3.4 Valla Beach

3.4.1 North Valla Beach

North Valla Beach is a healthy and stable beach system with a well developed and vegetated foredune and backdune. Like many of the beaches in the area, the foot of the foredune has been slightly eroded to form a small scarp, but had since been overgrown and stabilised by light vegetation. The beach was tens of meters in breadth in December 2008.

Following the storm event of May 2009, the beach had been significantly eroded, exposing bedrock on the beach berm.

3.4.2 South Valla Beach

South Valla Beach is separated from North Valla Beach by a rock platform. A carpark located close to the foredune is protected by a vertical rock wall approximately 1.5 - 2m high, similar to those constructed at Shelly and Main Beaches. In December 2008, the beach berm was over 100m in breadth. However, evidence of past erosion caused by creek entrance dynamics was seen (Figure 3.14).

Following the storm event of May 2009, the existing vertical rock wall had been buried in sand, and evidence of wave runup at the carpark was seen (Figure 3.15).

Consideration could be given to reconstruction of the rock wall here, to provide greater protection to the carpark and amenities block from erosion caused by re-alignment of the creek entrance. Evidence of a previous seawall at the eroded picnic area indicated that there was no geotextile layer, allowing fine material to wash through the wall and erosion to continue landward of the wall. Reconstruction of the existing wall should include a layer of large armour, underlain by smaller armour stones and a geotextile layer to prevent failure via this mechanism. Reconstruction of the rock wall could follow a standard design as shown in Figure 3.6.

The footbridge at Deep Creek was observed during the December site visit to be suffering from scour around the piers. Consideration could be given to providing scour protection around the bridge piers.

Figure 3.14 – Erosion at South Valla Beach carpark caused by creek entrance dynamics, December 2008

Figure 3.15 – South Valla Beach – December 2008 (Top), May 2009 (Bottom)

4 Coastal Hazard Assessment

4.1 Introduction

The coastal hazard assessment for Nambucca Shire comprised quantifying the three principal hazards, namely:

- short-term storm beach fluctuations (including design storm erosion and river entrance fluctuations);
- long term beach recession (measured long term recession and future long term recession as a result of sea level rise); and
- oceanic inundation.

For the beaches of Scotts Head, Nambucca Heads and at Valla Beach, the storm cut (or storm erosion demand) has been quantified empirically with data obtained photogrammetrically. An *equivalent* storm erosion volume has been derived empirically based on the schema presented in Nielsen *et al.* (1992) and storm erosion volumes derived from photogrammetry data. A detailed description of the protocol and the derivation of the results are provided in Appendix A.

The results of the coastal hazard assessment for Scotts Head, Nambucca Heads and Valla Beach are presented below.

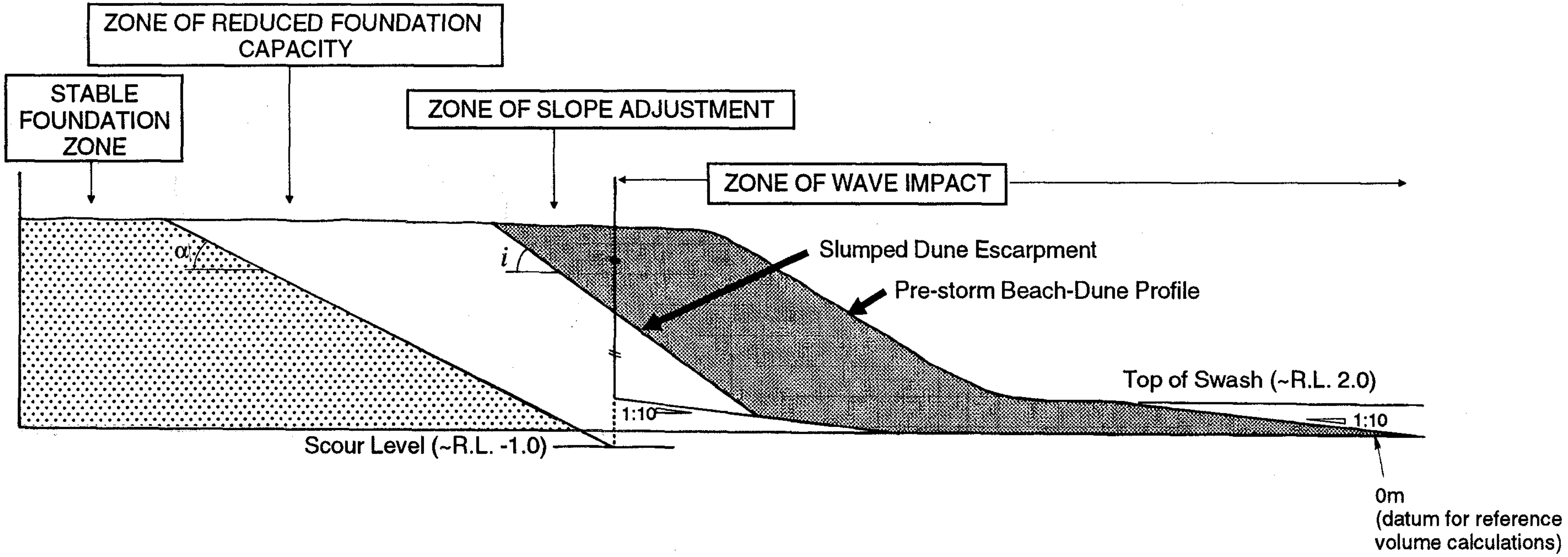
4.2 Scotts Head

4.2.1 Short Term Beach Fluctuations – Design Storm Erosion

Design storm erosion volumes for Scotts Head are calculated in Appendix A. An analysis of equivalent storm erosion volumes resulting from the 1995 storms followed the schema of Nielsen *et al.* 1992 (see Figure 4.1). The values were derived at the local maxima of the landward movement of the RL 4.0 m contour, as measured between the 1988 and 1995 photogrammetric data and applied to the whole beach, to take account of the formation of rip-heads and to arrive at a conservative estimate of storm erosion demand for the beach.

Equivalent storm erosion volumes were obtained from the analysis of the beachfront areas along the entire Scotts Head coastline. Analysis of the photogrammetric data between 1988 and 1996 showed that up to 250 m^3/m of erosion (representing a landward translation of the dune of around 20 m) for the March 1995 storm at Scotts Head had occurred over this time period, with a maximum value of 330 m^3/m (or around 26 m landward dune face translation). An envelope value of erosion volume between 1988 and 1996 was assessed for the various locations at Little Beach and Scotts Head. These values are also presented as a *storm erosion distance*, which represents the landward movement of the main beach dune as a result of the storm.

These values are given in Table 4.1.



Angle of repose of dune sand: $i \sim \phi \approx 34^\circ$

Safe angle of repose of dune sand: $\alpha = \tan^{-1}\{(\tan\phi)/1.5\} \approx 24^\circ$

All levels to AHD

Figure 4.1 - Dune stability schema (after Nielsen et al., 1992)

Block	Location	Storm bite allowance (m^3/m)	Storm erosion distance (m)
1	Little Beach	120	18
2	Scotts Head Surf Club	120	14
3	Southern end Forster Beach	190	22
4	Central portion Forster Beach	200	16
5	Northern end Forster Beach	250	20

Table 4.1 - Storm erosion for each photogrammetric block, Scotts Head

The lack of sufficient data immediately before and after storm events meant that it was not possible to perform a statistical analysis and assign a design encounter probability to the recommended storm erosion demand value. However, it is considered that a storm that would lead to the design storm erosion demand would have a very low risk of being exceeded over the next 50 years, given that the measured storm erosion demand was based on the combined effects of several storms and one cyclone of 1995. The estimated storm erosion demand from the 1995 storms for various locations along the coast at Scotts Head is plotted in Figure 4.2.

4.2.2 Long Term Recession

Processes such as sea level rise, aeolian processes and the littoral drift of sediment are natural loss components of the sediment budget of a beach. At Scotts Head, northward sediment transport along Forster Beach and into the Nambucca estuary is a natural loss mechanism for sand. Biogenic production of sand from the shells of benthic fauna, and sediment transported into the littoral zone from nearby estuaries are natural sources of sediment for a beach. If, in the long term, the losses of sediment from a beach are greater than the gains, then a gradual beach recession will result.

The two methods used for this measurement were the measurement of eroded sand volumes and the measurement of the translation of the dune face over time. On average, the analysis showed that significant erosion occurred between 1942 and 1973 at all Scotts Head beaches. Since 1973, Little Beach has remained relatively stable and has almost reached its initial profile volume of 1942. At Forster Beach, the beach profile was recovering and accreting between 1973 and 1988, when it almost reached the 1942 beach profile. However, between 1988 and 1996, a sharp beach volume decline occurred which could be the result of Cyclone Violet in March 1995 storm which impacted on the north coast of New South Wales. This storm appeared to greatly impact Forster Beach and since this storm, the photogrammetry indicates that the beach has resumed its accretion and recovery.

