mitigate erosion, unsightly, enhanced vegetation needed	Low	Benefit to community and the environment will be realised prior to SLR impacts	NA					
Undertake community education for local landholders and residents to demonstrate the 'Existing Structures Maintenance Guideline'.	All sections, but especially SS4, S11, SS13, SS14, SS15 & SS16 = Bundabah specific)	Modified	NA	Mangroves	High	As above	Low - Medium	Benefit to community and the environment will be realised prior to SLR impacts	High	Wider community	Low	High	High	Benefits to the community and environment will be realised before impacts from SLR manifest.

Strategy	Location(s) (SS = shoreline section)	1	2	3	4	5	6	7	8a	8b	8c	8d	8e	8f
Ensure Council officers who assess development applications are aware of the requirements in the 'Natural Foreshore Protection Guideline' and legislation applicable to activities on foreshore land.	SS1, SS2, SS3, SS7, SS8, SS9, SS10, SS12	Natural	NA	SEPP 14, saltmarsh, mangroves	NA	NA	Low	Regulating foreshore development is required as a long term strategy for future SLR impacts	NA					
Ensure Council officers who assess development applications are aware of the requirements in the 'Existing Structures Maintenance Guideline', and legislation applicable to activities on foreshore land.	SS4, SS11, SS13, SS14, SS15, SS16	Modified	NA	Mangroves	NA	NA	Low	Regulating foreshore development is required as a long term strategy for future SLR impacts	NA					
Include in the Estuary Foreshore Development Control Plan (DCP) the recommendations given in this study (Section 9.5) for foreshore management.	All sections	Natural & Modified	NA	SEPP 14, saltmarsh, mangroves	Medium	Long term sea level rise requires a reduction in foreshore development over time, to allow for shoreline recession and habitat movement	Low	Regulating foreshore development is required as a long term strategy for future SLR impacts	NA					
Rezone SEPP 14 Wetlands 756, 757, 757a and 757b as Environmental Conservation (E2) lands.	SS1, SS7, SS9, SS10	Natural	NA	SEPP 14, saltmarsh, mangroves	Private owners = unknown. Wider community = Medium	Wind waves, tidal currents, existing good vegetation on undeveloped lots. Future development precluded by SEPP 14 Wetlands	Low	Benefit to the environment and community will be realised prior to SLR impacts. This will also assist to reduce future impacts from SLR, by precluding additional foreshore development.	NA					
The following council owned lots should be converted into public reserves and rezoned as Environmental Conservation (E2) lands or similar: *Lots 2 to 7 and 14 to 17 of Section 44 DP 10869 (shoreline 7)* *Lots 12, 13, 48 and 49 Section C DP 13095 (shoreline 12)* *Lots 28 to 29 Section D DP 8287, Lots 15 to 21 Section Y DP 8287 and Lots 1 to 10 Section Z DP 8287 (shoreline 14)*	SS7, SS12, SS14	Natural	NA	SEPP 14, saltmarsh, mangroves	High	Wind waves, tidal currents, existing good vegetation on undeveloped lots. Future development precluded by sea level rise.	Low	Benefit to the community and the environment will be realised prior to SLR impacts. This will also assist to reduce future impacts from SLR, by precluding foreshore development and providing land for habitat migration.	NA					

Strategy	Location(s) (SS = shoreline section)	1	2	3	4	5	6	7	8a	8b	8c	8d	8e	8f
Illegal rock 'revetment' type protection works within Pig Hill Station Creek channel and outlet (Lot 10 Section 85 DP 10869) should be removed, by order to the property owner.	SS1	Natural	Recent	SEPP 14, saltmarsh, mangroves	Private owners = unknown. Wider community = High	Waves, wind waves, tides, historical recession now reducing. Natural foreshore vegetation enhancement is sufficient	Low	Benefit to community and the environment will be realised prior to SLR impacts.	NA					
Illegal vertical wooden seawalls on the foreshores of Lots 1 – 10 Section 85 DP 10869 should be removed, by order to the property owner(s)	SS2	Natural	Recent	SEPP 14, saltmarsh, mangroves	Private owners = unknown. Wider community = High	Waves, wind waves, tides, historical recession now reducing. Natural foreshore vegetation enhancement is sufficient	Low	Benefit to community and the environment will be realised prior to SLR impacts	NA					
Implement protection works to remediate erosion at the Norfolk Island Pine, boat ramp and adjacent foreshores, as per the conceptual diagram provided in Appendix H.	SS5, SS6	Modified	NA	Mangroves	High	Waves, wind waves, tides, very little vegetation. More structured approach required, as vegetation would preclude use of boat ramp. Vegetation appropriate at margins to reduce edge effects.	Medium - High	Benefit to community and the environment will be realised prior to SLR impacts	High	Wider community	In short term = low, in long term, slow degradation to adjacent mangroves may result in impacts to adjacent private property	High	Medium	Benefit to wider community will be realised prior to SLR impact
Promote growth and enhancement of native foreshore vegetation such as mangroves along shoreline section 5.	SS5	Natural	NA	Mangroves, saltmarsh	High	As above	Medium	Benefit to community and the environment will be realised prior to SLR impacts	High	Wider community	Low	High	High	Benefit to wider community and environment will be realised prior to SLR impact
The dumped building wastes and ad hoc 'structures' on Lot 2, 4 and 5 of Section N DP 8287 (shoreline section 8) should be removed by order to the landholder(s).	SS8	Natural	Recent	SEPP 14, saltmarsh, mangroves	Private owners = unknown. Wider community = High	Waves, wind waves, tides, historical recession now stabilised. SS8 has already existing good vegetation, enhancement will be sufficient, instead of unsightly and dangerous dumped wastes	Low	Benefit to community and the environment will be realised prior to SLR impacts	NA					

Strategy	Location(s) (SS = shoreline section)	1	2	3	4	5	6	7	8a	8b	8c	8d	8e	8f
The wooden vertical seawall-type structure on Lot 1 DP 177889 (Fish Depot) should be removed, by request / order to the landholder.	SS10	Natural	Old	SEPP 14, saltmarsh, mangroves	Private owners = unknown. Wider community = High	Waves, wind waves, tides, historical recession now stabilised. The seawall is showing signs of erosion at edges and of backfill, causing issues. Surrounding foreshore is well vegetated, area with wall should be rehabilitated.	Low	Benefit to community and the environment will be realised prior to SLR impacts	NA					
Remediate the erosion caused by the pipe outlets at the end of Warri Street and bordering property Lot 67 Section B DP 1084957, based on recommended works in Appendix I (from WBM, 2002).	SS11	Modified	NA	Mangroves	Relatively low wider community benefit, but reduces liability of Council from pipe outlet impacts	Erosion due to outflow from pipe outlets. Works required to stabilise and mitigate erosion at adjacent property	Medium	Benefit to private owners and the environment will be realised prior to SLR impacts.	Medium - Low	Private property owners	Medium - High	High	High	Benefits will be realised before SLR impacts manifest. Indeed, the works are unlikely to be affected negatively by sea level rise
Investigate the feasibility and need for formalising the currently informal boat ramp at the end of Wombo Street	SS11	Modified	NA	None	High	Tides, wind waves, causing longshore currents, no foreshore vegetation at present, street regularly used as ramp particularly as easier to access and better known than formal council ramp	Unknown	Benefit to the community will be realised prior to SLR impact. Environmental benefit likely to be secondary	High	Wider community	Low	NA	Medium - High	Benefits will be realised before SLR impacts manifest.
Undertake remediation of erosion from creek outlet along the border between Lot 3 Section C DP 8287 and Council owned Lot 12 Section C DP 13095, based on recommended works in Appendix I (from WBM, 2002).	SS12	Natural	NA	Mangroves, saltmarsh	Private owners = High. Wider community = medium	Erosion due to outflow from creek, property owner has attempted stabilise and divert flows. More environmental and effective works should be investigated	Medium - High	Benefit to private owners and the environment will be realised prior to SLR impacts.	Medium	Private property owners, community & environment in the future	Medium - High	High	High	Benefits will be realised before SLR impacts manifest
Implement protection works to stabilise the drain outlet at the end of Kiora Street and mitigate erosion at adjacent properties (Lot 35 Section C DP 8287 and Lot 1 Section D DP 8287), as per based on recommended works in Appendix I (from WBM, 2002).	SS13	Modified	NA	Mangroves	Medium	Erosion due to outflow from unstabilised drain. Works required to stabilise and mitigate erosion at adjacent properties	Medium - High	Benefit to community and the environment will be realised prior to SLR impacts	Medium	Private property owners	High	High	Medium	Benefits will be realised before SLR impacts manifest. Indeed, the works are unlikely to be affected negatively by sea level rise

APPENDIX G: FORESHORE PROTECTION GUIDELINES

Things You Can Do to Protect Your Foreshore

On natural shorelines, there are natural cycles of erosion during storms followed by accretion during good weather. The erosion events do not necessarily mean that the shoreline is receding over the long term.

On natural shorelines, 'hard' structures hinder sediment building up on the shoreline during good weather, and this means there is no buffer for erosion during storms. The actions below help the shoreline build up sand naturally.

- Plant native shrubs, trees and ground cover on your foreshore edge, which will help capture sediment and build the shoreline. Some good plants include Swamp Oak (Casuarina glauca), Coastal Wattle (Acacia longifolia subsp. sophorae) and Coastal Banksia (Banksia integrifolia). Refer to Council's website for more local species.
- Don't place waste such as bricks, concrete or rubble on the shoreline. It is a danger to the public accessing the foreshore, it is unsightly, and it is damaging to the environment.
- Remove any 'hard' materials placed on the foreshore, such as bricks, rubble, rocks, or concrete.
- After removing materials, stabilise the foreshore by replanting with native ground cover, shrubs, trees.
- Do not build structures such as walls, groynes, steps or ramps on the foreshore. All of these structures constrict the movement of water and sand, causing erosion around the structure.
- Don't damage or remove foreshore plants especially mangroves, mangrove seedlings or saltmarsh.
- Do not remove seaweed wrack from the foreshore (which assists with growth of plants and accumulation of sand on the shore).

All works on the foreshore require development consent from Council. Contact Council to find out what laws and approvals apply to the foreshore and adjacent marine park before undertaking works.

The foreshores of estuaries and beaches are for everyone to enjoy.

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Lower Pindimar Natural Foreshore Protection Guideline

Ways you can naturally protect the foreshore from erosion and improve the environment

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Natural Foreshores and Shoreline Protection

Natural foreshores in Lower Pindimar typically have a very gentle slope, where the land grades into the water. This is known as the inter-tidal zone, and many plants and animals thrive within this zone. Moving towards the water, there will usually be saltmarsh, then a strip of sandy sediments where wrack (dead seagrass) may deposit and break down to provide food for plants and animals, then a band of mangroves.

The gentle slopes help to protect the shoreline from erosion by reducing wave energy as it approaches the shore. Mangroves and other plants also reduce incoming waves and currents, protecting the shoreline behind. And, the mangroves and other foreshore plants capture sediment washed from the land, helping to build sediment stores on the shoreline.

Animals such as shore birds and crabs use mangroves and other plants for feeding, breeding and nesting. Mangroves, saltmarsh and other foreshore plants help to clean water flowing off the land into the estuary. In the water, there are seagrasses that provide a nursery for the spawning and growth of young fish. The combination of plants and animals all contribute to a healthy estuary that supports healthy fish stocks, dolphins and other animals.

