B4

AIRPORT AND SURROUNDS

COASTAL PROCESSES

Sunshine Coast COUNCIL | Sunshine Coast AIRPORT

CONTENTS

FIGURES

TABLES

APPENDICES (REFER SEPARATE APPENDICES DISK)

GLOSSARY

Australia Height Datum (AHD)	Datum for altitude measurement in Australia
beach profile	The profile (cross-section) of a beach
bed shear stress	Force imparted on the seabed associated with wave and current action
coffee rock	Rock-like formation of indurated sands
cross shore sediment transport	Sediment transport offshore and onshore, typically associated with storm erosion (offshore) and subsequent beach recovery (onshore)
Highest Astronomical Tide (HAT)	The highest tide that can occur from the influence of celestial bodies – this excludes local effects such as atmospheric pressure and wind effects
longshore current	Currents flowing parallel to the shore within the inshore and nearshore zones
longshore sediment transport	Sediment transport along the coast due to longshore current
Lowest Astronomical Tide (LAT)	The lowest theoretical tide level
maximum wave height	Maximum wave height in a wave record
Mean High Water Spring (MHWS)	The highest level spring tides reach on average
Mean Low Water Spring (MLWS)	The lowest level spring tides reach on average
neap tide	The smaller tides observed during the spring-neap cycle
sea waves (or “seas”)	Local wind-generated waves
sediment budget	An accounting of the rate of sediment supply from all sources (credits) and the rate of sediment loss to all sinks (debits) from an area of coastline to obtain the net sediment supply.
semi-diurnal tide	Classification describing a tidal regime with approximately two high waters and two low waters each day
shoreline accretion	The accumulation of sand on the beach by the action of marine and/or aeolian sediment transport processes causing a seaward movement of the shoreline
shoreline recession	A net long-term landward movement of the shoreline caused by a net loss in the sediment budget.
significant wave height	The average wave height of one-third of the highest waves in a wave record

spring tide	The larger tides observed during the spring-neap cycle
storm surge	The increase in coastal water level caused by the effects of storms. Storm surge consists of two components: the increase in water level caused by the reduction in barometric pressure (barometric set-up) and the increase in water level caused by the action of wind blowing over the sea surface (wind set-up)
storm tide	The water level observed at the shoreline during a storm (the storm surge superimposed on the astronomical tide)
surf zone	Coastal waters between the outer wave breaking zone and the swash zone characterised by broken swell waves moving shoreward in the form of bores
swell waves	Wind waves remote from the area of generation (fetch) having a uniform and orderly appearance characterised by regularly spaced wave crests
wave orbital motion	The motion of water particles under waves
wave period	The time it takes for a wave to travel the distance equal to its wavelength

4.1
INTRODUCTION

This chapter of the Environmental Impact Statement (EIS) addresses the physical coastal processes within the vicinity of Marcoola Beach that may affect the design, construction and operation of the Sunshine Coast Airport Expansion Project (the Project) and provides a risk assessment of the potential impacts from the Project on coastal resources and values.

The baseline component of the report defines the existing conditions at Marcoola Beach and the nearshore areas. Conditions at adjacent areas are also described in order to establish a baseline for which the potential impacts of the Project can be assessed.

The impact assessment addresses key project components, including:

- Beach and dune disturbance during the construction phase
- Dredge pipeline and interruption to longshore sediment transport
- Dredge mooring location and the potential for spilled dredge material

The study area and components of the Project relevant to the coastal processes impact assessment are indicated in **Figure 4.1a**.