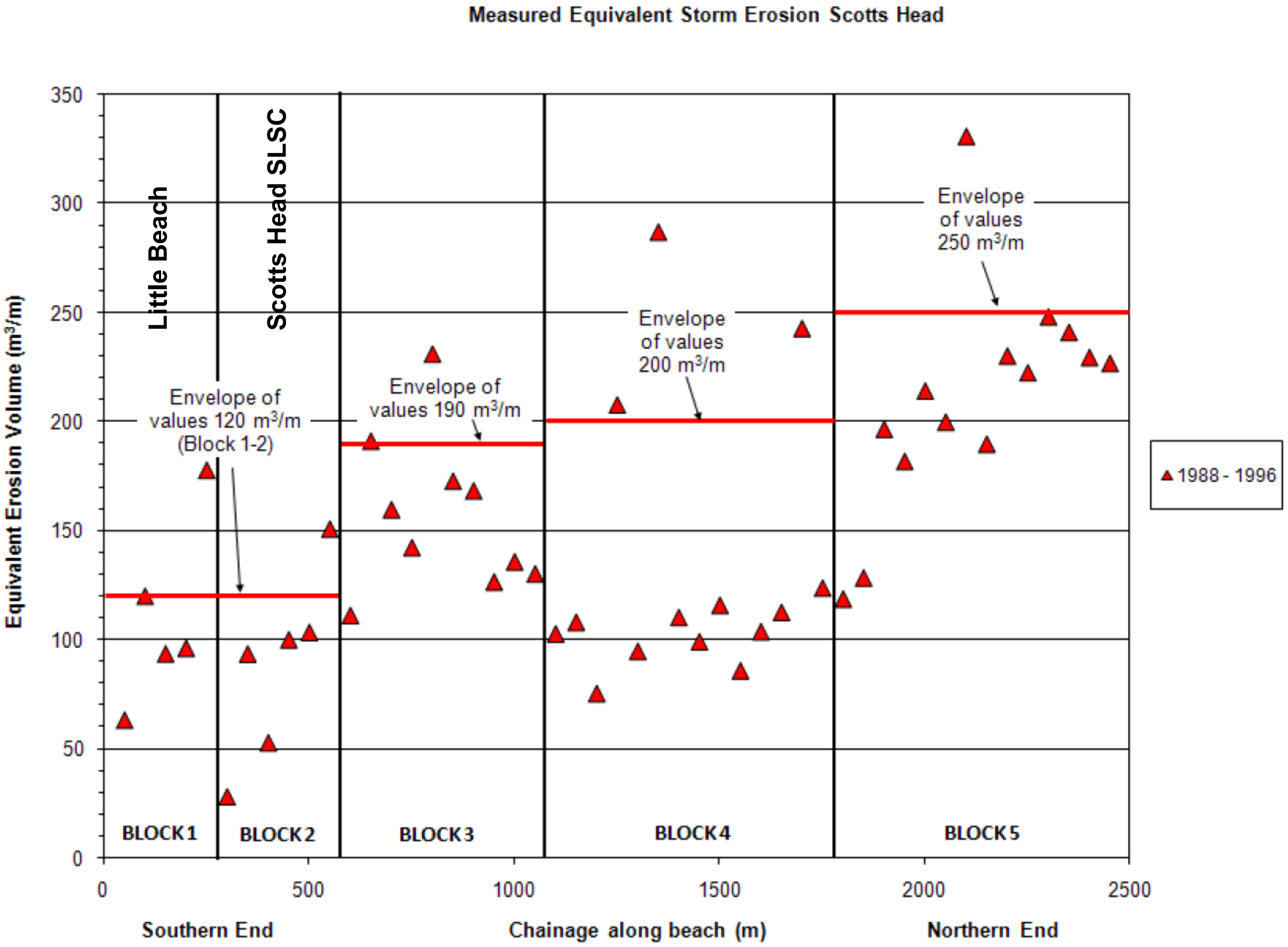


Figure 4.2 – Measured Equivalent Storm Erosion, Scotts Head 1988 - 1996

Detailed measurements of the sediment budget for the beach at Scotts Head were beyond the scope of this study. However, from a combination of the photogrammetric evidence and geomorphological studies of the beach (Goodwin, 2009), it was found that the beaches at Scotts Head appear to be relatively stable or accreting in the long term. This may be due to the net supply of littoral drift from the south being greater than the losses toward the north. For this reason, a long term recession of zero has been used to determine the location of the hazard lines at Scotts Head, and this is described in Appendix A.

Further assessments in the future may change this prognosis for long term beach recession as more photogrammetry data are collected and analysis techniques improve.

4.2.3 Future Beach Recession – Sea Level Rise

Sea level rise may lead to a shoreline response of coastal recession. The most widely accepted method of estimating shoreline response to sea level rise is the Bruun Rule (Appendix B). Measurements of sea level rise show that there is considerable variation in the data. These variations are due to processes acting at inter-decadal scales, such as the El Niño Southern Oscillation (ENSO) phenomenon.

Figure 2.6 illustrates the concept of beach recession as a result of sea level rise. Appendix B provides detail on the *Bruun* analysis carried out for Scotts Head. Table 4.2 provides estimates of the overall long-term recession expected at Scotts Head due to sea level rise.

BLOCK 1						
Total Predicted Sea Level Rise (m)			**Total Beach Recession (m)**		**Total Beach Erosion (m^3/m)**	
Scenario	**2050**	**2100**	**2050**	**2100**	**2050**	**2100**
Central	0.25	0.55	14.6	32.1	87.5	192.5
High	0.40	0.90	23.3	52.5	140.0	315.0
BLOCK 2-3						
Total Predicted Sea Level Rise (m)			**Total Beach Recession (m)**		**Total Beach Erosion (m^3/m)**	
Scenario	**2050**	**2100**	**2050**	**2100**	**2050**	**2100**
Central	0.25	0.55	17.6	38.7	123.2	271.0
High	0.40	0.90	28.2	63.4	197.1	443.5
BLOCK 4-5						
Total Predicted Sea Level Rise (m)			**Total Beach Recession (m)**		**Total Beach Erosion (m^3/m)**	
Scenario	**2050**	**2100**	**2050**	**2100**	**2050**	**2100**
Central	0.25	0.55	18.0	39.5	197.5	434.5
High	0.40	0.90	28.7	64.6	316.0	711.0

Table 4.2 – Predicted Future Beach Erosion and Recession due to Sea Level Rise at Scotts Head

4.2.4 Inundation

Coastal inundation at Scotts Head due to wave runup would only occur if the frontal dune is low enough to allow overtopping during a major storm. Wave runup levels on the beaches at Scotts Head were estimated using parameters from long term wave statistics at the Coffs Harbour and Crowdy Head Waverider buoys, as detailed in Appendix A.

Table 4.3 gives the results for the wave runup assessment. The analysis indicated that due to the relatively high embankment, there are few areas at risk of coastal inundation due to wave runup. The only area that would most likely experience inundation due to wave runup would be the SLSC located between Little and Forster Beach as the building is not protected by any dune and the retaining wall on the side of the SLSC fronting Little Beach would certainly be overtopped if a 5m high run up occurs. Wave inundation may also impact the carpark adjacent to the surf club, which may also affect the adjacent caravan park.

Figure 4.3 shows the expected limit of maximum wave runup for the 0.1% AEP storm event.

Table 4.3 – Wave Runup levels for Scotts Head, 0.1% AEP storm event

Profile	Location	Deepwater significant Wave Height (m)	Nearshore Water Level (m)	Nearshore Beach Slope (1:X)	Maximum Wave Runup Level (m)	2% Wave Runup Level (m)	*Significant* Wave Runup Level (m)	Maximum Runup+Set up+High Tide (m AHD)
1-1	Little Beach	11	1.10	17	3.12	2.57	1.92	**5.71**
1-5		11	1.13	22	2.46	2.05	1.53	**5.07**
2-1	Surf Club	11	1.15	30	1.60	1.35	1.01	**4.23**
2-5	Southern end Forster Beach	11	1.14	18	2.30	1.88	1.40	**4.92**
3-1	Mid Forster Beach	11	1.10	18	2.91	2.40	1.79	**5.49**
3-9		11	1.14	22	2.13	1.76	1.31	**4.77**
4-1	Forster Beach (mid-north)	11	1.13	14	3.18	2.57	1.91	**5.79**
4-7		11	1.14	17	2.54	2.07	1.54	**5.16**
4-14		11	1.15	17	2.43	1.97	1.46	**5.06**
5-1		11	1.17	18	2.32	1.89	1.41	**4.97**
5-7		11	1.14	17	2.35	1.91	1.42	**4.97**
5-14		11	1.15	24	1.79	1.48	1.10	**4.42**

4.2.5 Wind-driven Dune Instability Hazard

Windborne sediment transport can result from destruction of the dune vegetation canopy – removal of dune vegetation can lead to areas of sand being destabilised by the wind, leading to a dune “blowout”.