There will always be natural cycles of erosion during storms followed by accretion during calm conditions on natural shorelines. Long term recession occurs when the shoreline does not recover between storms, but continues to move further back (landward) over time.

When mangroves and other plants are removed and gentle slopes are replaced with vertical walls, the protection for the shoreline is also removed. Sand may be washed away and the shoreline may start to recede permanently next to areas protected by vertical walls.

Seawalls and ‘Hard’ Structures in Lower Pindimar

When vertical walls replace gentle slopes, there is no reduction in wave energy before the waves reach the wall. This means that the full impact of waves is felt at the shoreline, and the reflected wave energy erodes the sediment at the base of the wall. When isolated seawalls are constructed in the middle of a natural foreshore, the wall also causes erosion in the adjacent soft shoreline. This is called an ‘edge effect’.

Waves crash over the top of seawalls and wet the soil behind. If the seawalls are solid and don’t allow drainage (like concrete, wood or cemented rocks) water may pool behind the wall and build up pressure that can cause the wall to collapse. On the other hand, if water drains too freely through the seawall, the fill behind the wall may wash out, forming ‘sinkholes’ that can also cause the wall to collapse.

In Lower Pindimar, high, vertical walls have also caused problems with wrack decay. Rather than being deposited at the high tide mark where it is able to dry and decompose quickly, the wrack is instead deposited in the low tide zone at the base of the walls, decaying to form an organic ooze. The ooze may destroy the seagrass and be poisonous to other marine animals. Healthy seagrasses are a nursery for juvenile fish, so they are vital for good fish stocks in the estuary.

History of the Lower Pindimar Shoreline

Piggies Beach has extensive sand and mud flats. The shoreline experiences moderate to high waves, however, there is no long term recession at present. The foreshore remains stable due to a gentle natural slope and sandy beach with low vegetated dune. There are few mangroves because the waves make it difficult them to colonise. The sand flats provide open water for birds and animals to forage for food.

The land west of Piggies Beach has receded over many decades, with large decaying trees evident on the shoreline from many years ago. The erosion of Myall Point off Winda Woppa in 1927-9 is likely to have exposed this shoreline to bigger waves. However, ‘hard’ structural protection is not required because the recession is a natural process and is not threatening property at this time. If structural protection were built, the impacts and erosion from waves and currents would probably be transferred to nearby Piggies Beach where properties would then be threatened.

Things You Can Do to Protect Your Foreshore

Many locals will know the effort required to maintain vertical walls, and this is because the walls are directly impacted by waves and currents, instead of reducing this energy.

You can improve the performance of your existing structures to reduce erosion and improve the habitat for fish and shorebirds, as follows.

- Place rock (armour stone) in front of the vertical wall to produce a gentle slope (1:4), ensuring that the rocks are of a sufficient size to withstand the wave energy (see diagram).
- Place the rocks to give variations in slope and crevices.
- Encourage mangrove seedlings to grow in gaps between the rocks at the toe of the seawall.
- Plant native shrubs, trees and ground cover on your foreshore behind the seawall, for example, 'Coastal Pigface' (Carpobrotus glaucescens), Coastal Wattle (Acacia longifolia subsp. sophorae) and Coastal Banksia (Banksia integrifolia). Refer to Council's website for more local species.
- Don't place waste such as bricks, concrete or wood on the shoreline or as part of any structure. It is a danger to the public accessing the foreshore, it is unsightly, and it is damaging to the environment.
- Don't damage or remove foreshore plants especially mangroves, mangrove seedlings or saltmarsh.
- Do ensure your existing structure has a geotextile fabric so that backfill does not erode from behind the structure.
- Do ensure your existing structure allows drainage for water to escape from behind the wall. Without drainage, land behind the wall can become saturated and cause the wall to collapse.
- Don't construct groynes as part of any structure. These cause erosion at adjacent shorelines. Groynes are also dangerous to the community walking along the foreshore.
- Do not remove seaweed wrack from the foreshore (which assists with growth of plants and accumulation of sand on the shore).

All structural works on the foreshore require development consent from Council. Contact Council to find out what laws and approvals apply to the foreshore and adjacent marine park before undertaking works.

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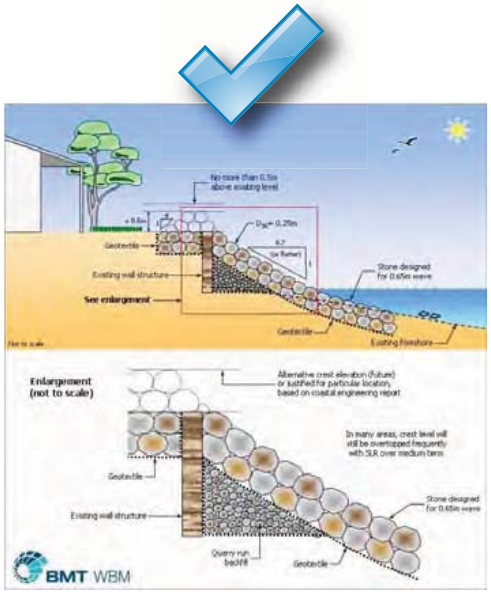

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Lower Pindimar Existing Structures Maintenance Guideline

Ways you can improve protection by your foreshore structure and the environment

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The gentle slopes help to protect the shoreline from erosion by reducing wave energy as it approaches the shore. Mangroves and other plants also reduce incoming waves and currents, protecting the shoreline behind. And, the mangroves and other foreshore plants capture sediment washed from the land, helping to build sediment stores on the shoreline.

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Waves crash over the top of seawalls and wet the soil behind. If the seawalls are solid and don't allow drainage (like concrete, wood or cemented rocks) water may pool behind the wall and build up pressure that can cause the wall to collapse. On the other hand, if water drains too freely through the seawall, the fill behind the wall may wash out, forming 'sinkholes' that can also cause the wall to collapse.

In Lower Pindimar, high, vertical walls have also caused problems with wrack decay. Rather than being deposited at the high tide mark where it is able to dry and decompose quickly, the wrack is instead deposited in the low tide zone at the base of the walls, decaying to form an organic ooze. The ooze may destroy the seagrass and be poisonous to other marine animals. Healthy seagrasses are a nursery for juvenile fish, so they are vital for good fish stocks in the estuary.

Groynes

Groynes can capture sediments drifting along the shoreline, but this causes erosion of the shoreline further up becuse there is no sand being transferred along the shore. In Lower Pindimar, the groynes do not appear to be capturing sand, which means there is little or no transport of sand along the shore. This also means the groynes are unnecessary. Instead, groynes are a danger to the public attempting to walk along the shoreline.

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Piggies Beach has extensive sand and mud flats. The shoreline experiences moderate to high waves, however, there is no long term recession at present. The foreshore remains stable due to a gentle natural slope and sandy beach with low vegetated dune. There are few mangroves because the waves make it difficult them to colonise. The sand flats provide open water for birds and animals to forage for food.

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On natural shorelines, 'hard' structures hinder sediment building up on the shoreline during good weather, and this means there is no buffer for erosion during storms. The actions below help the shoreline build up sand naturally.

- Plant native shrubs, trees and ground cover on your foreshore edge, which will help capture sediment and build the shoreline. Some good plants include Swamp Oak (Casuarina glauca), Coastal Wattle (Acacia longifolia subsp. sophorae) and Coastal Banksia (Banksia integrifolia). Refer to Council's website for more local species.
- Don't place waste such as bricks, concrete or rubble on the shoreline. It is a danger to the public accessing the foreshore, it is unsightly, and it is damaging to the environment.
- Remove any 'hard' materials placed on the foreshore, such as bricks, rubble, rocks, or concrete.
- After removing materials, stabilise the foreshore by replanting with native ground cover, shrubs, trees.
- Do not build structures such as walls, groynes, steps or ramps on the foreshore. All of these structures constrict the movement of water and sand, causing erosion around the structure.
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Pindimar Natural Foreshore Protection Guideline

Ways you can naturally protect the foreshore from erosion and improve the environment

Great Lakes COUNCIL

Natural Foreshores and Shoreline Protection

Natural foreshores in Pindimar typically have a very gentle slope, where the land grades into the water. This is known as the inter-tidal zone, and many plants and animals thrive within this zone. Moving towards the water, there will usually be saltmarsh, then a strip of sandy sediments where wrack (dead seagrass) may deposit and break down to provide food for plants and animals, then a band of mangroves.

The gentle slopes help to protect the shoreline from erosion by reducing wave energy as it approaches the shore. Mangroves and other plants also reduce incoming waves and currents, protecting the shoreline behind. And, the mangroves and other foreshore plants capture sediment washed from the land, helping to build sediment stores on the shoreline.

Animals such as shore birds and crabs use mangroves and other plants for feeding, breeding and nesting. Mangroves, saltmarsh and other foreshore plants help to clean water flowing off the land into the estuary. In the water, there are seagrasses that provide a nursery for the spawning and growth of young fish. The combination of plants and animals all contribute to a healthy estuary that supports healthy fish stocks, dolphins and other animals.

There will always be natural cycles of erosion during storms followed by accretion during calm conditions on natural shorelines. Long term recession occurs when the shoreline does not recover between storms, but continues to move further back (landward) over time.

When mangroves and other plants are removed and gentle slopes are replaced with vertical walls, the protection for the shoreline is also removed. Sand may be washed away and the shoreline may start to recede permanently next to areas protected by vertical walls.

Seawalls and 'Hard' Structures in Pindimar

When vertical walls replace gentle slopes, there is no reduction in wave energy before the waves reach the wall. This means that the full impact of waves is felt at the shoreline, and the reflected wave energy erodes the sediment at the base of the wall. When isolated seawalls are constructed in the middle of a natural foreshore, the wall also causes erosion in the adjacent soft shoreline. This is called an 'edge effect'.

Waves crash over the top of seawalls and wet the soil behind. If the seawalls are solid and don't allow drainage (like concrete, wood or cemented rocks) water may pool behind the wall and build up pressure that can cause the wall to collapse. On the other hand, if water drains too freely through the seawall, the fill behind the wall may wash out, forming 'sinkholes' that can also cause the wall to collapse.

Groynes

In Upper Pindimar, sand naturally moves along the shore towards the north. Groynes can capture the sediment, but this causes erosion of the shoreline further up because there is no sand being transferred along the shore. Groynes are also dangerous to the public attempting to walk along the shoreline.

History of the Pindimar Shoreline

In Pindimar, most of the foreshore mangroves were grazed by cattle in the 1920s to 1940s. During this time there was extensive recession of the shoreline, particularly at Orungall Point. After the 1960s mangroves began to grow in coverage, especially at Orungall Point and Pindimar. Since this time the foreshore at Orungall Point and Pindimar has stabilised. Only the public boat ramp area is still receding where there are no mangroves and the foreshore is exposed to boat wash.

For Pindimar, the best option for foreshore management at individual properties is to allow mangroves to regenerate along the foreshore. Mangroves provide better protection than poorly built structures, rubble, rocks that can also make erosion worse. Significant structural works are only needed at the public boat ramp, to provide the community with ongoing access to the waterway.