4.2
METHODOLOGY AND ASSUMPTIONS

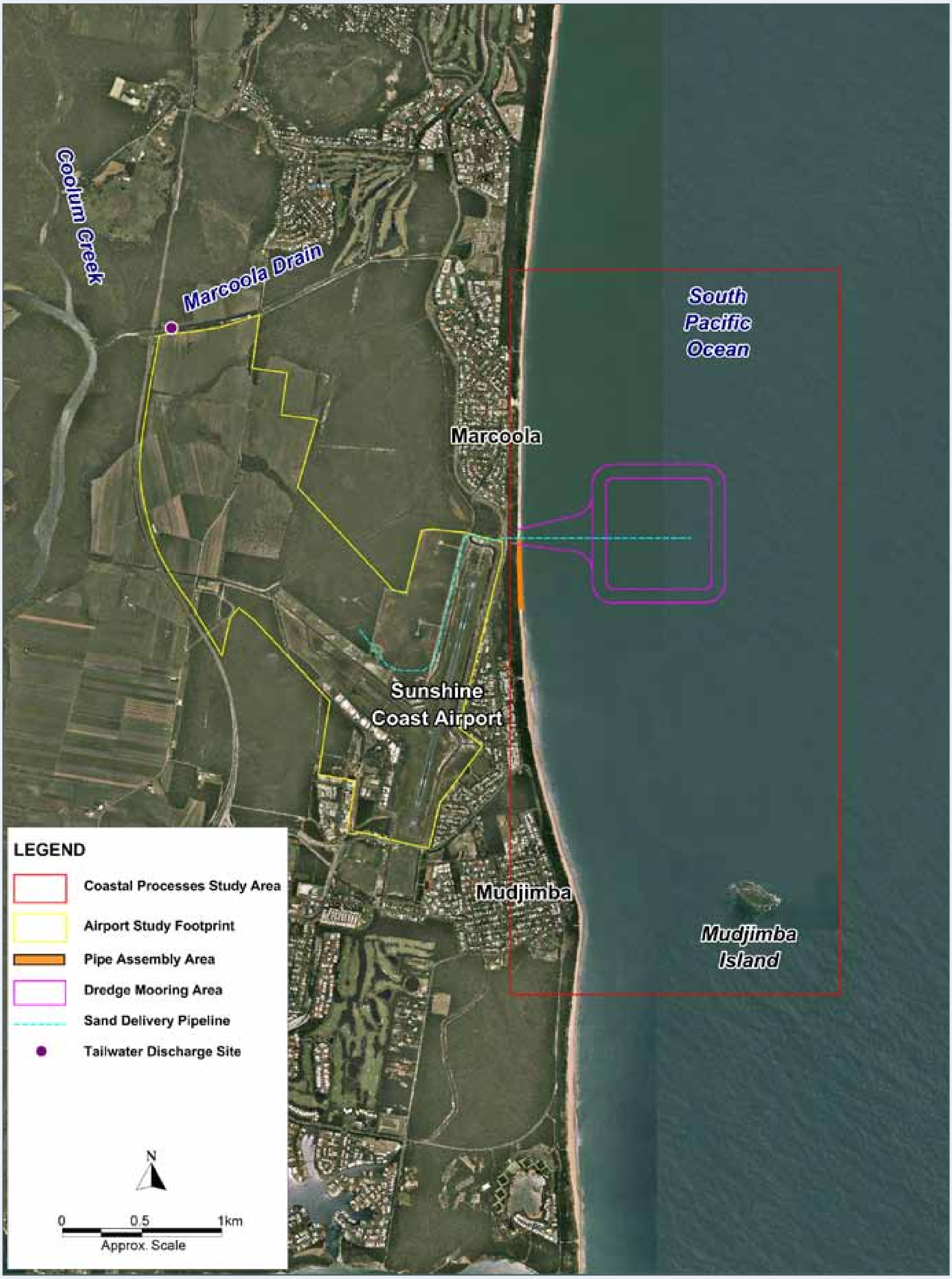
4.2.1 Methodology

This chapter describes the existing physical conditions at Marcoola Beach and potential impacts associated with the proposed works. These primarily relate to wave processes and the associated sand transport that may be modified during the construction and operational phases of the Project.

The nature and behaviour of the existing physical processes within the study area is described in **Section 4.3** and draws on previous studies, observations (recorded data) and numerical modelling.

The objective of this study is to assess the risks to the Project associated with any potential undesirable impacts to Marcoola Beach coastal processes.