Examination of historical aerial photography shows that parts of Forster Beach were formerly subject to this type of hazard, as dune vegetation cover was sparse. However, there are no urban areas within Scotts Head that are currently subject to this type of hazard, as the dune has since been well stabilised by native vegetation.

Ongoing protection of dune vegetation from damage is critical in avoiding this type of coastal hazard in the future.

Figure 4.3 – 100 year ARI Wave Runup level, Scotts Head

4.2.6 Beach Rotation and Longshore Drift

There is no significant evidence of beach rotation taking place at the beach compartment immediately surrounding Scotts Head. The coastline is impacted almost in the same way all along the beach, i.e. changes on the southern side of the beach were positively correlated with changes at the centre of the beach. The planform of Forster Beach and deposition of sand at the mouth of Nambucca River could be an indicator of the net northward longshore drift. Morphological studies for the region indicate that northerly longshore drift supplies sand volumes to the region in the order of 50,000 m^3/year. This represents a net sediment accumulation at Nambucca Shire, as the supply of sand is higher than what is needed to maintain a stable coastline.

Beach fluctuations over the 240 m of Little Beach for a ±1° beach rotation may reach 2 m over the sandy portion of the beach – for a beach berm height of 2.0m AHD, this represents a sand volume fluctuation of approximately ±4 m^3/m which is not significant.

Beach fluctuations over the 10,800 m of Forster Beach for a ±0.75° beach rotation may reach a maximum of 70 m over the sandy portion of the beach – for a beach berm height of 2.0m AHD, this represents a sand volume fluctuation of approximately ±140 m^3/m. This is significant, due to the length of the beach. However, as the beach is undergoing net northerly longshore drift, the potential for beach rotation would manifest itself as an increase or decrease in the rate of northerly longshore drift.

Calculation of beach rotation at Scotts Head is provided in Appendix B.

4.3 Nambucca Heads

4.3.1 Short Term Beach Fluctuations – Design Storm Erosion

Design storm erosion volumes for Nambucca Heads are calculated in Appendix A. An analysis of equivalent storm erosion volumes resulting from the 1974 storms followed the schema of Nielsen *et al.* 1992 (see Figure 3.1). The values were derived at the local maxima of the landward movement of the RL 4.0m contour, as measured between the 1973 and 1980 photogrammetric data and applied to the whole beach, to take account of the formation of rip-heads and to arrive at a conservative estimate of storm erosion demand for the beach.

Six areas have been delineated, corresponding to profile locations in the photogrammetric analysis, for the purposes of assessing storm erosion volumes. These areas include:

- Block 1 – northern end of Forster Beach, encompassing Nambucca River entrance berm;
- Block 2 – small pocket beach at northern end of river entrance;
- Block 3 and 4 – Shelly and Beilbys Beaches;
- Block 5 – Main Beach Surf Club
- Block 6 – Main Beach and Swimming Creek

At other locations in NSW, a relationship between beach erosion and whether an adjacent river entrance is open or closed has been found – such a relationship was found at

Shoalhaven Heads on the NSW south coast (SMEC Australia, 2007). It was found that more beach erosion occurred when a coastal storm event coincides with an open entrance.

Equivalent storm erosion volumes were obtained from the analysis for the beachfront areas along the entire Nambucca Heads coastline. From this analysis, an envelope of values for the loss of sand volume has been assessed for the May-June 1974 storms at Nambucca Heads. These envelopes are 290 m^3/m for Block 1 (representing a landward translation of the dune of around 32 m), 100 m^3/m for Block 2 (representing a landward translation of the dune of around 25 m), 190 m^3/m for Blocks 3 – 4 (representing a landward translation of the dune of around 38 m) and 160 m^3/m for Blocks 5 – 6 (representing a landward translation of the dune of around 23 m) between 1973 and 1980. The values of storm erosion shown here for Block 1 are higher than typical values of 200 – 250 m^3/m that have been measured on other open-coast beaches along the NSW coast. This is as a result of the dynamic nature of fluctuations at the river entrance. On average, the storm erosion is comparable to or slightly lower than the typical values experienced for open coastlines in NSW, possibly as a result of the presence of underlying rock along the coastline.

The lack of sufficient data immediately before and after storm events meant that it was not possible to perform a statistical analysis and assign a design encounter probability to the recommended storm erosion demand value. However, it is considered that a storm that would lead to the design storm erosion demand would have a very low risk of being exceeded over the next 50 years. The estimated storm erosion demand from the 1974 storms for various locations along the beach at Nambucca Heads is plotted in Figure 4.4.

4.3.2 Short Term Beach Fluctuations – River Entrance Instability

Short term beach fluctuations can be enhanced at natural estuary entrances such as the entrance of the Nambucca River. It was found that this hazard is restricted to the zone along the beach berm at the entrance of the river (Blocks 1 and 2).

Outside of the immediate berm area, the river entrance dynamics may have some influence on the dune erosion. For example, at the northern end of Forster Beach south of the entrance channel, escarpment crests are very low (below 4 m AHD) and storm overwash of these areas could easily occur.

Further south along Forster Beach away from the entrance area, river entrance dynamics may influence dune erosion, though the escarpment crests are above 9m AHD and storm overwash of these areas is extremely unlikely.

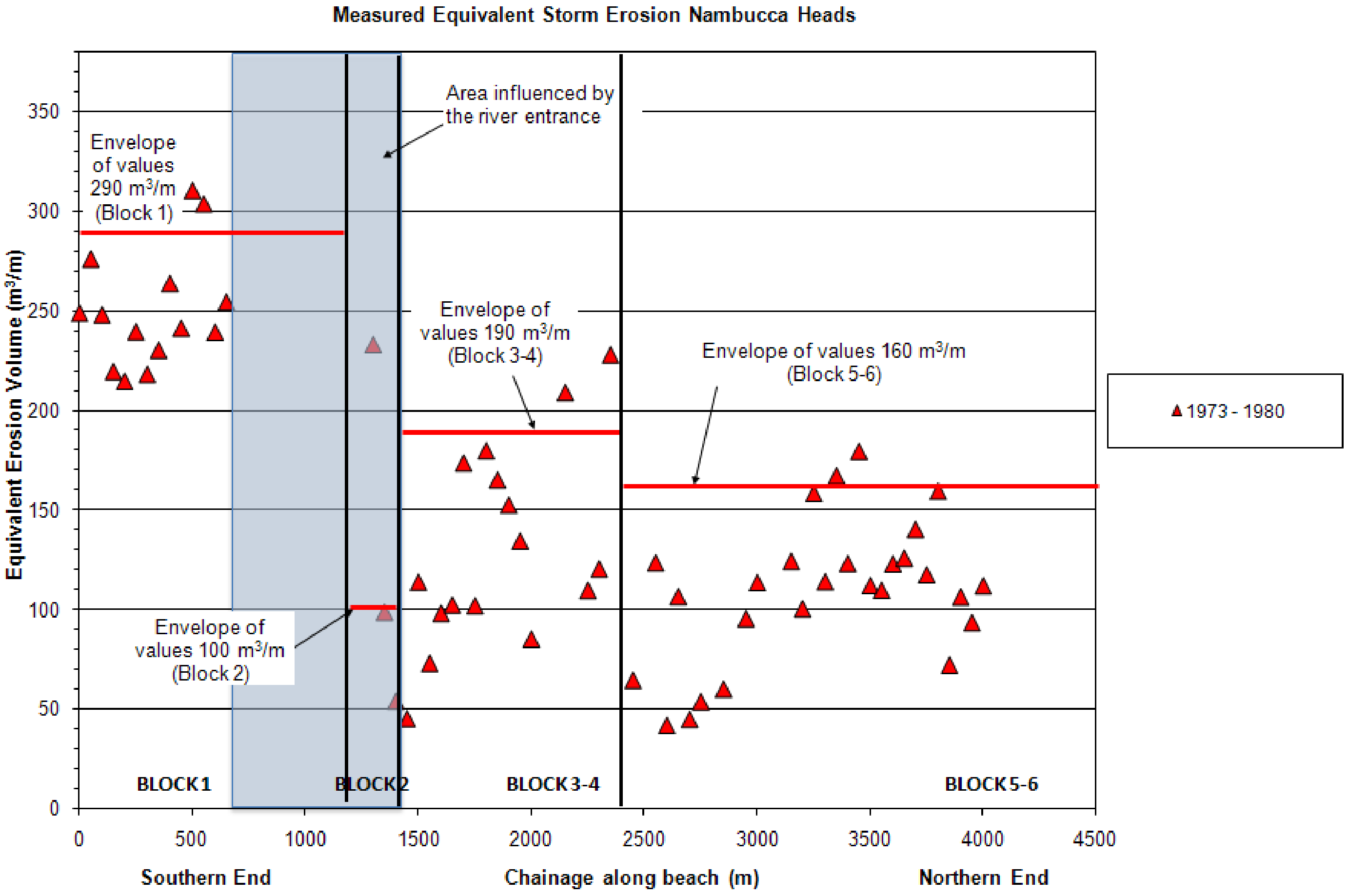


Figure 4.4 – Measured equivalent storm erosion, Nambucca Heads 1973 - 1980

4.3.3 Long Term Recession

Processes such as sea level rise, aeolian processes and the littoral drift of sediment are natural loss components of the sediment budget of a beach. At Nambucca Heads, sand may on occasions be transported into the Nambucca River estuary or move alongshore toward the northern end of Forster Beach. Similarly, biogenic production of sand from the shells of benthic fauna, and sediment transported into the littoral zone from nearby estuaries are natural sources of sediment for a beach. If, in the long term, the losses of sediment from a beach are greater than the gains, then a gradual beach recession will result.