Things You Can Do to Protect Your Foreshore

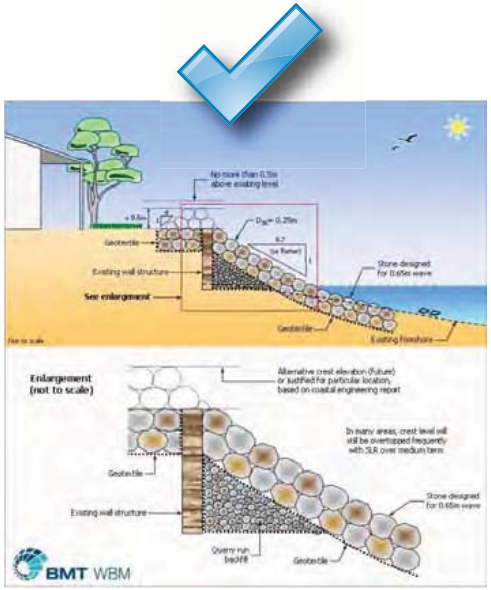
Many locals will know the effort required to maintain vertical walls, and this is because the walls are directly impacted by waves and currents, instead of reducing this energy.

You can improve the performance of your existing structures to reduce erosion and improve the habitat for fish and shorebirds, as follows.

- Place rock (armour stone) in front of the vertical wall to produce a gentle slope (1:4), ensuring that the rocks are of a sufficient size to withstand the wave energy (see diagram).
- Place the rocks to give variations in slope and crevices.
- Encourage mangrove seedlings to grow in gaps between the rocks at the toe of the seawall.
- Plant native shrubs, trees and ground cover on your foreshore behind the seawall, for example, 'Coastal Pigface' (Carpobrotus glaucescens), Coastal Wattle (Acacia longifolia subsp. sophorae) and Coastal Banksia (Banksia integrifolia). Refer to Council's website for more local species.
- Don't place waste such as bricks, concrete or wood on the shoreline or as part of any structure. It is a danger to the public accessing the foreshore, it is unsightly, and it is damaging to the environment.
- Don't damage or remove foreshore plants especially mangroves, mangrove seedlings or saltmarsh.
- Do ensure your existing structure has a geotextile fabric so that backfill does not erode from behind the structure.
- Do ensure your existing structure allows drainage for water to escape from behind the wall. Without drainage, land behind the wall can become saturated and cause the wall to collapse.
- Don't construct groynes as part of any structure. These cause erosion at adjacent shorelines. Groynes are also dangerous to the community walking along the foreshore.
- Do not remove seaweed wrack from the foreshore (which assists with growth of plants and accumulation of sand on the shore).

All structural works on the foreshore require development consent from Council. Contact Council to find out what laws and approvals apply to the foreshore and adjacent marine park before undertaking works.

The foreshores of estuaries and beaches are for everyone to enjoy.



Great Lakes COUNCIL

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"Where will our knowledge take you?"

Upper Pindimar Existing Structures Maintenance Guideline

Ways you can improve protection by your foreshore structure and the environment

Great Lakes COUNCIL

Natural Foreshores and Shoreline Protection

Natural foreshores in Pindimar typically have a very gentle slope, where the land grades into the water. This is known as the inter-tidal zone, and many plants and animals thrive within this zone. Moving towards the water, there will usually be saltmarsh, then a strip of sandy sediments where wrack (dead seagrass) may deposit and break down to provide food for plants and animals, then a band of mangroves.

The gentle slopes help to protect the shoreline from erosion by reducing wave energy as it approaches the shore. Mangroves and other plants also reduce incoming waves and currents, protecting the shoreline behind. And, the mangroves and other foreshore plants capture sediment washed from the land, helping to build sediment stores on the shoreline.

Animals such as shore birds and crabs use mangroves and other plants for feeding, breeding and nesting. Mangroves, saltmarsh and other foreshore plants help to clean water flowing off the land into the estuary. In the water, there are seagrasses that provide a nursery for the spawning and growth of young fish. The combination of plants and animals all contribute to a healthy estuary that supports healthy fish stocks, dolphins and other animals.

There will always be natural cycles of erosion during storms followed by accretion during calm conditions on natural shorelines. Long term recession occurs when the shoreline does not recover between storms, but continues to move further back (landward) over time.

When mangroves and other plants are removed and gentle slopes are replaced with vertical walls, the protection for the shoreline is also removed. Sand may be washed away and the shoreline may start to recede permanently next to areas protected by vertical walls.

Seawalls and ‘Hard’ Structures in Pindimar

When vertical walls replace gentle slopes, there is no reduction in wave energy before the waves reach the wall. This means that the full impact of waves is felt at the shoreline, and the reflected wave energy erodes the sediment at the base of the wall. When isolated seawalls are constructed in the middle of a natural foreshore, the wall also causes erosion in the adjacent soft shoreline. This is called an ‘edge effect’.

Waves crash over the top of seawalls and wet the soil behind. If the seawalls are solid and don’t allow drainage (like concrete, wood or cemented rocks) water may pool behind the wall and build up pressure that can cause the wall to collapse. On the other hand, if water drains too freely through the seawall, the fill behind the wall may wash out, forming ‘sinkholes’ that can also cause the wall to collapse.

Groynes

In Upper Pindimar, sand naturally moves along the shore towards the north. Groynes can capture the sediment, but this causes erosion of the shoreline further up because there is no sand being transferred along the shore. Groynes are also dangerous to the public attempting to walk along the Uppershoreline.

History of the Upper Pindimar Shoreline

In Upper Pindimar, most of the foreshore mangroves were grazed by cattle in the 1920s to 1940s. From the late 1940s onwards, vertical ‘seawall’ structures were built in some sections of the shoreline. A set of railway sleepers placed as ‘groynes’ on the shoreline in 1948 show how the shoreline has remained stable, in the same place behind sleepers over time. Towards the north in locations without structures, the shoreline has accreted over time.

At Upper Pindimar, waves and currents at the shoreline as well as vertical walls reflecting wave energy have made it difficult for mangroves to regrow, or for sediment to build at the base of the walls. The existing structures do not meet engineering standards or encourage fish and birds into the area. Modifications to these structures to help them act as effective erosion buffers can also improve the numbers of fish and birds coming into Pindimar Bay.

Things You Can Do to Protect Your Foreshore

On natural shorelines, there are natural cycles of erosion during storms followed by accretion during good weather. The erosion events do not necessarily mean that the shoreline is receding over the long term.

On natural shorelines, 'hard' structures hinder sediment building up on the shoreline during good weather, and this means there is no buffer for erosion during storms. The actions below help the shoreline build up sand naturally.

- Plant native shrubs, trees and ground cover on your foreshore edge, which will help capture sediment and build the shoreline. Some good plants include Swamp Oak (Casuarina glauca), Coastal Wattle (Acacia longifolia subsp. sophorae) and Coastal Banksia (Banksia integrifolia). Refer to Council's website for more local species.
- Don't place waste such as bricks, concrete or rubble on the shoreline. It is a danger to the public accessing the foreshore, it is unsightly, and it is damaging to the environment.
- Remove any 'hard' materials placed on the foreshore, such as bricks, rubble, rocks, or concrete.
- After removing materials, stabilise the foreshore by replanting with native ground cover, shrubs, trees.
- Do not build structures such as walls, groynes, steps or ramps on the foreshore. All of these structures constrict the movement of water and sand, causing erosion around the structure.
- Don't damage or remove foreshore plants especially mangroves, mangrove seedlings or saltmarsh.
- Do not remove seaweed wrack from the foreshore (which assists with growth of plants and accumulation of sand on the shore).

All works on the foreshore require development consent from Council. Contact Council to find out what laws and approvals apply to the foreshore and adjacent marine park before undertaking works.

The foreshores of estuaries and beaches are for everyone to enjoy.

Great Lakes COUNCIL

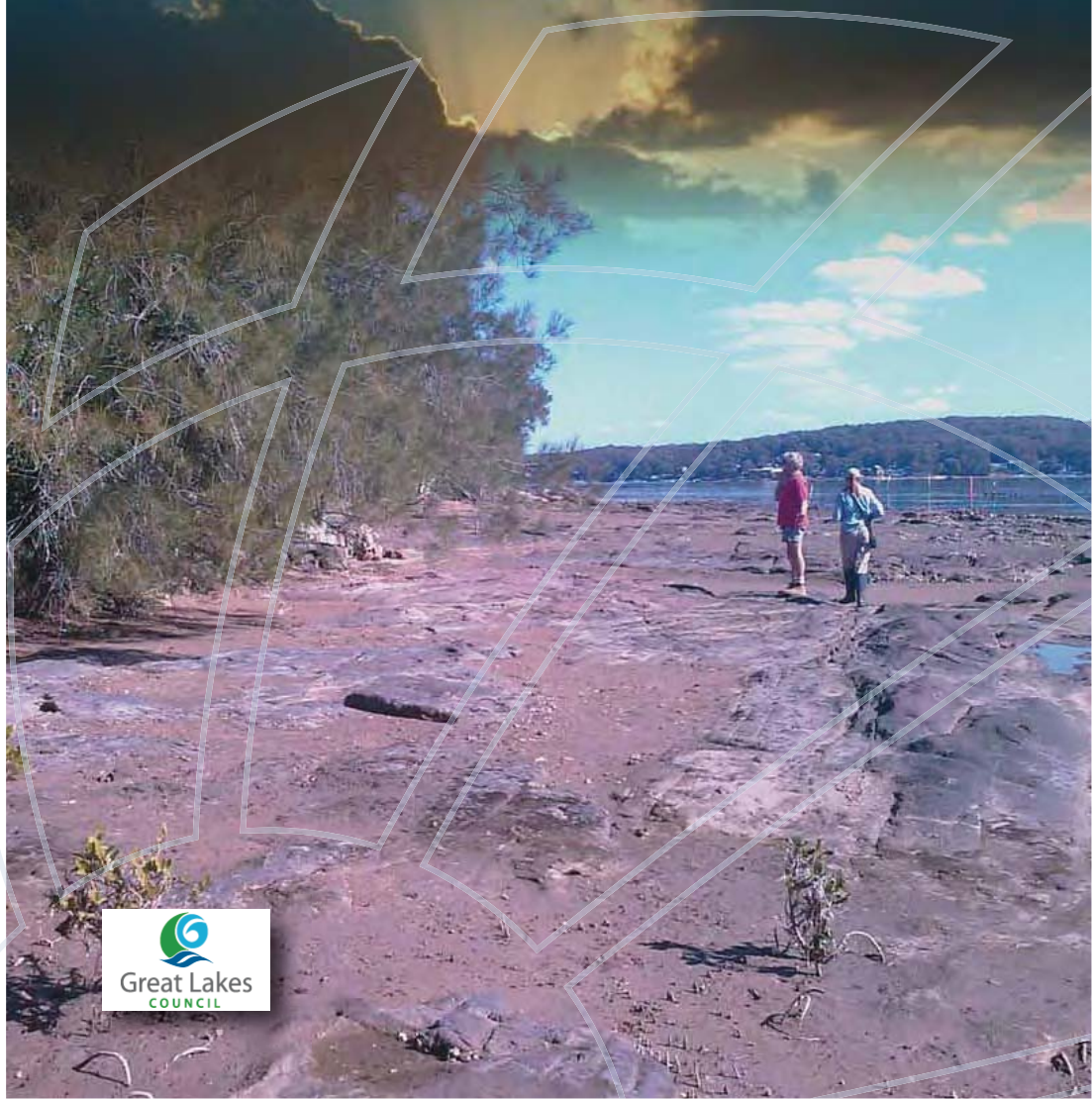
A part of BMT in Energy and Environment

BMT WBM

"Where will our knowledge take you?"