Figure 4.1a: Coastal processes impact assessment study area



4.2.2 Policy context and legislative framework

4.2.2.1 Coastal plans and policies

The Queensland Government addresses potential impacts to coastal processes and water quality through state planning policies, action plans and planning schemes. Those relevant to the Project include the following:

- The Queensland Coastal Plan (DERM, 2012) was prepared under the *Coastal Protection and Management Act 1995* in February 2012. The Coastal Plan consists of the State Policy for Coastal Management (SPCM), containing policies and guidance for coastal land managers on managing and maintaining coastal land. This document has recently been replaced by the Draft Coastal Management Plan (2013), noting the policy outcomes sought by the Draft Plan carry forward policies outlined in the SPCM.
- The Coastal Protection State Planning Regulatory Provision (the Coastal SPRP) took effect on April 2013. Previously, the Draft Coastal SPRP had suspended the operation of the State Planning Policy 3/11: Coastal Protection (Coastal SPP). The Coastal SPRP provides outcomes for development assessment in the coastal management district.
- Sections and parts of the SPCM and Coastal SPRP that are relevant to this chapter include:
  - coastal hazards
  - nature conservation
  - coastal dependent development
  - dredging and disposal of dredged material.

The relevance and consistency of the project with the State Policy for Coastal Management and Coastal SPRP based on the key findings of this chapter are outlined in Chapter A6 – Planning and Legislation, and Chapter B2 – Land Use and Tenure.

Relevant coastal water quality values identified by the Environmental Protection Act 1994 and Environmental Protection (Water) Policy 2009 (EPP Water) are described in Chapter B6 – Surface Hydrology and Quality.

4.3
EXISTING CONDITIONS

4.3.1 Geological context

On a geological timescale the Sunshine Coast has experienced moderate change. Over the last 120,000 years large variations in sea level have influenced the evolution of the coastline:

- Approximately 120,000 years ago sea levels were 1-3 m higher than present. Since this time the sea level varied due to numerous glacial cycles. The lowest sea level, 120 m below the present level, is believed to have occurred approximately 18,000 years ago
- Major sea level change occurred between 18,000 and 6,500 years ago. During this period the sea rose to its present level
- Since the “stillstand”, 6,500 years ago, sea levels have remained approximately at their present level. Along the Sunshine Coast however, the continued evolution and reshaping of the shoreline has occurred in response to gradients in littoral drift.

The present coastline is not static. Most of the flat areas behind the present coastline are formed by sediments deposited during the previous high sea level (about 120,000 years ago). During the high sea period the coastline was further to the west and the headlands of Noosa, Coolum and Point Cartwright were islands. Low barrier sand spits formed between these islands (present headlands), and shallow tidal deltas accumulated behind them. Inland from these tidal deltas were extensive bays of open water backed by mangroves, estuaries and mud flats, which over time gradually filled with muds and sands. The glacial period that followed caused a major drop in sea level (up to approximately 120 m), resulting in the eastern migration of the shoreline.

Between 18,000 and 6,500 years ago the sea level rose again, approximately reaching its present level. In response to the rising sea, the shoreline moved landward submerging the former coastal plain. During this transgression, the existing older Pleistocene alluvial and coastal sediments were reworked at the shoreface and, in part, transported onshore.

Since the stillstand, anecdotal evidence suggests the coastline from north of Currimundi, including the study area at Marcoola Beach, has experienced a persistent trend of erosion. This is indicated by the present widespread exposure of humic sandstone (coffee rock) along the coast within the study area (Jones, 1992; Willmott, 2007).

Jones (1992) comments that the persistent trend in erosion north of Currimundi is the result of littoral drift gradients occurring north of the Caloundra Headland. Based on sediment samples, Jones (1992) identifies that Caloundra Headland represents a littoral drift divide, with alongshore transport directed away from the headland to both the north and south. North of this location a gradient in littoral drift is resulting in a persistent trend in erosion at a rate which is considered low. Jones (1992) attributes the low rates of persistent long term erosion to the shallow wide offshore inner shelf bathymetry, causing incoming waves to refract, becoming almost shore parallel and resulting in only weak alongshore currents and low littoral drift rates.