Detailed measurements of the sediment budget for the beach at Nambucca Heads were beyond the scope of this study. However, an assessment of the long term beach recession rate has been made empirically using photogrammetric data, and this is described in Appendix A.

The two methods used for the estimation of long term recession were the measurement of eroded sand volumes and the measurement of the translation of the dune face over time. From the analysis, the average long term position of the 4.0m AHD contour level moved landward on average since 1942 for Blocks 1 to 4, indicating long term recession, and seaward for Blocks 5 and 6, indicating an accretion area. This conclusion was confirmed by the volumetric photogrammetry analysis. Based on this, and adjusting for effects such as measured sea level rise over the 20th Century, a long term recession rate of 0.4 m/y was adopted for the northern end of Forster Beach. Long term recession was measured but found to be very low for Shelly and Beilbys beaches, and long term accretion was seen at Main Beach. This could be an indicator of net northerly longshore drift. The values of long term recession at Shelly and Beilbys beaches were low enough to be accounted for by sea level rise that has occurred over the 20th Century, so the long term recession term has been neglected for these beaches. Further assessments in the future may change this prognosis for long term beach recession as more photogrammetry data are collected and analysis techniques improve.

4.3.4 Future Beach Recession – Sea Level Rise

Sea level rise may lead to a shoreline response of coastal recession. The most widely accepted method of estimating shoreline response to sea level rise is the Bruun Rule (Appendix B). Measurements of sea level rise show that there is considerable variation in the data. These variations are due to processes acting at inter-decadal scales, such as the El Niño Southern Oscillation (ENSO) phenomenon.

Figure 2.6 illustrates the concept of beach recession as a result of sea level rise. Appendix B provides detail on the *Bruun* analysis carried out for Nambucca Heads. Table 4.4 provides estimates of the overall long-term recession expected at Nambucca Heads due to sea level rise. It is possible that these estimates are conservative, as the Bruun analysis does not take the presence of bedrock underlying sand layers.

Table 4.4 – Predicted Future Beach Erosion and Recession due to Sea Level Rise at Nambucca Heads

Northern end Forster Beach (BLOCK 1)						
Total Predicted Sea Level Rise (m)			Total Beach Recession		Total Beach Erosion (m^3/m)	
Scenario	2050	2100	2050	2100	2050	2100
Central	0.25	0.55	22.8	50.3	205.6	452.3
High	0.40	0.90	36.5	82.2	328.9	740.0

Northern breakwater (BLOCK 2)						
Total Predicted Sea Level Rise (m)			Total Beach Recession		Total Beach Erosion (m^3/m)	
Scenario	2050	2100	2050	2100	2050	2100
Central	0.25	0.55	21.4	47.0	85.5	188.2
High	0.40	0.90	34.2	77.0	136.8	307.9

Shelly and Beilbys Beach (BLOCK 3-4)						
Total Predicted Sea Level Rise (m)			Total Beach Recession		Total Beach Erosion (m^3/m)	
Scenario	2050	2100	2050	2100	2050	2100
Central	0.25	0.55	24.2	53.2	120.8	265.8
High	0.40	0.90	38.7	87.0	193.3	435.0

Main Beach and Swimming Creek (BLOCK 5-6)						
Total Predicted Sea Level Rise (m)			Total Beach Recession		Total Beach Erosion (m^3/m)	
Scenario	2050	2100	2050	2100	2050	2100
Central	0.25	0.55	23.7	52.1	165.6	364.4
High	0.40	0.90	37.9	85.2	265.0	596.3

4.3.5 Inundation

Coastal inundation at Nambucca Heads due to wave runup would only occur if the frontal dune is low enough to allow overtopping during a major storm. Wave runup levels on the beaches at Nambucca Heads were estimated using parameters from long term wave statistics at the Coffs Harbour and Crowdy Head Waverider buoys, as detailed in Appendix A.

Coastal inundation is possible, however, for low-lying properties along the Nambucca River as a result of storm surge penetrating into the lower reaches of Nambucca River. Parts of these properties and the roadway at Wellington Drive are below 4 m AHD.

Modelling of wave penetration into the entrance of Nambucca River was carried out, using the wave transformation modelling software SWAN (**S**imulating **WA**ves **N**earshore). Wave penetration into the entrance is possible when the entrance is open, following a major flood event. Wave penetration is most dependent on the bathymetry of the lower entrance area, as well as the oceanic water level due to storm surge and barometric setup (as described in Figure 2.18). Inundation due to freshwater flows from upstream is to be examined in detailed in the Lower Nambucca Flood Study (WBM, in preparation).

Bathymetry of scoured entrance conditions was obtained for the lower Nambucca area following the flood event of May 2009. A 100 year Annual Recurrence Interval (ARI) water level of 2.4 m was modelled, together with an offshore significant wave height of 7 m (based on Waverider buoy data). It was found that waves would be depth-limited in the lower estuary, and wave breaking would occur on the many shoals. However, under the right conditions, ocean waves up to 0.9 m in height could penetrate into the harbour (through the “hole” in the breakwall) at Wellington Drive, and waves up to 0.5 m in height could reach Bellwood Park, if the entrance is open and the ocean water level is high enough (Figure 4.5). Wave heights at Bellwood Park and Wellington Drive are independent of the offshore wave height – the above wave heights could occur even under average ocean wave conditions if the ocean water level is high enough and the entrance scoured deeply enough.

Wave runup levels could reach an additional 1 m above the nearshore water level, based on the nearshore slope and wave height at Wellington Drive and Bellwood Park. This would inundate the roadway of Wellington Drive, and low-lying parts of Riverside Drive. Wave runup levels would likely increase by 2100 as a result of sea level rise due to climate change. The extent of any future increase cannot be quantified at this time, due to future morphological changes in the lower estuary affecting future runup levels.

Wave overtopping of the main breakwater east of the V-wall (between the V-wall and Wellington Rocks) is also likely in a large storm event. While the main breakwall is generally well constructed and has withstood the forces of many large storms, the crest level is only around 4 m AHD and wave overtopping in a large storm would result in a hazard to pedestrians using the walkway behind the breakwall. Wave overflow water could pond on the northern side of the breakwall, as the ability for water to drain back through the breakwall would be limited if the water levels are high in the river. This may result in nuisance flooding of the White Albatross caravan park and carpark, especially as parts of these areas are below 2 m AHD. However, the Caravan Park would not be subject to erosion or reduced foundation capacity as a result of storms.

Table 4.5 gives the results for the wave runup assessment for the open coast beaches. The analysis indicated that wave overwash of the berm at the river entrance would be possible (and would be a frequent event).

Table 4.5 – Wave Runup levels for Nambucca Heads, 0.1% AEP storm event

Profile	Location	Deepwater significant Wave Height (m)	Nearshore Water Level (m)	Nearshore Beach Slope (1:X)	Maximum Wave Runup Level (m)	2% Wave Runup Level (m)	*Significant* Wave Runup Level (m)	Maximum Runup+Set up+High Tide (m AHD)
1-1	Entrance berm area	11	1.144	19.5	2.11	1.73	1.29	**4.73**
1-6		11	1.119	20	2.08	1.71	1.27	**4.68**
1-13		11	1.137	20	2.04	1.68	1.25	**4.66**
1-20		11	1.159	35.5	1.32	1.12	0.84	**3.96**
1-26		11	1.269	52.5	1.1	0.96	0.73	**3.85**
2-2	Northern breakwater	11	1.169	31	1.54	1.3	0.97	**4.19**
3-2	Shelly Beach	11	1.073	21.5	2.15	1.78	1.32	**4.70**
4-1	Beilbys Beach	11	1.081	15	2.86	2.32	1.72	**5.42**
4-8		11	1.058	14.5	2.9	2.35	1.74	**5.44**
4-16		11	1.034	12	3.5	2.8	2.08	**6.01**
5-1	Main Beach Surf Club	11	1.04	14	3.14	2.54	1.88	**5.66**
6-1	Main Beach	11	1.014	19	2.46	2.02	1.51	**4.95**
6-7		11	1.022	10.5	3.79	3	2.22	**6.29**
6-15		11	0.978	19	2.6	2.15	1.6	**5.06**
6-22		11	1.004	21	2.23	1.84	1.37	**4.71**
6-30		11	1.016	19.5	2.3	1.89	1.41	**4.80**

From the photogrammetric data, this indicates that some areas would experience inundation due to wave runup. These areas include:

- the sand berm area at the entrance of the river (Block 1) but no infrastructure are at risk there;
- the toilet infrastructure at Shelly Beach (but the effect should be minimal as a seawall has been built at this location); and
- the Main Beach SLSC as it is directly exposed to the sea. The light protection provided by the 0.3m high concrete slab placed in front of the surf club would not be sufficient to prevent flooding of the lower level of the building due to the 5.7 m high wave runup that is possible in a 0.1% AEP storm.