Bundabah Natural Foreshore Protection Guideline

Ways you can naturally protect the foreshore from erosion and improve the environment



Great Lakes COUNCIL

Natural Foreshores and Shoreline Protection

In Bundabah, some of the foreshore is steep and some of the foreshore is gently sloped.

The steep foreshores are bedrock with a thin layer of sediment on top. 'Fretting' of the overlying soft sediments may occur during storms, but the shoreline does not recede because of the underlying rock. Rocky shores are home to animals such as crabs and oysters that live in the crevices, ledges and pools that hold water at high tide. These animals are food for fish.

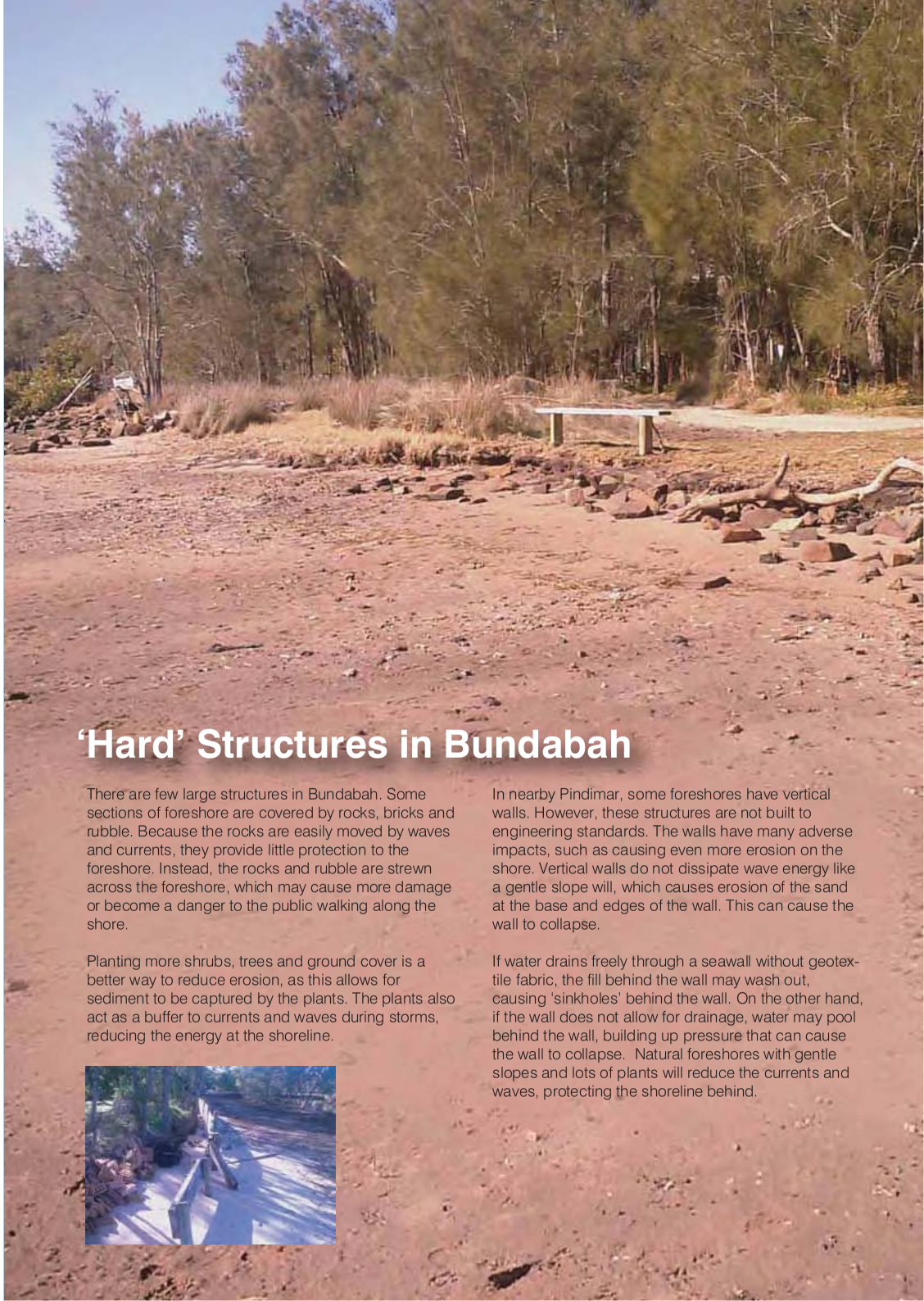
Plants and trees can grow in the sediment overlying the rocky shores. The plants help to bind the sediment and stop it from eroding during storms. The foreshore vegetation is also important habitat for birds. And the plants clean the water flowing off the land, which is good for the fish in the estuary.

In some parts of Bundabah, the foreshore has a gentle slope where the land grades into the water. Many plants and animals thrive in this inter-tidal zone. Moving towards the water, there may be saltmarsh, then a strip of muddy sediments where wrack (dead seagrass) may deposit and break down to provide food for plants and animals, then mangroves.

The gentle slopes and plants help to protect the foreshore from erosion by reducing the current and wave energy as it approaches the shoreline. Mangroves and other plants also reduce incoming currents and waves, protecting the shoreline behind. And, the mangroves and other foreshore plants capture sediment washed from the land, helping to build sediment stores on the shoreline.

Within the water, there are seagrasses that provide a nursery for spawning and the growth of young fish. The combination of plants and animals all contribute to a healthy estuary that supports healthy fish stocks, dolphins and other animals.

There will always be natural cycles of erosion during storms followed by accretion during calm conditions on natural shorelines. Long term recession occurs when the shoreline does not recover between storms, but continues to move further back (landward) over time. When mangroves and other plants are removed, the protection for the shoreline is also removed and the shoreline may start to recede permanently, or the overlying sediment may be stripped.



'Hard' Structures in Bundabah

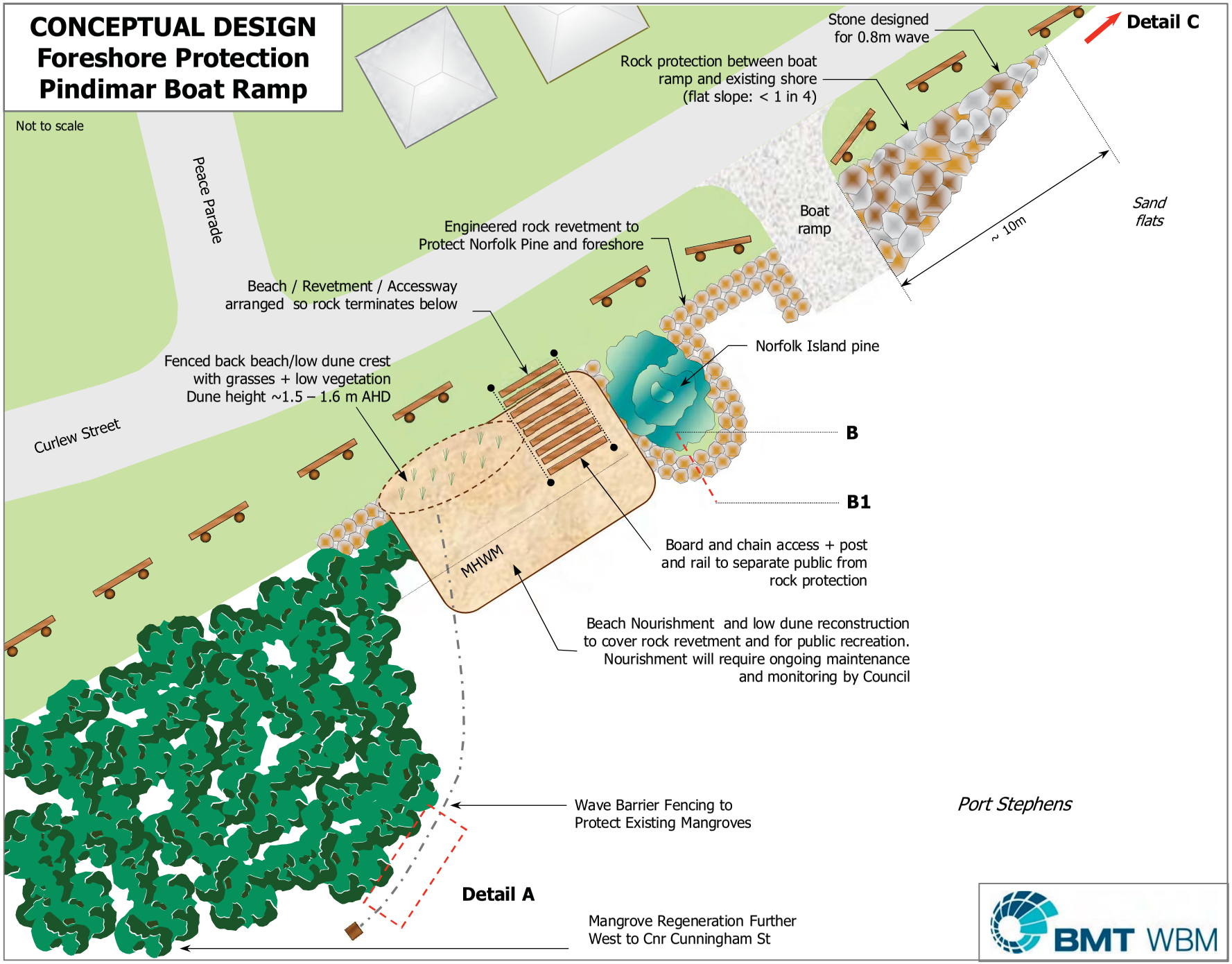
There are few large structures in Bundabah. Some sections of foreshore are covered by rocks, bricks and rubble. Because the rocks are easily moved by waves and currents, they provide little protection to the foreshore. Instead, the rocks and rubble are strewn across the foreshore, which may cause more damage or become a danger to the public walking along the shore.

Planting more shrubs, trees and ground cover is a better way to reduce erosion, as this allows for sediment to be captured by the plants. The plants also act as a buffer to currents and waves during storms, reducing the energy at the shoreline.

In nearby Pindimar, some foreshores have vertical walls. However, these structures are not built to engineering standards. The walls have many adverse impacts, such as causing even more erosion on the shore. Vertical walls do not dissipate wave energy like a gentle slope will, which causes erosion of the sand at the base and edges of the wall. This can cause the wall to collapse.