In addition to the low littoral drift rates, onshore sediment supply from the inner shelf may also reduce the magnitude of the shoreline erosion driven by the littoral drift gradients. Recent studies completed by Patterson (2009) for the Gold Coast, approximately 150 km south of the Sunshine Coast, indicate that the supply of sediment to the nearshore active profile from the inner shelf may occur in locations where inner shelf slopes are milder than the equivalent deepwater equilibrium slope. This may also occur along some sections of the Sunshine Coast where a mild inner shelf slope is present.

4.3.2 Tides

The tides in the region are predominantly semi-diurnal. At locations adjacent to the study area (Maroochydore Beach and Coolum) the mean spring tide range is 1.4 m while the extreme tidal range under astronomical conditions is 2.17 m. The tidal planes for Maroochydore Beach, Coolum and the nearby Mooloolaba standard port are shown in **Table 4.3a**. As indicated in **Table 4.3a**, there is no measureable phase or amplitude difference in water level between the Mooloolaba Standard Port and the Maroochydore Beach and Coolum secondary places.

4.3.3 Waves

The Sunshine Coast wave climate is a combination of ocean swell and locally wind-generated "seas". The swell waves are of long period (typically 7 – 12 seconds) and experience significant modification due to refraction, bed friction and shoaling as they propagate to the shoreline from the deep ocean. The region experiences a persistent ground swell from the south-east however Moreton Island acts to shelter a large section of the Sunshine Coast from these swells. The sheltering influence from Moreton Island progressively decreases moving north along the Sunshine Coast. More locally to the study area, Mudjimba Island also modifies the swell wave height and direction which in turn influences the local sediment transport regime. The influence of Mudjimba Island on the local shoreline position is considered further in **Section 4.3.8**. Wind generated sea waves are of relatively short period (generally less than 4 seconds) and are not substantially affected by the offshore bathymetry prior to breaking nearshore.

The Department of Environment and Heritage Protection (DEHP) operate and maintain a wave buoy located due east of Yaroomba, commonly referred to as the "Mooloolaba Buoy". Non-direction wave recordings commenced in 2000 and in 2005 a directional wave recorder was installed. The instrument is presently located approximately 8 km offshore in a water depth of 33 m. A sample of recorded significant wave height and direction is provided in **Figure 4.3a** and a wave rose and wave frequency recurrence table based on recordings from July 2006 to April 2008 is provided in **Figure 4.3b** and **Table 4.3b**. The available offshore wave data suggests:

- The offshore wave climate is of moderate to high energy, with a median significant height of 1.3 m. It is noted that a maximum wave height (Hmax) of 10.5 m was recently recorded at this location during ex-Tropical Cyclone (TC) Oswald (January 2013). This is the largest wave measured since the 2005 directional wave buoy installation. This

Table 4.3a: Mooloolaba standard port tidal planes (Maritime Safety Queensland, 2012)

	Water level relative to metres below LAT*			Time difference	
Location	**MHWS**	**MLWS**	**Mean Spring Range (m)**	**High Water**	**Low Water**
Mooloolaba	1.66	0.26	1.4	Standard Port	
Maroochydore Beach	1.66	0.26	1.4	0.00	0.00
Coolum	1.66	0.26	1.4	0.00	0.00

**LAT at Mooloolaba is 0.99 m below AHD*

Table 4.3b: Wave frequency (per cent recurrence) table July 2006 to April 2008 – Mooloolaba wave buoy

	Directional Bin (deg)								
Hsig Bin (m)	**0**	**22.5**	**45**	**67.5**	**90**	**112.5**	**135**	**157.5**	**Total %**
0.5	0.00	0.04	0.12	0.04	0.73	0.31	0.08	0.00	1.33
1.0	0.19	2.14	1.54	5.75	12.25	10.47	0.17	0.03	32.54
1.5	0.12	1.16	1.44	14.66	13.53	7.91	0.42	0.02	39.26
2.0	0.00	0.04	0.13	6.63	7.34	4.55	0.41	0.01	19.11
2.5	0.00	0.00	0.01	1.66	1.73	1.11	0.22	0.02	4.75
3.0	0.00	0.00	0.00	0.65	0.65	0.23	0.02	0.00	1.55
> 3.0	0.00	0.00	0.00	0.33	0.91	0.20	0.00	0.00	1.45
Total %	0.31	3.39	3.25	29.73	37.14	24.78	1.33	0.08	100.00