Figures 4.6 and 4.7 indicate the areas subject to wave runup inundation both for the beaches and lower estuary areas.

4.3.6 Wind-driven Dune Instability Hazard

Windborne sediment transport can result from destruction of the dune vegetation canopy – removal of dune vegetation can lead to areas of sand being destabilised by the wind, leading to a dune “blowout”. This phenomenon has happened at Beilbys Beach in the past, and has also been observed in historical aerial photography along the northern end of Forster Beach.

However, at present, most of the beach areas are well stabilised by dune vegetation, with large expanses of bare sand restricted to the Nambucca River entrance area and to Forster Beach in areas not backed by urban development. As such, there are no urban areas within Nambucca Heads that are currently subject to this type of hazard, provided dune vegetation is maintained into the future.

4.3.7 Beach Rotation and Longshore Drift at Nambucca Heads

There is no real evidence of beach rotation at the entrance berm to Nambucca River, or at the small beach adjacent to the northern breakwall. The sand transport at the Nambucca entrance area is dominated by local estuarine processes, as is the case with the small beach adjacent to the northern breakwall.

There is also little evidence of beach rotation taking place at Main, Shelly and Beilbys beaches. Shelly and Beilbys beaches are undergoing long term recession at a low rate, as discussed in Appendix A, while Main Beach is accreting. These beaches are flanked by considerable expanses of offshore rocky reefs, which have shaped the plan-form of the coastline and form natural boundaries between the beaches. This is evident at the southern end of Main Beach, which is held in place by the rocky reef immediately adjacent to the Main Beach Surf Club. This reef acts as a natural groyne, trapping the northward transport of sand. This is evident by examining aerial photographs, with a significant dune at the northern end of Beilbys Beach, but reduced sand stores in front of Main Beach Surf Club.

At Nambucca Heads, beach fluctuations over the 450 m distance including Beilbys and Shelly Beaches for a ±0.5° beach rotation may reach 4 m over the sandy portion of the beach – for a beach berm height of 2.0m AHD, this represents a sand volume fluctuation of approximately ±8 m^3/m.

Beach fluctuations over the 700 m distance including Main Beach and Swimming Creek for a ±0.5° beach rotation may reach 6 m over the sandy portion of the beach – for a beach berm height of 2.0m AHD, this represents a sand volume fluctuation of approximately ±12 m^3/m.

Beach rotation would be limited by the presence of the rock outcrops along the beach which control the beach plan-form.

Calculation of beach rotation at Nambucca Heads is provided in Appendix B.