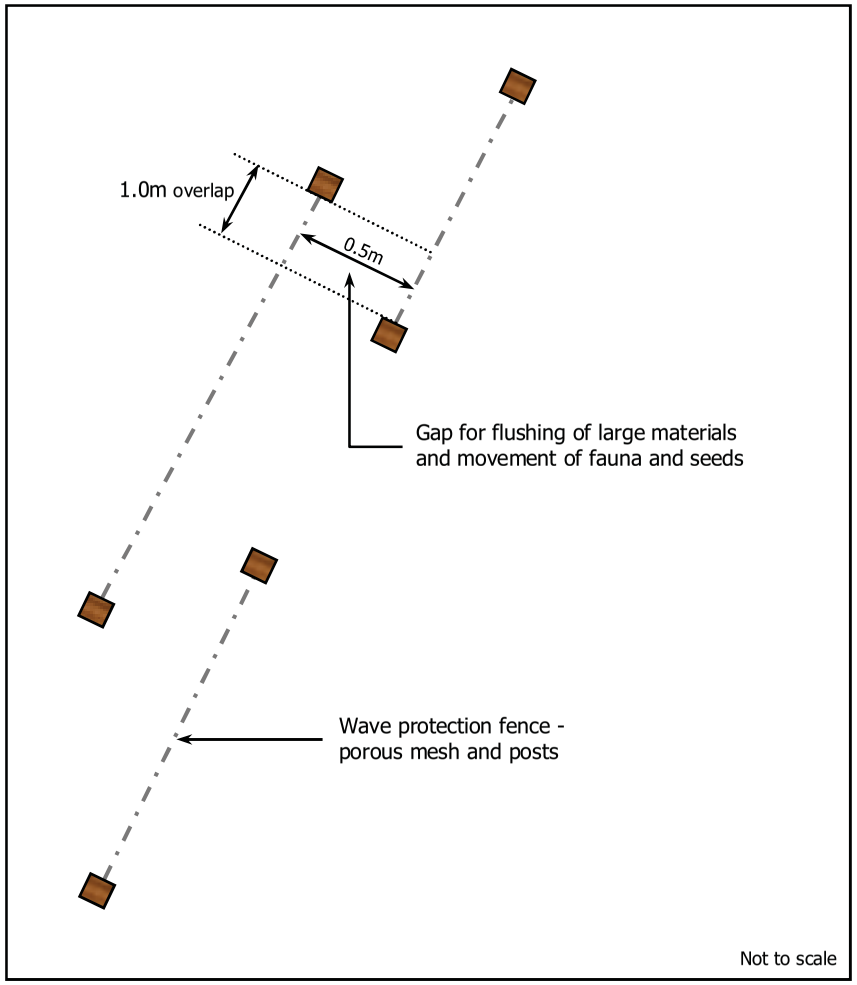
If water drains freely through a seawall without geotextile fabric, the fill behind the wall may wash out, causing 'sinkholes' behind the wall. On the other hand, if the wall does not allow for drainage, water may pool behind the wall, building up pressure that can cause the wall to collapse. Natural foreshores with gentle slopes and lots of plants will reduce the currents and waves, protecting the shoreline behind.

APPENDIX H: CONCEPTUAL DIAGRAMS

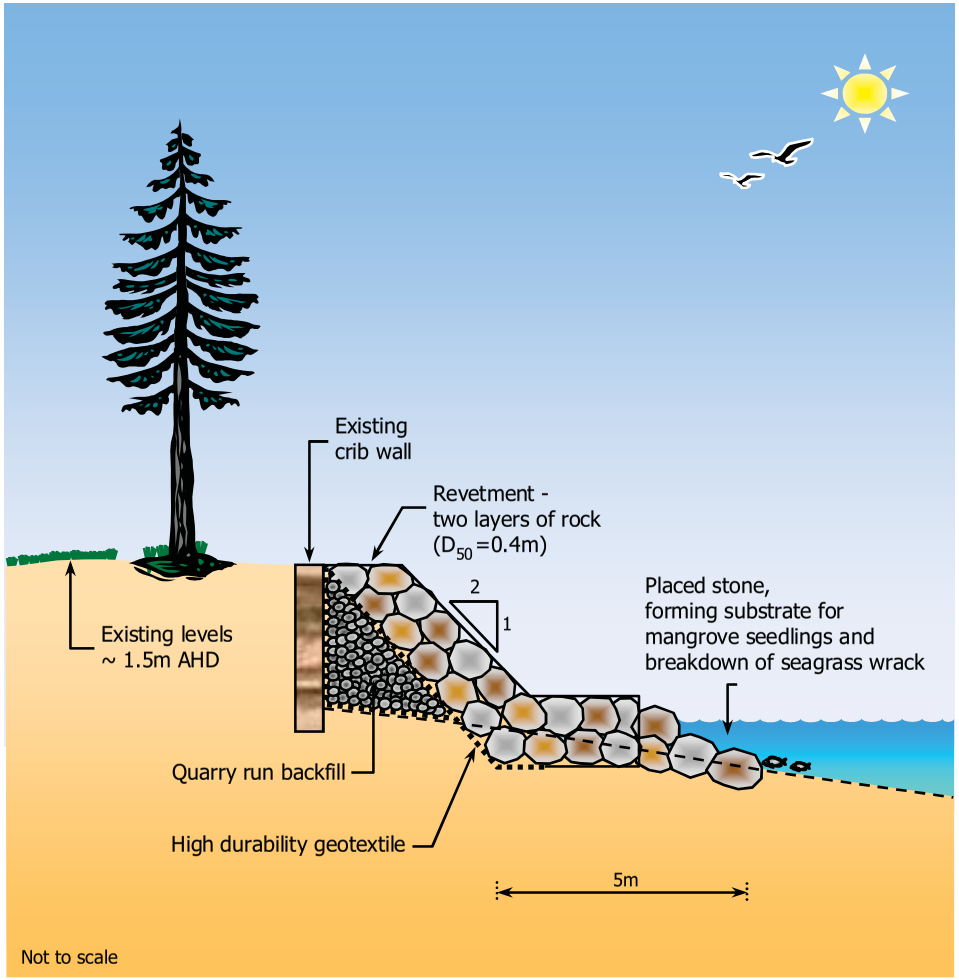

CONCEPTUAL DESIGN
Foreshore Protection
Pindimar Boat Ramp
Not to scale
Peace Parade
Curlew Street
Stone designed for 0.8m wave
Detail C
Rock protection between boat ramp and existing shore (flat slope: < 1 in 4)
Boat ramp
~ 10m
Sand flats
Engineered rock revetment to Protect Norfolk Pine and foreshore
Beach / Revetment / Accessway arranged so rock terminates below
Fenced back beach/low dune crest with grasses + low vegetation Dune height ~1.5 – 1.6 m AHD
Norfolk Island pine
B
B1
MHWM
Board and chain access + post and rail to separate public from rock protection
Beach Nourishment and low dune reconstruction to cover rock revetment and for public recreation. Nourishment will require ongoing maintenance and monitoring by Council
Wave Barrier Fencing to Protect Existing Mangroves
Port Stephens
Detail A
Mangrove Regeneration Further West to Cnr Cunningham St
BMT WBM

CONCEPTUAL DESIGN
Foreshore Protection Pindimar Boat Ramp

Detail A
Temporary Fence



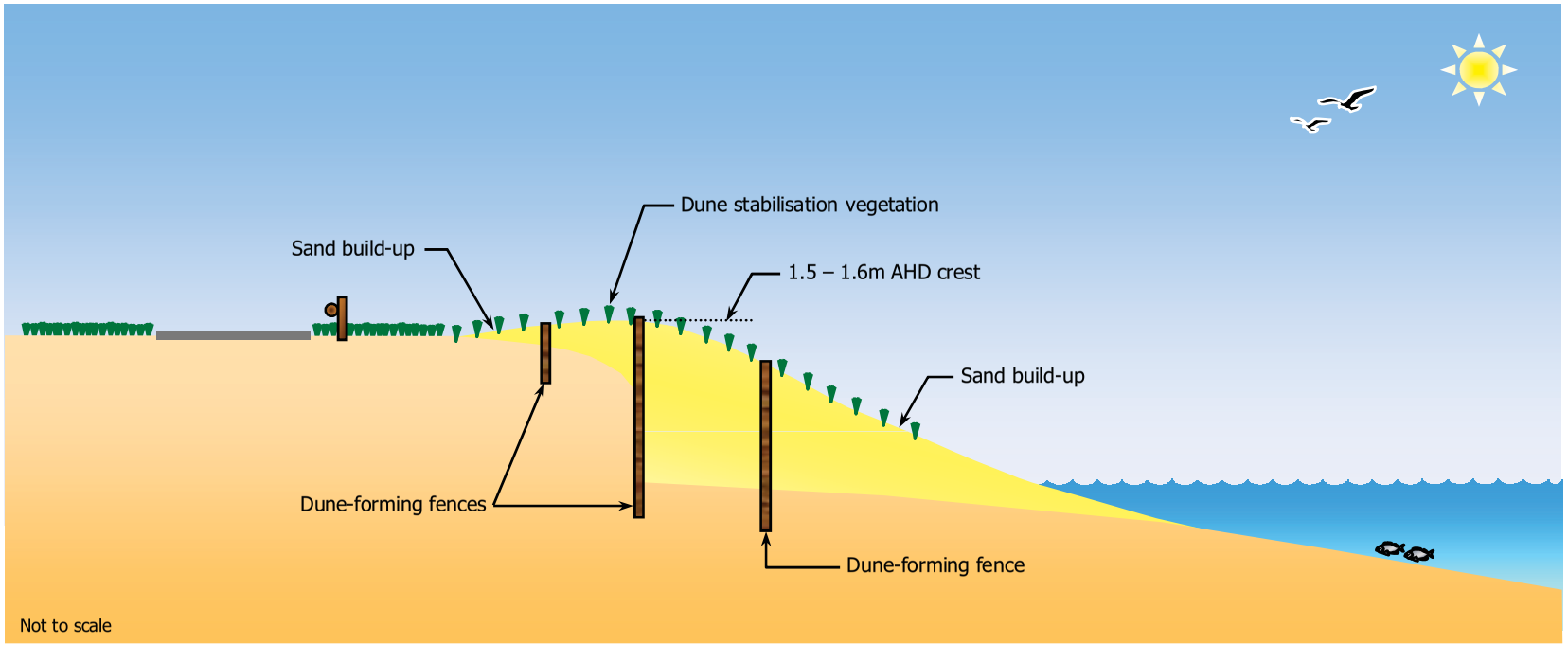
Cross Section B – B1



BMT WBM

CONCEPTUAL DESIGN
Foreshore Protection Pindimar Boat Ramp

Detail C



Beach to East of Boat Ramp

1. At low points in dune ⟶ Reconstruct with sand and replant with vegetation

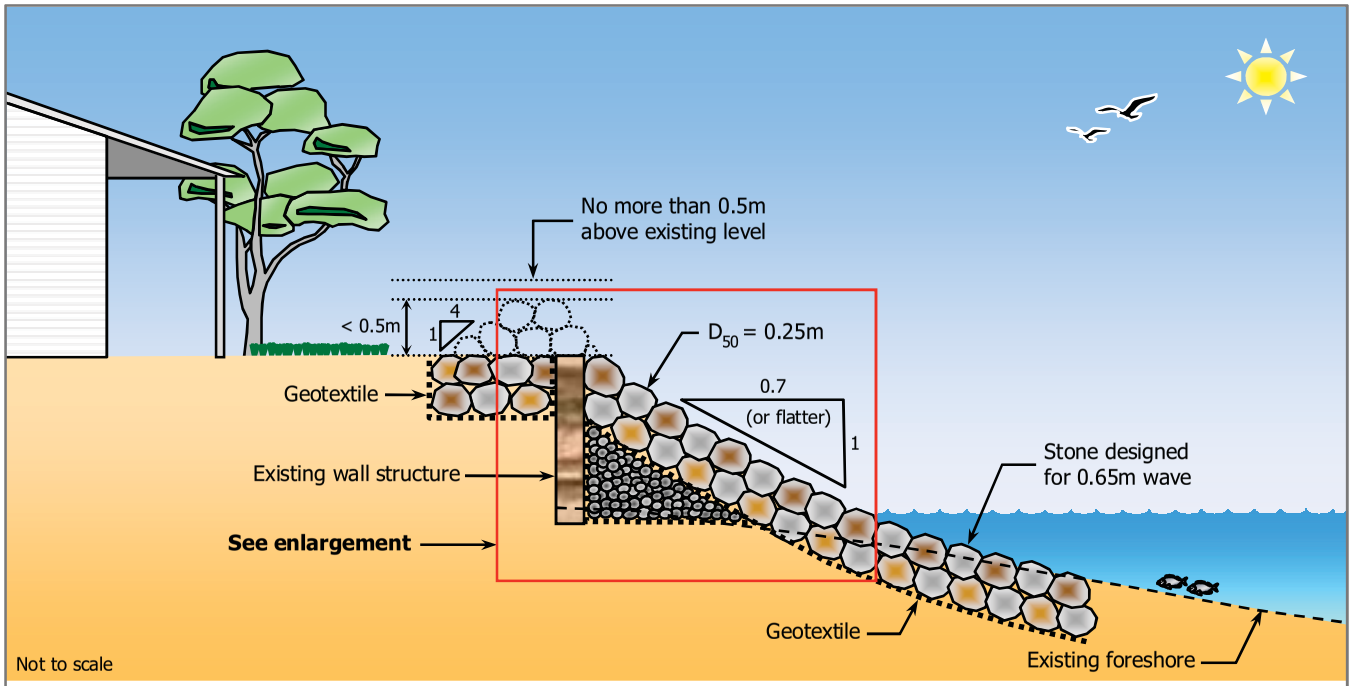
2. Clear rubble off beach, use low key fencing and top with sand ⟶ Build low dune with creepers and low vegetation
   ⟶ Direct access appropriately
   ⟶ Monitor use to determine whether broader scale nourishment suitable