Figure 4.3a: Recorded significant wave height and direction July 2006 to April 2008 – Mooloolaba wave buoy

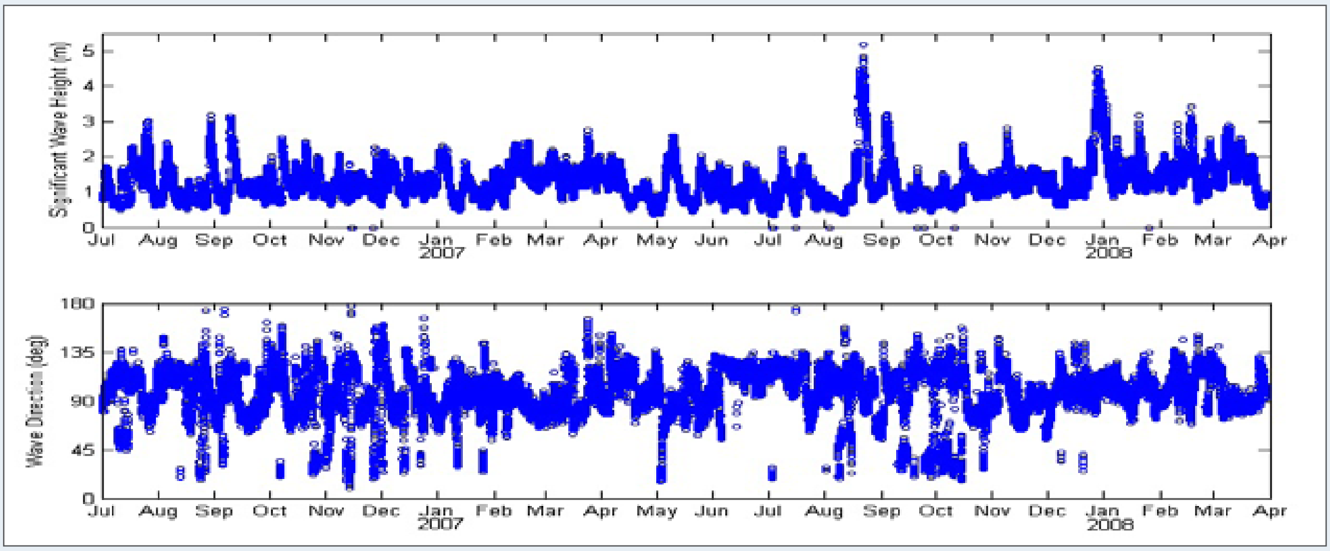
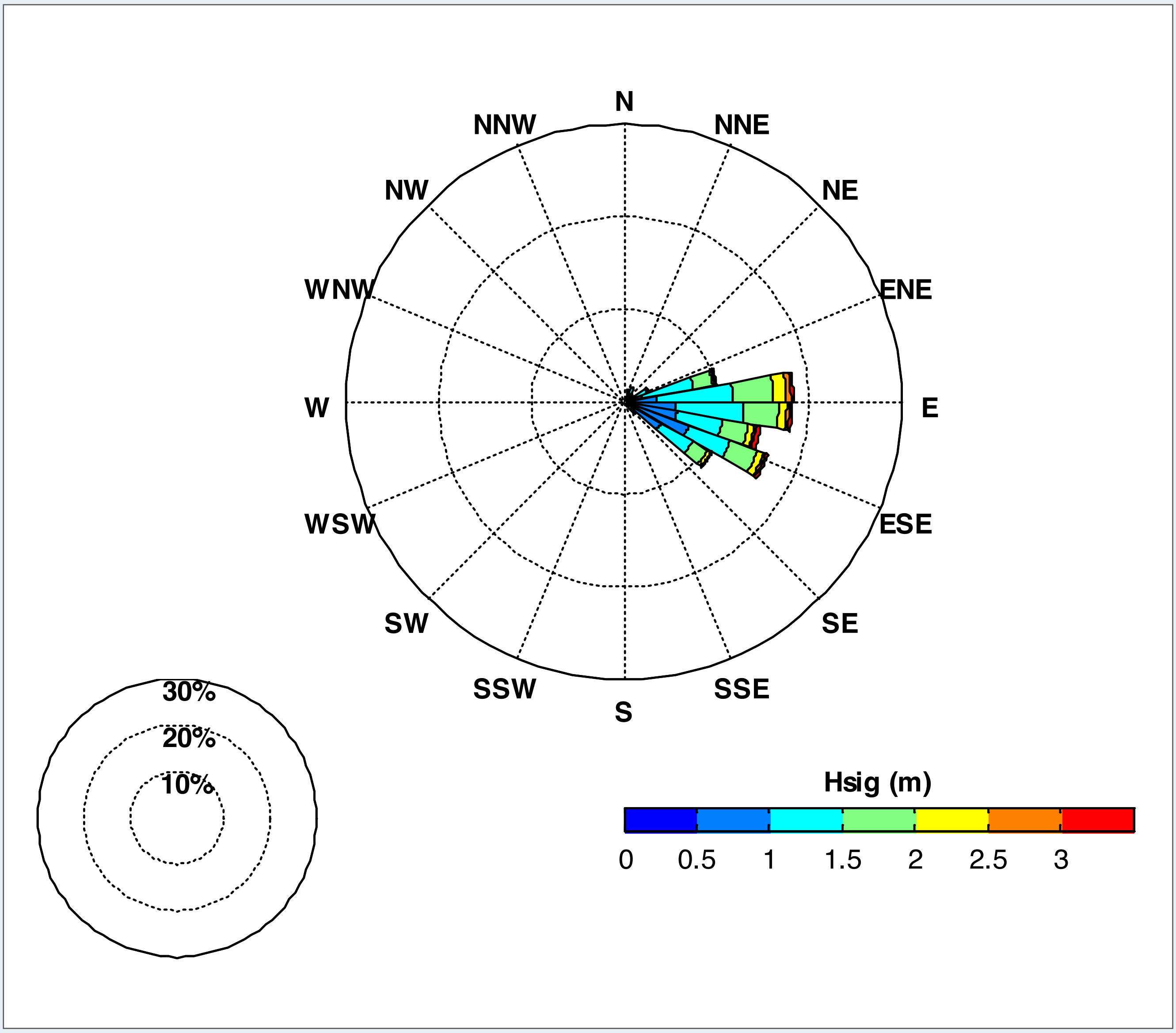