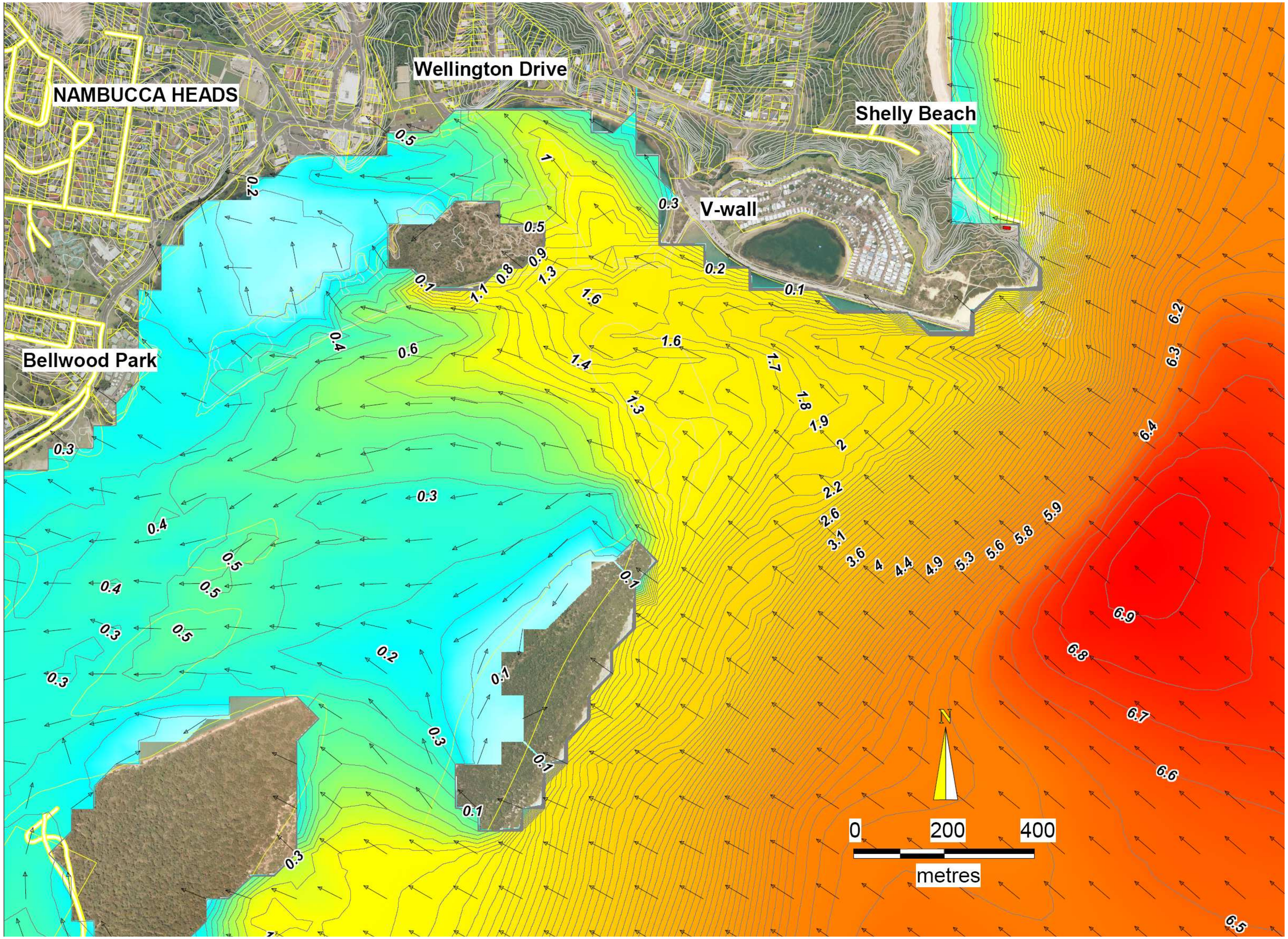


Figure 4.5 – Modelled wave penetration into lower Nambucca River

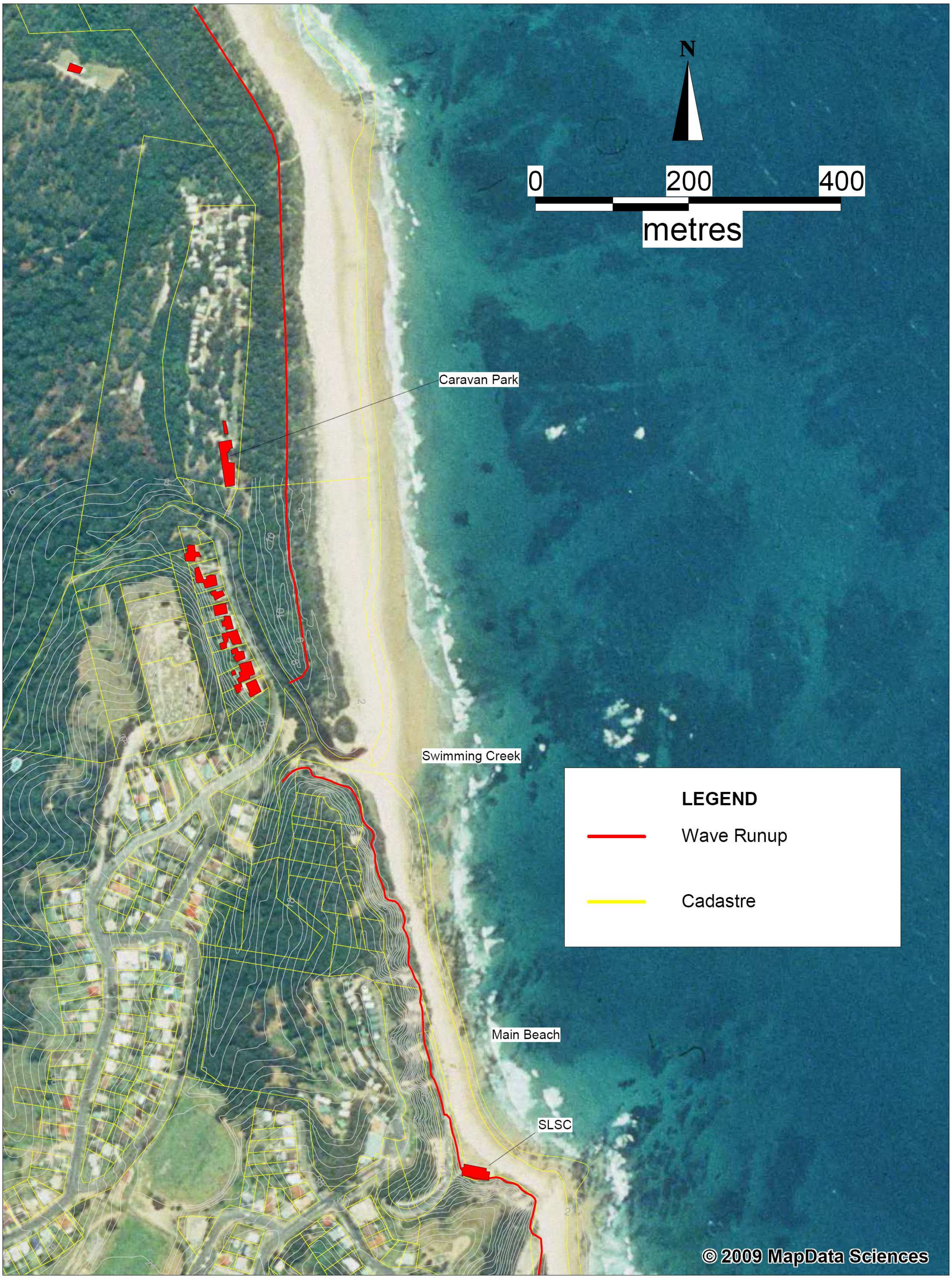


Figure 4.6 – Wave Runup limits, Main Beach, Nambucca Heads

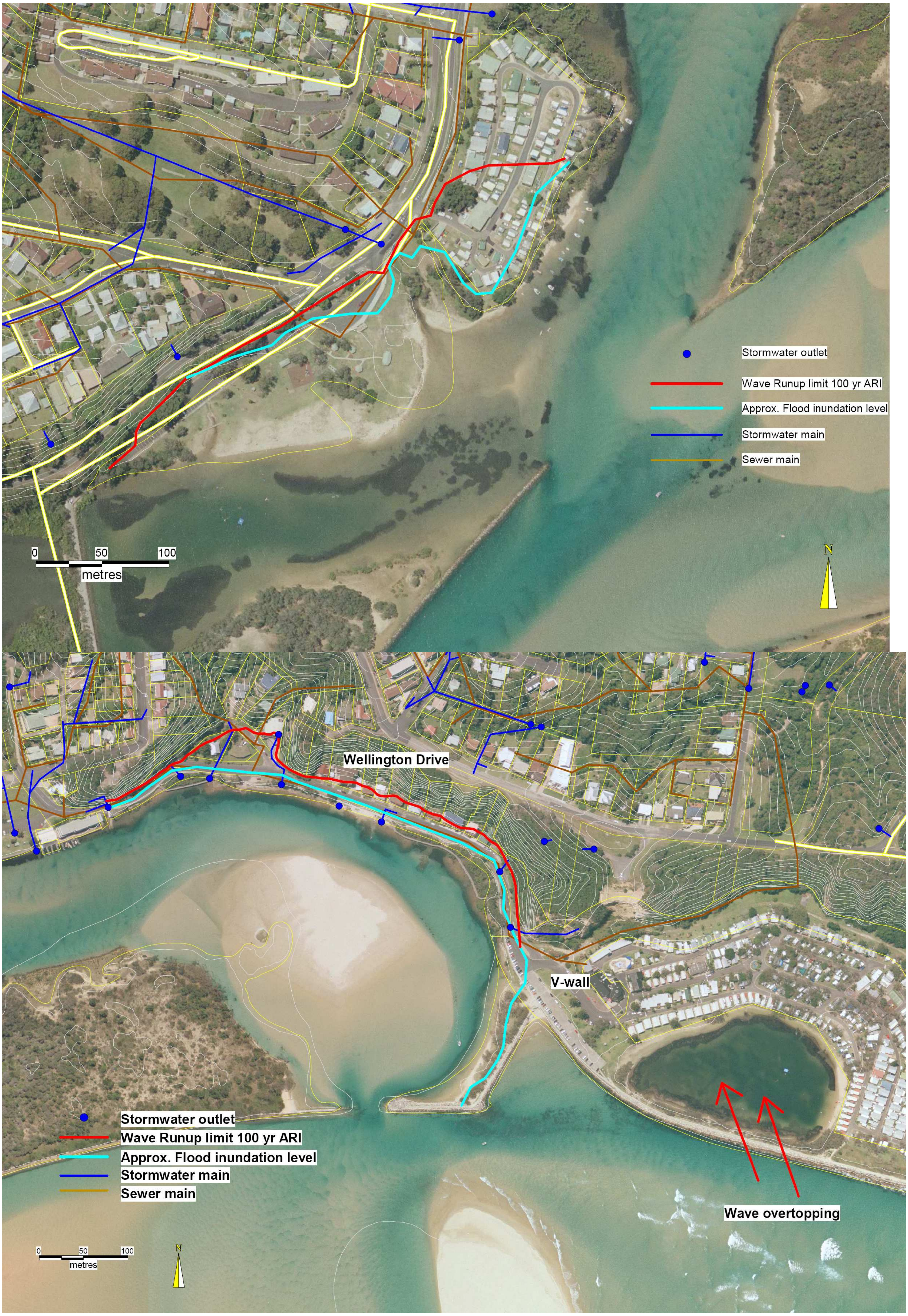


Figure 4.7 – Wave Runup limits, Top – Bellwood Park, Bottom, Wellington Drive, Nambucca Heads

Figure 4.7a – Wave Runup limits, Nambucca entrance, Shelly Beach and Beilbys Beach, Nambucca Heads

4.4 Valla Beach

4.4.1 Short Term Beach Fluctuations – Design Storm Erosion

Design storm erosion volumes for Valla Beach are calculated in Appendix A. An analysis of equivalent storm erosion volumes resulting from the 1990 storms followed the schema of Nielsen *et al.* 1992 (see Figure 3.1). The values were derived at the local maxima of the landward movement of the RL 4.0m contour, as measured between the 1988 and 1991 photogrammetric data and applied to the whole beach, to take account of the formation of rip-heads and to arrive at a conservative estimate of storm erosion demand for the beach.

Equivalent storm erosion volumes were obtained from the analysis of the beachfront areas along the entire Valla Beach coastline. Analysis of the photogrammetric data between 1988 and 1991 showed that most of the erosion values range from 150 to 290 m^3/m for Block L and from 50 to 230 m^3/m for Blocks M and N. Some higher values were noted but were checked and found to be outliers, due to inconsistencies in the photogrammetric data. Maximum storm erosion demand values of **280 m^3/m for Block L** (equivalent to a loss of 25 m of dune)**, 230 m^3/m for Blocks M and N** (equivalent to a loss of 33 m of dune) **and 250 m^3/m for Block O** (equivalent to a loss of 42 m of dune) were therefore adopted for the 1990 storms at Valla Beach. The values are close to the typical values of 200 – 250 m^3/m adopted for open coast beaches elsewhere along the NSW coast where the beaches consist of unconsolidated sands. However, it should be noted that erosion along some parts of the coastline will be limited as the dunes are backed by rocky cliffs and bluffs.

The lack of sufficient data immediately before and after storm events meant that it was not possible to perform a statistical analysis and assign a design encounter probability to the recommended storm erosion demand value. However, it is considered that a storm that would lead to the design storm erosion demand would have a very low risk of being exceeded over the next 50 years, given that the measured storm erosion demand was based on the combined effects of three storm events and a Tropical Cyclone in 1990. The estimated storm erosion demand from the 1990 storms for various locations along the beach at Valla Beach is plotted in Figure 4.8.