3. Ensure nourishment does not obstruct stormwater outlets

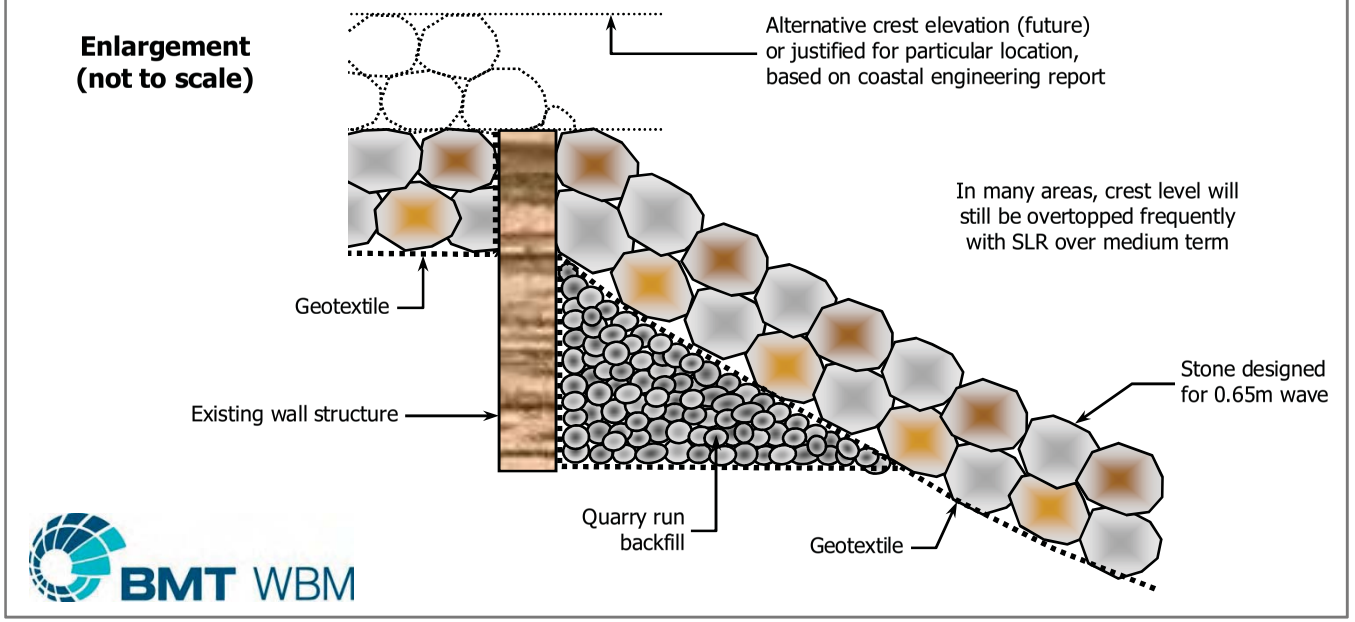
BMT WBM

CONCEPTUAL DESIGN

Enlargement from the *Existing Modified Foreshore Protection Guideline*

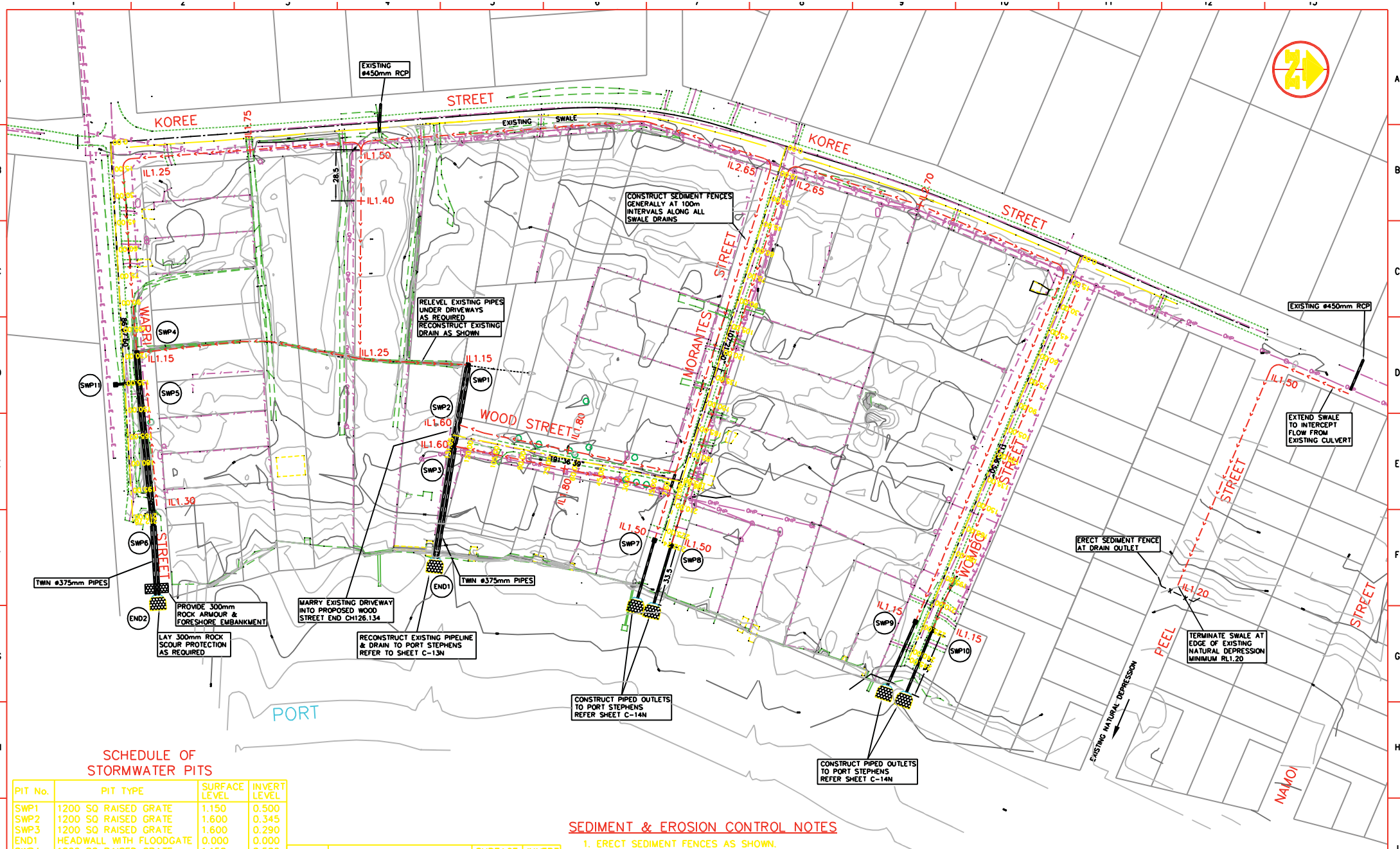


Enlargement (not to scale)



BMT WBM

APPENDIX I: RECOMMENDED EROSION MANAGEMENT AT KIORA ST., WARRI ST., AND PEEL ST. OUTLETS



SCHEDULE OF STORMWATER PITS

PIT No.	PIT TYPE	SURFACE LEVEL	INVERT LEVEL
SWP1	1200 SQ RAISED GRATE	1.150	0.500
SWP2	1200 SQ RAISED GRATE	1.600	0.345
SWP3	1200 SQ RAISED GRATE	1.600	0.290
END1	HEADWALL WITH FLOODGATE	0.000	0.000
SWP4	1200 SQ RAISED GRATE	1.150	0.500
SWP5	1200 SQ RAISED GRATE	1.200	0.440
SWP6	1200 SQ MD GRATE	1.250	0.145
END2	HEADWALL WITH FLOODGATE	0.000	0.000
SWP11	900 SQ RAISED GRATE	1.150	1.150
SWP5	1200 SQ RAISED GRATE	1.200	0.500

PIT No.	PIT TYPE	SURFACE LEVEL	INVERT LEVEL
SWP7	600 SQ RAISED GRATE	1.500	0.500
SWP8	600 SQ RAISED GRATE	1.500	0.500
SWP9	600 SQ RAISED GRATE	1.150	0.500
SWP10	600 SQ RAISED GRATE	1.150	0.500

SEDIMENT & EROSION CONTROL NOTES

1. ERECT SEDIMENT FENCES AS SHOWN.
2. PROGRESSIVELY SEED ALL DISTURBED AREAS AS WORKS ARE COMPLETED.
3. PROVIDE SANDBAG CHECK DAMS UPSTREAM OF ALL PIPED DRIVEWAY CROSSINGS
4. ERECT SEDIMENT FENCES AROUND ALL PROPOSED INLET PITS.

REV.	DATE	BY	DESCRIPTION	CHECKED	APPROVED
B	9.4.02	MAK	COUNCIL AMENDMENTS	SWO	PEH
A	0.02.02	MAK	ISSUE FOR COMMENT	SWO	PEH

NOTES
1. REFER SHEET C-12N FOR KIORA STREET DRAINAGE REMEDIATION DETAILS.
2. ALL INVERT LEVELS SHOWN REFER TO SWALE INVERT LEVELS.
3. RAISED GRATE DETAIL REFER TO SHEET C-14N
4. CONSTRUCT CONCRETE PIPE SUPPORT AS REQUIRED. REFER DETAIL SHEET C-14N.