Figure 4.3b: Mooloolaba buoy wave rose – recorded data July 2006 to April 2008



event and the associated shoreline erosion are discussed in **Section 4.3.6.2**.

- Both longer period (8 to 15 seconds) swell and shorter period (5 to 7 seconds) sea waves are common along the open coast and at times may co-exist, sometimes with differing directions.
- The offshore swell waves are predominantly from the east-north-east to south-east directions. The east-north-east sector waves are seasonal, predominantly during spring through summer and are typically generated by local winds. These waves are typically of lower height and shorter period than the prevailing south-east sector swell waves.
- The exception is when an east coast low or tropical cyclone system develops in the Coral Sea and produces high-energy, north-easterly conditions.

A long term wave climate model for the study area calculated using hindcasting techniques is presented and described in **Section 4.3.7.1**.

4.3.4 Extreme waves

Hardy et al. (2004) presented offshore design wave heights for the Sunshine Coast as part of a long term storm tide risk assessment. Design significant wave heights and periods at the 100 and 500 year Annual Recurrence Interval (ARI) were reported for offshore locations adjacent to the study area (Maroochydore Beach and Coolum) and are summarised in **Table 4.3c**.

4.3.5 Storm tide

The Sunshine Coast is within a region where large scale storm systems capable of generating a storm surge occur. The storm surge develops primarily due to low atmospheric pressure and wind stresses acting on the sea surface. The observed water level is a combination of the surge and tide and is referred to as the 'storm tide'. For exposed coastal locations, wave setup and wave runup processes also contribute to the observed water levels.