4.4.2 Short Term Beach Fluctuations – Estuary Entrance Instability

Short term beach fluctuations can be enhanced at natural estuary entrances such as the entrance of Deep Creek. Estuary entrance instability has been examined in Appendix A, and it was found that this hazard is restricted to within 500 metres of the entrance to Deep Creek. Outside of the entrance area, the entrance dynamics may influence dune erosion, though the escarpment crests are above 10m AHD and storm overwash of these areas is unlikely in the short term. Future breakthrough of the Deep Creek entrance further south along South Valla Beach is possible if the dune at the southern end of the entrance is eroded due to sea level rise. This could threaten the existing footbridge and change the nature of the coastline, whereby the existing, protected foreshore of Deep Creek may become a future open coastline fully exposed to ocean waves.

This entrance instability hazard has caused past erosion damage to the picnic area at South Valla Beach. Outside of the berm area, the river entrance dynamics may influence the dune erosion. Storm overwash and coastal inundation are quantified in Appendix A. Any influences of river entrance dynamics on storm erosion are therefore incorporated in the design storm erosion demand.

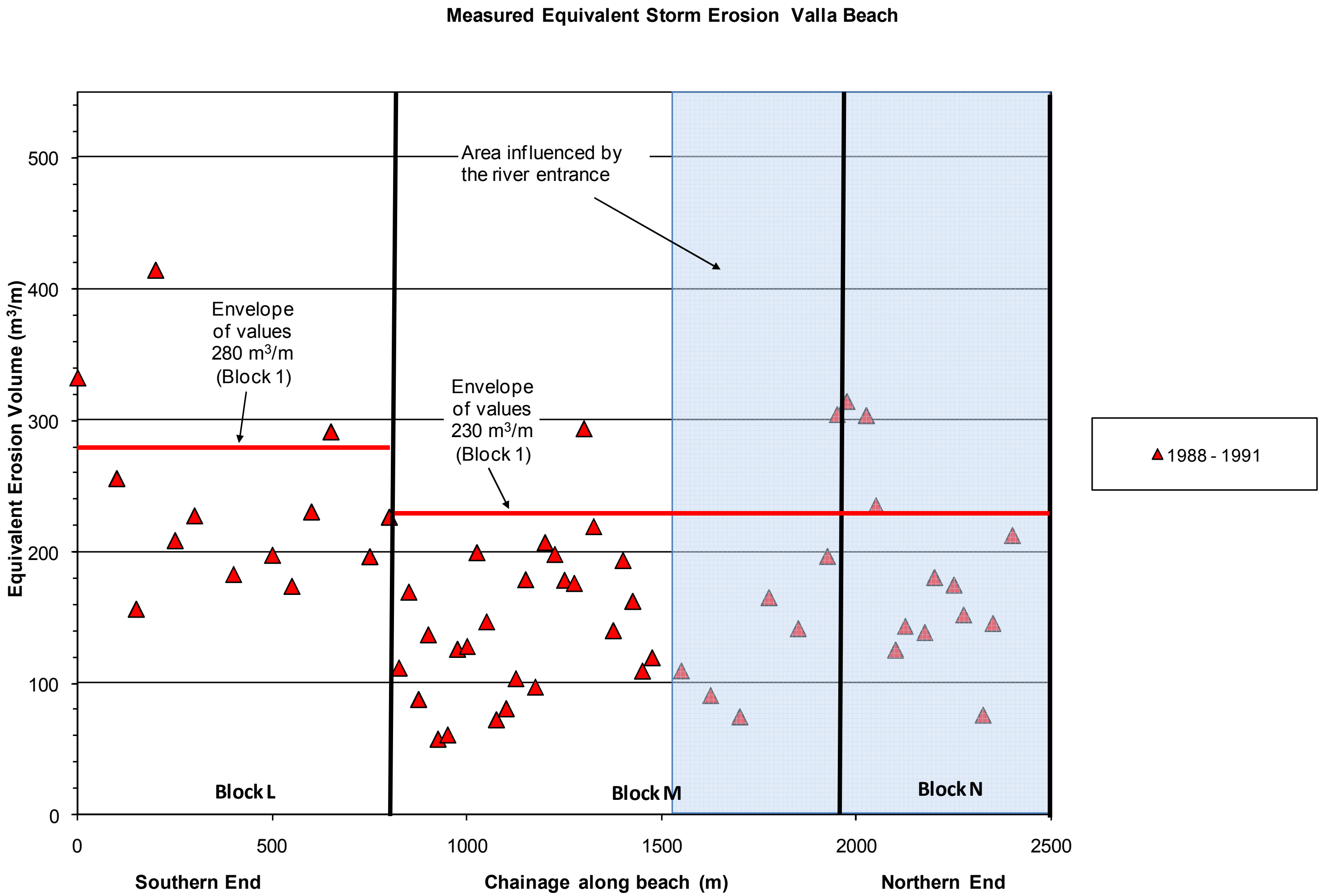


Figure 4.8 – Valla Beach measured equivalent storm erosion 1988 - 1991

The entrance to Deep Creek is currently artificially opened when the water level in Deep Creek reaches 0.95 m AHD. Artificial opening of the creek entrance modifies the sediment transport processes around the entrance and impacts on the tidal regime of the lower estuary area. The opening is often carried out at the southern end of the entrance migration area, which prevents build up of sand in this area and minimises the impact on the toilet block and carpark. As flooding only begins to affect infrastructure when water levels reach 2 m AHD, artificial openings could be reduced in frequency to when water levels reach 1.8 m AHD to reduce the impact on coastal processes. This could be adopted in the interim, pending adoption of a formal entrance management policy for Deep Creek.

4.4.3 Long Term Recession

Processes such as sea level rise, aeolian processes and the littoral drift of sediment are natural loss components of the sediment budget of a beach. At Valla Beach, sand may on occasions be transported into the Deep Creek estuary or move alongshore toward the northern end of South Valla Beach. Similarly, biogenic production of sand from the shells of benthic fauna, and sediment transported into the littoral zone from nearby estuaries are natural sources of sediment for a beach. If, in the long term, the losses of sediment from a beach are greater than the gains, then a gradual beach recession will result.

Detailed measurements of the sediment budget for the beach at Valla Beach were beyond the scope of this study. However, an assessment of the long term beach recession rate found that the beach is undergoing net long term accretion. Subsequently, no allowance was made for long term recession at Valla Beach, This assessment was based on empirical analysis of photogrammetric data, and this is described in Appendix A.

The photogrammetric analysis indicated long-term erosion is not noticeable along the beaches at Valla Beach.

The two methods used for the estimation of long term recession were the measurement of eroded sand volumes and the measurement of the translation of the dune face over time. From the analysis of dune face locations, it can be seen that there was a general movement of the RL 4.0m and RL 5.0m contours seaward between the dates of the 1942 and 2004 photography, and that this seaward translation varies along the beach. In addition, there has been a slight increase in subaerial beach volumes between 1940 and 2004. The volume change in the dune south of Deep Creek entrance has been increasing steadily over time, with a net volume gain of 160 m^3/m between 1942 and 2004. South Valla Beach (Block N) is significantly affected by the river entrance and the volume change is continuously flucuating which makes observation of an increase or decrease difficult. North Valla Beach (Block O) is relatively stable and slightly accreting.

Both of these methods indicated that long term recession is not noticeable at Valla Beach and yielded similar results. Based on this, the long term recession rate has been neglected and the long term changes have not been taken into account. Further assessments in the future may change this prognosis for long term beach recession as more photogrammetry data are collected and analysis techniques improve.

4.4.4 Future Beach Recession – Sea Level Rise

Sea level rise may lead to a shoreline response of coastal recession. The most widely accepted method of estimating shoreline response to sea level rise is the Bruun Rule (Appendix B). Measurements of sea level rise show that there is considerable variation in the data. These variations are due to processes acting at inter-decadal scales, such as the El Niño Southern Oscillation (ENSO) phenomenon.

Figure 2.6 illustrates the concept of beach recession as a result of sea level rise. Appendix B provides detail on the *Bruun* analysis carried out for Valla Beach. Table 4.6 provides estimates of the overall long-term recession expected at Valla Beach due to sea level rise. It is possible that these estimates are conservative, as the Bruun analysis does not take into account the presence of bedrock underlying sand layers or the presence of rock reefs seaward of the beachfront, both of which could significantly reduce the recession due to sea level rise.