WBM OCEANICS AUSTRALIA
ENGINEERING AND ENVIRONMENTAL CONSULTANTS

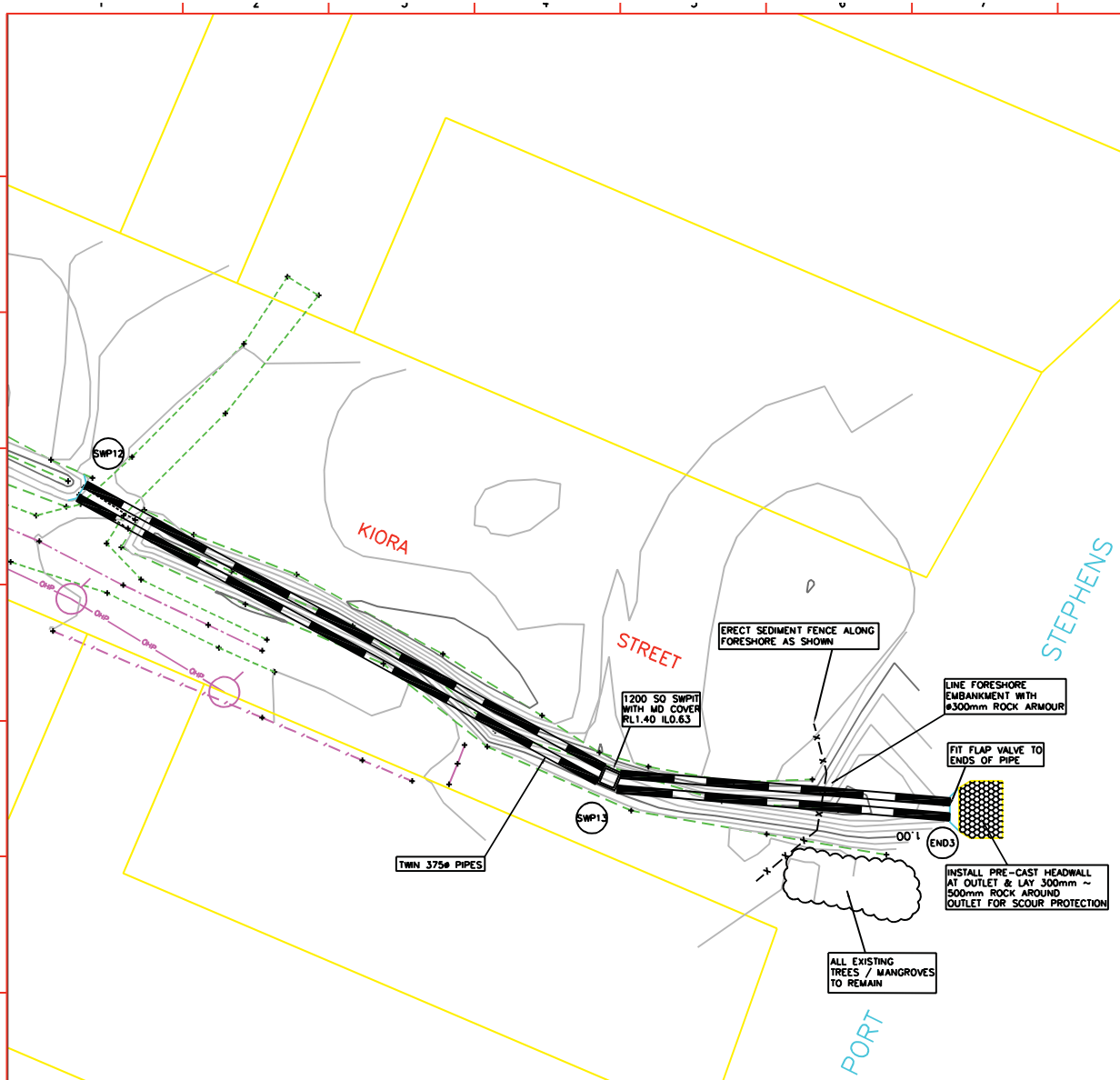
PROJECT: ROAD AND STORMWATER DRAINAGE RECONSTRUCTION WORKS NORTH PINDIMAR

TITLE: DRAINAGE LAYOUT & SEDIMENT EROSION CONTROL PLAN SHEET 1

DRAWN IN AUTOCAD

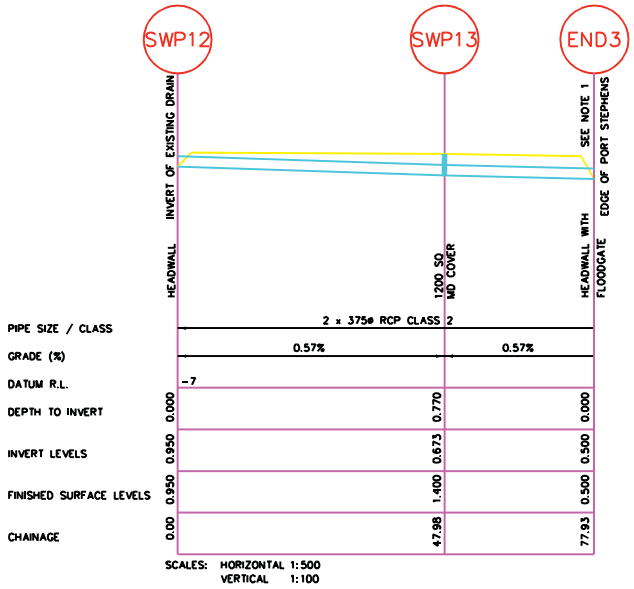
SCALE: 1:1000
PROJ. NO.: N0636
DRG. NO.: C-11N

FILENAME: N0636-C11N.DWG



SEDIMENT & EROSION CONTROL NOTES

1. ERECT SEDIMENT FENCES AS SHOWN.
2. PROGRESSIVELY SEED ALL DISTURBED AREAS AS WORKS ARE COMPLETED.
3. PROVIDE SANDBAG CHECK DAMS UPSTREAM OF ALL PIPED DRIVEWAY CROSSINGS
4. ERECT SEDIMENT FENCES AROUND ALL PROPOSED INLET PITS.



LONGSECTION OF PIPELINE AND OPEN DRAIN DEVIATION

REV.	DATE	BY	DESCRIPTION	CHECKED	APPROVED
B	9.4.02	MAK	COUNCIL AMENDMENTS	SWO	PEH
A	09.02.02	MAK	ISSUE FOR COMMENT	SWO	PEH

NORTH POINT

NOTES
1. CONSTRUCT CONCRETE PIPE SUPPORT AS REQUIRED. REFER DETAIL SHEET C-14N.

WBM OCEANICS AUSTRALIA
ENGINEERING AND ENVIRONMENTAL CONSULTANTS

PROJECT
ROAD AND STORMWATER DRAINAGE RECONSTRUCTION WORKS
NORTH PINDIMAR

TITLE
DRAINAGE LAYOUT SHEET 2

DRAWN IN AUTOCAD

SCALE 1:200
PROJ. NO. N0636
DRG. NO. C-13N

FILENAME: N0636-C13N.DWG

APPENDIX J: SUMMARY OF SUBMISSIONS DURING PUBLIC EXHIBITION

Code	Submission comment	No. Submissions	Response and amendment (if required)	Section of the study	Change completed
	Overall feedback				✓
4, 12, 13, 17, 19, 23	In principal support for the depth and breadth of the study. Scientific integrity of the study. Also support layout of the document.	6	To be noted		✓
8, 12, 13, 19	Endorse educational strategy and restorative activities in plan.	4	To be noted		✓
12, 16,19	Endorse removal of illegal inadequately built structures	2	To be noted		✓
12	Support of the improvement of structures in the "modified" sections as proposed in the Guidelines	1	Noted		✓
19	Support the re-establishment of SEPP 14 Wetlands which have structures interfering with their natural function	1	To be noted		✓
10, 16	Support the intention to maintain natural foreshores and deter further hard engineering structures.	1	Noted		✓
19	Support planting of mangroves where they have been illegally removed	1	Noted		✓
16	More emphasis on the role of vegetation on the foreshore in preventing erosion in addition to mangroves e.g. Juncus and Lomandra.	1	The foreshore protection guidelines already emphasis the role of other native plants and foreshore vegetation in general in providing protection. No change required	Appendix G - Foreshore Protection Guidelines	N/A
19	Wider and shallow drainage swales discharging into Port Stephens	1	Whilst may have merit should be considered in wider drainage strategy and asset management. No change required.		N/A
19	Well-constructed but wrong type of seawalls be allowed/encouraged to place rocks on seaside of wall to absorb wave energy	1	Existing Structures Maintenance Guideline recommends improving the performance of existing sea walls by placing armour rock in front of the vertical wall. No change required	Appendix G - Foreshore Protection Guidelines	N/A
19	Detailed signage at all public areas highlighting flora and fauna and environmental benefits	1	Recommended for education purposes for restoration areas. Considered superfluous for all reserve areas.	Section 6.8.2.1 and 9.4	✓
19	GLC adhere to local Drainage Strategy, ensure all drainage levels are surveyed to stop the high tide water flowing into the system.	1	Noted. Issue for drainage strategy implementation not erosion study		✓

Code	Submission comment	No. Submissions	Response and amendment (if required)	Section of the study	Change completed
2	Object to mangroves being encourage – devalue property and removes view.	1	Mangrove colonisation will naturally protect foreshores. Without mangrove fringing the foreshore areas will be more vulnerable to erosion. Hard structural solutions are unlikely to be resourced or practical. In the future the community will need to consider options for slowing the impacts of sea level rise induced recession. No changes required (except changes to Pindimar conceptual design as noted above). Also noted that foreshore protection guidelines recommend a range of native species in addition to mangroves.		N/A
13, 19	That greater consideration to balancing environmental issues with public use and access of foreshore	2	Noted. Study attempts to achieve this as do amendments.		✓
4	Indicative costs and timeframes require further review as they either say nothing or present a commitment that may never be achieved	1	Most actions involve staff resources which will need to be prioritised amongst other projects. It is recognised that slippage of time frames may occur subject to available resources. The highest priority actions are generally administrative matters involving orders to remove illegal structures, education, rezoning of wetlands and drainage works associated with the WBM (2002) Pindimar Trunk Drainage Design and REF Report. The implementation of study recommendations will be noted to be subject to availability of resources and external grants.	Table 1. Strategies for Foreshore Protection	✓
19	Medium to long term actions should be short to medium term	1	Time frames have been considered in relation to priority. Available resources do not permit a reduction in the time frames.		N/A
13	Strategy Recommendation 4 "Ensure Council officers who assess development applications area aware of the requirements in the Natural Foreshore Protection Guideline and Existing Structures Maintenance Guideline" should be High priority and have immediate timeframe.	1	Agreed. Action amended to High Priority. Already has an immediate priority but will be achieved as soon as possible.	Amend Table 1 and Table 9.1 Strategies for Foreshore Protection	✓
13	Support the development of a Estuary Foreshore DCP	1	Noted		✓
16	Foreshore Protection Guidelines should clearly state principles about; maintenance of public access, the need to gain approval first and how to go about assessment of suitable rock size when improving or maintaining existing sea walls, emphasise importance of an unmown foreshore buffer. A foreshore planting guide maybe useful.	1	Suggestions supported. Guidelines amended to ensure principles are made clear.	Appendix G - Foreshore Protection Guidelines	✓