Significant historical storm surge events at the Sunshine Coast have been associated with tropical cyclone (TC) activity and have typically occurred between December and March, including:

- Unnamed tropical cyclone event (1953/54 season)
- TC Dinah (1966/67 season)
- TC Daisy (1971/72 season).

Historical water level recordings at Mooloolaba during TC Dinah indicate a maximum surge of approximately 0.6 m. Anecdotal evidence suggests TC Dinah generated significant storm tide levels at other Sunshine Coast locations with reports of cane farm inundation at Bli Bli and knee deep water levels in Hastings St at Noosa (Bureau of Meteorology, 2013).

The results of a tropical cyclone generated storm tide risk assessment for the Sunshine Coast have been previously reported by Hardy et al. (2004). The estimated storm tide water levels for the 100, 500 and 1,000 year ARI event at Coolum and Maroochydore (adjacent locations to the study area) are summarised in **Table 4.3d**.

Highest Astronomical Tide (HAT) at Maroochydore and Coolum is predicted to be 1.18 m AHD (Maritime Safety Queensland, 2012). The design water levels in **Table 4.3d** can be considered relative to HAT and are summarised in **Table 4.3e**.

Table 4.3c: Design offshore wave height estimates (from Hardy et al., 2004)

		100 year ARI		**500 year ARI**	
Location	**Depth (m)**	**H_s (m)**	**T_p (s)**	**H_s (m)**	**T_p (s)**
Maroochydore	32	9.22	11 -19	12.98	14 -19
Coolum	34	9.64	12 - 19	13.67	14-19

Table 4.3d: Design storm tide estimates including wave setup (from Hardy et al., 2004)

		Water Level (mAHD)	
Location	**100 year ARI**	**500 year ARI**	**1000 year ARI**
Maroochydore	2.50	2.86	2.98
Coolum Beach	2.44	2.76	2.88

Table 4.3e: Design storm tide estimates including wave setup relative to HAT

		Water Level above HAT (m)	
Location	**100 year ARI**	**500 year ARI**	**1000 year ARI**
Maroochydore	1.32	1.68	1.80
Coolum Beach	1.26	1.58	1.70

4.3.6 Shoreline processes

The study area shoreline (Marcoola Beach) is morphologically dynamic and fluctuations in shoreline position are the result of the prevailing physical forcing.

Waves have four key effects on sand transport, namely:

- Waves break and generate so-called radiation stresses which drive the longshore current within surf zone
- The wave orbital motion impacts on the seabed causing bed shear stresses that mobilise and put into suspension the seabed sand
- Wave asymmetry in shallower water causes a significant differential in the forcing on the bed sediments, stronger towards the shoreline in the forward direction of wave travel leading to an onshore mass transport of sand
- Waves cause a bottom return current in the surf zone, strongest during storms when they typically dominate over the mass transport and move sand offshore.

Currents provide the primary mechanism for the transport of the sand that has been mobilised and put into suspension by the wave/current action. The currents also impose a bed shear stress that may mobilise the seabed sand. The total bed shear stress results from a complex, non-linear interaction between waves and currents. Along the extended beach section between Mudjimba to Point Arkwright the longshore current generated by waves breaking at an angle to the shoreline will be the dominant sediment transport mechanism.

Sand transport on open coasts can be described as a complex interaction between cross-shore and longshore processes. Cross-shore sand transport involves:

- Erosion of sand from the upper beach ridge area during large storm wave events, with the sand being taken offshore where it is commonly deposited as a sand bar located in the vicinity of the wave break area
- Subsequent slow transport of the eroded sand back to the beach, often over many months or several years.

On dynamically stable beaches, there is a balance in the amount of sand that is taken offshore and is subsequently returned to the beach and dune.

Longshore sand transport results predominantly from waves breaking at an angle to the shore with an alongshore component of their radiation stress that drives longshore currents. The wind and tide may also contribute to the generation of currents near the beach. The longshore sand transport is distributed across the surf zone and typically peaks near the wave break point where the wave height, longshore current and bed shear are greatest.