Table 4.6 – Predicted Future Beach erosion and recession due to sea level rise

BLOCK L						
Total Predicted Sea Level Rise (m)			**Total Beach Recession (m)**		**Total Beach Erosion (m^3/m)**	
Scenario	**2050**	**2100**	**2050**	**2100**	**2050**	**2100**
Central	0.25	0.55	25.0	55.0	275.0	605.0
High	0.40	0.90	40.0	90.0	440.0	990.0
BLOCK M						
Total Predicted Sea Level Rise (m)			**Total Beach Recession (m)**		**Total Beach Erosion (m^3/m)**	
Scenario	**2050**	**2100**	**2050**	**2100**	**2050**	**2100**
Central	0.25	0.55	26.7	58.7	186.7	410.7
High	0.40	0.90	42.7	96.0	298.7	672.0
BLOCK N						
Total Predicted Sea Level Rise (m)			**Total Beach Recession (m)**		**Total Beach Erosion (m^3/m)**	
Scenario	**2050**	**2100**	**2050**	**2100**	**2050**	**2100**
Central	0.25	0.55	26.8	59.0	80.4	176.9
High	0.40	0.90	42.9	96.5	128.7	289.5
BLOCK O						
Total Predicted Sea Level Rise (m)			**Total Beach Recession (m)**		**Total Beach Erosion (m^3/m)**	
Scenario	**2050**	**2100**	**2050**	**2100**	**2050**	**2100**
Central	0.25	0.55	25.3	55.6	151.7	333.7
High	0.40	0.90	40.4	91.0	242.7	546.0

4.4.5 Inundation

Coastal inundation at Valla Beach due to wave runup would only occur if the frontal dune is low enough to allow overtopping during a major storm. Wave runup levels on the beach at Valla Beach were estimated using parameters from long term wave statistics at the Coffs Harbour and Crowdy Head Waverider buoys, as detailed in Appendix A.

Table 4.7 gives the results for the wave runup assessment. From the photogrammetric data, this indicated that, at a maximum, wave runup would not overtop the existing dune embankment except at Block N and there would be no impact on dwellings or other infrastructure. The only area that would experience overtopping due to wave runup would be the sand berm area at the entrance of Deep Creek as the berm heights are very low there. This wave runup could affect the existing carpark, picnic area and toilet block in the area immediately landward of the entrance berm to Deep Creek. Figure 4.9 shows the expected limit of maximum wave runup for the 0.1% AEP storm event.

Table 4.7 – Wave Runup levels for Valla Beach, 0.1% AEP storm event

Profile Number	**Deepwater significant Wave Height (m)**	**Nearshore Water Level (m)**	**Nearshore Beach Slope (1:X)**	**Maximum Wave Runup Level (m AHD)**	**2% Wave Runup Level (m AHD)**	***Significant* Wave Runup Level (m AHD)**	**Maximum runup+Set Up+High Tide (m AHD)**
L-1	11	1.039	32.5	1.35	1.14	0.85	**3.869**
L-8	11	1.046	31.5	1.31	1.1	0.82	**3.836**
L-16	11	1.052	54	0.87	0.76	0.57	**3.402**
M-1	11	1.041	58.5	0.884	0.73	0.55	**3.361**
M-11	11	1.057	54	0.88	0.76	0.57	**3.417**
M-23	11	1.047	37.5	1.25	1.06	0.79	**3.777**
M-34	11	1.058	41.5	1.15	0.98	0.74	**3.688**
M-46	11	1.049	45.5	1.13	0.97	0.73	**3.659**
N-1	11	1.03	37.5	1.23	1.04	0.78	**3.74**
N-12	11	1.033	39.5	1.17	1	0.75	**3.683**
N-24	OVERTOPPED						
O-1	11	1.144	23.5	1.85	1.53	1.14	**4.474**
O-8	11	1.178	13.5	2.81	2.25	1.67	**4.508**
O-15	11	1.116	13.5	3.43	2.77	2.06	**6.026**
O-22	11	1.184	22	1.97	1.63	1.21	**4.634**

4.4.6 Wind-driven Dune Instability Hazard

Windborne sediment transport can result from destruction of the dune vegetation canopy – removal of dune vegetation can lead to areas of sand being destabilised by the wind, leading to a dune “blowout”. This phenomenon could happen on the dune located between the river and the ocean, as this is a dynamic area with limited time for vegetation to become established.

There are no urban areas within Valla Beach that are currently subject to this type of hazard.

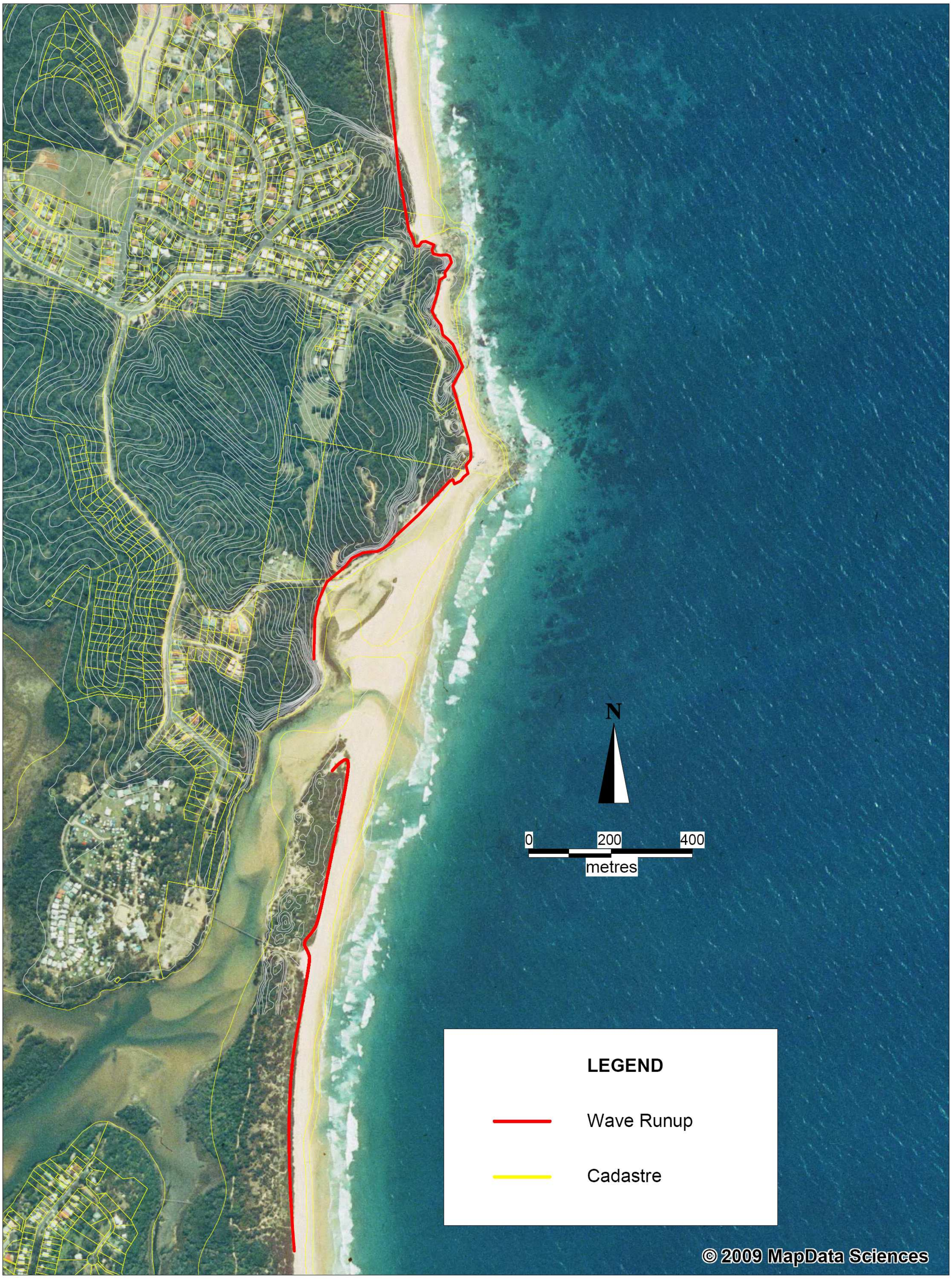


Figure 4.9 – Wave Runup limits, Valla Beach

4.4.7 Rotation and Longshore Drift at Valla Beach

There is little evidence of beach rotation taking place at the beach compartment immediately surrounding Valla Beach, with beach fluctuations generally correlated positively with changes along the entire region where photogrammetry is available.

From the analysis in Appendix B, beach fluctuations over the 1250 m including Main and South Valla Beach for a ±0.75° beach rotation may reach 16 m over the sandy portion of the beach – for a beach berm height of 2.0m AHD, this represents a sand volume fluctuation of approximately ±32 m^3/m.

Beach fluctuations over the 250 m at the southern end of North Valla Beach for a ±0.75° beach rotation may reach 3 m over the sandy portion of the beach – for a beach berm height of 2.0m AHD, this represents a sand volume fluctuation of approximately ±6 m^3/m.
Beach fluctuations over the 2500 m distance between Valla Beach and Wenonah Head for a ±0.75° beach rotation may reach 32 m over the sandy portion of the beach – for a beach berm height of 2.0m AHD, this represents a sand volume fluctuation of approximately ±64 m^3/m.

Beach rotation would be limited by the presence of the rock outcrops along the beach, which control the beach planform.

Calculation of beach rotation at Nambucca Heads is provided in Appendix B.