Code	Submission comment	No. Submissions	Response and amendment (if required)	Section of the study	Change completed
16	Council on collection of sea wrack from foreshore should be made clear	1	Suggestion supported. Foreshore Protection Guideline amended to address issue.	Appendix G - Foreshore Protection Guidelines	✓
17	Do not accept that oyster leases have not affected shoreline movement. Removal of lease produces increase in sand flats.	1	Noted		N/A
17, 22	Fretting and undercutting of vegetated shoreline should not be considered as a minor problem. Why have no comments be made on the effects of the new open drain constructed by council	2	Evidence indicates that this shoreline is presently stable although it has experienced some movement in the past. Scour from drain is very minor in the context of the overall coastal processes along the beach. Natural variability in the height and alignment of the beach is related to natural processes on a wide variety of time scales. No changes required.		N/A
17	Object to statement that sea walls have not offered protection of the foreshore. Walls have prevented tree loss	1	Study notes that the sea walls have not offered much protection in this area except for allowing reclamation to a height well above the natural foreshore level. No change required as the comment is a general assessment of the overall section. The natural variability of the foreshore in response to weather conditions and coastal dynamics should be considered before a sea wall solution is adopted.		N/A
17	In considering sea level rise why has the foreshore survey provided no details on changes to mean tide levels. Surely the increase has begun.	1	Sea level rise is based on mean sea level. The study was based on sea level rise projections adopted by Council based on NSW guidelines. Sea level rise is occurring between 1-3.1 mm per year depending on locality. No change required.		N/A
17	Proposed guidelines should have been included in the draft report for public comment. Finds the attitude expressed in the report disappointing as promote leave things as they are and hope for the best and promoting the growth of mangroves and building ramps	1	Guidelines were included as Annexure G. Natural variability of foreshore needs to be appreciated. Why undertake superfluous interventions. If interventions are required should be sustainable.		N/A
8	Why were we not engaged or informed and why have we not been issued with the draft report	1	All foreshore residents were written to advising of the study and opportunity to meet with the consultants and Council staff. A second letter advised of the draft report being on exhibition and the community drop in session. It is unrealistic and financially wasteful to issue a 170 page technical draft report to all residents. Noted.		N/A

Code	Submission comment	No. Submissions	Response and amendment (if required)	Section of the study	Change completed
	Lower Pindimar and Pindimar				
16, 19	Support the re-establishment of the fore dune and stabilisation of sand at the south Pindimar Beach. Need to stop mowing foreshore grass and cease boat storage. Reserve maintenance guidelines required.	1	Noted. Management guidelines will need to be considered by Council Parks and Reserve and operations staff once adopted.		N/A
2, 19	Support use of rock revetment around boat ramp and Norfolk Island Pine tree.	1	To be noted		✓
16	Consideration of additional native trees along foreshore near the end of Cook Street for shade	1	Noted. Not related to foreshore erosion study.		N/A
16, 19	Improvement and extension of rock wall at the corner of Curlew and Cunningham Streets where road drainage discharges onto beach. Re-establish of the native vegetation foredune.	1	Study plan will recommend limited rock protection in this area to reduce erosion scour from road drainage.	Section 6.8.2.1	✓
19	Provision for the replacement of the south Pindimar historical jetty by not planting mangroves on the south eastern side of the boat ramp		Replanting is not recommended for south eastern side of the boat ramp. Suggest the submission means south west side. Area suggested to be planted with mangroves is amended to provide for sandy beach swim area and potential for future jetty.	Section 6.8.2.1 and Appendix H - Conceptual Diagrams	✓
1,2,14,15,16, 18, 19	Maintain beach adjacent to Norfolk Pine Tree. Not supportive of rock revetment or mangroves in this area	7	Area suggested to be planted with mangroves is significantly reduced and the recommendation amended to maintain existing sandy beach area. Revetment removed south west of pine tree.	Section 6.8.2.1 and Appendix H - Conceptual Diagrams	✓
16, 18	Sharp stones on beach are not from eroded road but from original gravel boat ramp.	2	Comment - noted.		N/A
17	Disputes that prior to 1986 there were no mangroves in Shoreline section 1 based on 30 years of living at Pindimar. Disagrees that there has been natural movement of Pig Station Creek.	1	Noted. Photogrammetry shows limited areas of mangroves. Minor movements of the creek would be natural.		N/A
17	Shoreline Section2 – agree that shoreline is affected by the creek outlet but not made clear if it is the presumed change in the position of the outlet that is affecting the process. Sand flats are making it more difficult for mangroves to spread.	1	The change is assumed from interpretation of natural processes acting on the area. Noted.		N/A
17	Cannot understand how stable shorelines of 2001 and 1986 suggest that there may have been a period of erosion between 1951 and 1958	1	The period of erosion was between 1951 and 1968 (not 1958). Between 5-11 m was lost in this time but there has been accretion of the shoreline between 1968 and 1986. No changes required.		N/A

Code	Submission comment	No. Submissions	Response and amendment (if required)	Section of the study	Change completed
17	Agree outlet of creek may have precluded the colonisation of mangroves but points out the outlet of the creek between Upper and Lower Pindimar is extensively colonised.	1	Noted. There are differences in the substrate with a muddier substrate at Duck Hole Creek. It is known that mangrove trees have been vandalised in the Pindimar area in the past but it is unknown if this has occurred in the area in question.		N/A
17	Protection structure consisting of an illegal rock revetment is not 1 km east of the creek outlet In Shoreline Section1 but immediately to the west and possibly outside section1.	1	Correct. This has been amended	Section 5.3	✓
17	Shoreline Section 4 – Cost of structure to bring seawalls to an appropriate coastal engineering standard would be prohibitive an eyesore and no guarantee they would be successful	1	Many existing structures are poorly maintained and designed, failing and result in changes to the shoreline. Structures are not cost prohibitive as they are likely to require minimal maintenance in the long term. The submission may have over-estimated the size of the structures recommended. No changes required.		N/A
17	Why is large and long rock wall in Section 1 not scheduled for removal	1	Sea wall was constructed prior to the inspection and study. Long standing illegal structures will not be recommended for removal as illegal structures but rather modification or non-replacement recommended. This structure does not require modification to meet required coastal engineering design. No changes required.		N/A
8	Have installed a front boundary fence which is effective in stopping erosion. Do not want to remove the "front boundary fence" unless the Council is willing to replace this with an erosion protection system and guarantee no further loss of land. Do not want mangroves.	1	The sea wall in question is recently illegal since approximately late 2008. They are recommended for removal by order to the property owner(s). The structures provide little or no protection to the shoreline and are in fact more likely to enhance foreshore erosion and adversely affect public access. No change required.		N/A
	Upper Pindimar				
12	Do not support proposal to implement the Pindimar Trunk Drainage Design works near Lot 30 Section B DP 255453. Consider unnecessary and would cause more erosion and water quality problems. Waste of ratepayers money as no significant pondage of water.	1	The Pindimar Trunk Drainage Design called for the reconstruction of the existing pipeline and drain to Port Stephens. The reason for the reference in this study to the design is to address erosion problems. It is reasonable given the age (2002) of the Drainage Design that a review of options and priorities be considered. As such the recommendation will be amended so that erosion remediation from pipe outlets is subject to a prior review of the relevant recommendation and rational/priority of the Pindimar Trunk Drainage Design (2002).	Section 7.8.2.2 recommendations for Shoreline Section 11.	✓
12	Agree with conclusion that Council Reserve at Wood Street is not suitable for a boat ramp	1	Noted		N/A

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3	Asbestos super six sheeting potentially contaminating part of the Wood Street foreshore.	1	Noted. Counil officers to inspect and advice as to whether it needs to be removed.		N/A
6, 7, 10, 11, 12, 21	Do not agree with a formalised boat ramp at the end of Wombo Street as would create more environmental damage.	7	Amend study recommendation to remediation erosion at the end of Wombo Street but not to formalise the current informal boat ramp or investigate the need and feasibility of doing so.	Section 7.8.2.2 recommendations for Shoreline Section 11.	✓
7, 10, 12	Do not believe a boat ramp is required in Upper Pindimar	1	Noted. Not part of this study		N/A
12	Disused oyster leases exist in front of Shoreline Section 11 and 12	1	Noted. Amend	Section 7.2	✓
9	Figure 7-8 is not illegal reclamation of crown land but within the owners surveyed title	1	Land below the mean high water mark is Crown Land.		N/A
9	Need to deal with 5 government agencies to get approval for works	1	Relevant legislative approvals would need to be addressed in a DA for a foreshore structure		N/A
9	Report does not recognise the benefit of the illegal, ad-hoc groynes. Groynes are required to accumulate sand on the northern side when wind is from the south.	1	The dominant coastal process is tidal current and wind waves which predominantly moves sand south to north. As such sand accumulates on the southern side of the groynes. No change required.		N/A
9	Larger lots allow for natural protection. Vertical walls have protected smaller blocks	1	The report recommends enhancing existing structures to reduce offsite impacts and enhance their sustainability. The study also recommends natural protection for most shorelines without structures.		N/A
	Bundabah				
5	Don't approve of vegetation along the shoreline as rubbish builds up and becomes overgrown attracting snakes and therefore is very dangerous. A large amount of sand would stop the erosion.	1	The study notes that the area is experiencing minor fretting and is without foreshore vegetation. The area is a public reserve. Natural foreshore vegetation protects the foreshore through allowing the build-up of sand/sediment. The removal of rubbish (likely to be wrack) exposes the shoreline. Sensible use of fringing foreshore vegetation can prevent fretting and avoid the creation of snake habitat. No changes required.		N/A
20	4 knot zone required off Taylor Reserve near boat ramp required to avoid conflict with users and erosion from wash.	1	Noted. NSW Maritime will be advised of this issue.		N/A
20	Council designated helicopter emergency landing pad is under water at king tide events. No mention of the pad in the draft	1	Agreed. Will be amended to be mentioned in the draft but a separate management issue rather than a recommendation of the erosion study	Section 8.8.2.1	✓

BMT WBM Brisbane
Level 11, 490 Upper Edward Street Brisbane 4000
PO Box 203 Spring Hill QLD 4004
Tel +61 7 3831 6744 Fax +61 7 3832 3627
Email wbm@wbmpl.com.au
Web www.wbmpl.com.au

BMT WBM Denver
14 Inverness Drive East, #B132
Englewood Denver Colorado 80112 USA
Tel +1 303 792 9814 Fax +1 303 792 9742
Email wbmdenver@wbmpl.com.au
Web www.wbmpl.com.au

BMT WBM Mackay
Suite 1, 138 Wood Street Mackay 4740
PO Box 4447 Mackay QLD 4740
Tel +61 7 4953 5144 Fax +61 7 4953 5132
Email wbmmackay@wbmpl.com.au
Web www.wbmpl.com.au

BMT WBM Melbourne
Level 5, 99 King Street Melbourne 3000
PO Box 604 Collins Street West VIC 8007
Tel +61 3 8620 6100 Fax +61 3 8620 6105
Email wbmmelbourne@wbmpl.com.au
Web www.wbmpl.com.au

BMT WBM Newcastle
126 Belford Street Broadmeadow 2292
PO Box 266 Broadmeadow NSW 2292
Tel +61 2 4940 8882 Fax +61 2 4940 8887
Email wbmnewcastle@wbmpl.com.au
Web www.wbmpl.com.au

BMT WBM Perth
1 Brodie Hall Drive Technology Park Bentley 6102
Tel +61 8 9328 2029 Fax +61 8 9486 7588
Email wbmperth@wbmpl.com.au
Web www.wbmpl.com.au

BMT WBM Sydney
Level 1, 256-258 Norton Street Leichhardt 2040
PO Box 194 Leichhardt NSW 2040
Tel +61 2 9713 4836 Fax +61 2 9713 4890
Email wbmsydney@wbmpl.com.au
Web www.wbmpl.com.au

BMT WBM Vancouver
1190 Melville Street #700 Vancouver
British Columbia V6E 3W1 Canada
Tel +1 604 683 5777 Fax +1 604 608 3232
Email wbmvancouver@wbmpl.com.au
Web www.wbmpl.com.au