Beach compartments will remain stable in the long term (without net recession or accretion) where there is a balance between the sand entering the system and the sand leaving the system. Recession of a sandy beach is the result of a long term and continuing net loss of sand from the beach compartment. According to the sediment budget concept, this occurs when more sand is leaving than entering the beach compartment.

Recession tends to occur when:

- Outgoing longshore transport from a beach compartment is greater than the incoming longshore transport
- There are sediment sinks within the system or sand is removed from the active beach system
- There is a landward loss of sediment by windborne transport.

A beach may remain stable (without net recession or accretion) where the longshore sand transport is uniform along the coast. However, where there are differentials in the rates of longshore transport, including any interruption of the sand supply to an area, the beach will erode or accrete in response. Because longshore and cross-shore transport coexist, progressive net sand losses due to a longshore transport differential may not manifest as erosion of the upper beach until storm erosion occurs, and less sand is subsequently returned to the beach/dune than was previously there.

4.3.6.1 Shoreline position – historical data

Mudjimba Island modifies the height and direction of swell approaching the shore from all prevailing directions (south - south-east to north - north-east) and has had a significant effect on the evolution of the coastline between Mudjimba and Point Arkwright. The longshore transport patterns adapt to the modified prevailing wave climate and, over time, have created the tombolo at Mudjimba that extends approximately five kilometres alongshore.

Development along shoreline relevant to the Project is generally landward of the active beach system and therefore the beach is able to naturally respond to erosion events. While significant short term fluctuations in the shoreline position are observed in historical beach profile data and aerial photography, the beach appears relatively stable over the long term.

Analysis of historical aerial photography between 1940 and 1994 (WBM, 1996) identified a relatively stable shoreline over the medium-long term with a slight trend of shoreline retreat (conservatively estimated at 0.2 m per year). More recent aerial photography (post 1994) also suggests a dynamically stable shoreline between Mudjimba and Point Arkwright.

A detailed analysis of existing Beach Protection Authority (BPA) beach profile data (commonly referred to as "ETA profiles") to determine changes in the beach system between the Maroochy River mouth and Coolum was previously undertaken by WBM (1996). The profiles deemed most suitable for analysis extended from the dune to deep water (approximately 20 m depth) and spanned a period close to 20 years (April 1974 to August 1993).

The volumetric change between 1974 and 1993 was calculated at each profile location and from the analysis it was concluded there was a net annual loss of sand from the beach system of about 1.6-3.2 m^3/m, corresponding to minor shoreline retreat of 0.1-0.2 m/year. This finding suggests that the upper limit of shoreline retreat in the intervening years since completion of the analysis is approximately 4 m.

Since completion of the analysis undertaken by WBM (1996) significant change has occurred at the Maroochy River entrance located to the south of the study area. In 1999, continued erosive pressure resulted in a breakthrough of the entrance to the south of Pincushion Island. The entrance has remained at this location and during the intervening period the beach to the north of the river entrance has accreted significantly. Pincushion Island is presently connected to the mainland via the north shore.

A digital elevation model (DEM) created from a 2011 bathymetric survey of the study area (Queensland Government, 2012) allows the changes to the shoreline since the WBM (1996) study to be assessed. Cross sectional profiles have been extracted from the DEM that correspond to the profiles established by the BPA (note that the BPA surveys were not continued beyond 1993). The profile locations are indicated in **Figure 4.3c**. Profiles from 1974, 1993 and 2012 are compared in **Figure 4.3d** through **Figure 4.3l** and indicate the following trends:

- The 1974 profiles were surveyed following TC Dinah (1966/67) and TC Daisy (1971/72) which caused significant erosion along the South East Queensland coast. During such events material is typically eroded from the upper beach and transported seaward. A large offshore sandbar can be clearly identified in the 1974 profiles north of Mudjimba Island (ETA546 to ETA562) between depths of 5-15 m below AHD. A general trend of onshore sandbar migration and a slight steepening of the offshore profile are evident throughout the study area in the subsequent 1993 and 2011 profiles.
- Upper beach accretion is evident at the two southern most survey profile locations considered (ETA540 and ETA542). The 2011 profile suggests significant profile change to an offshore depth of approximately 12 m below AHD. This change is associated with onshore sandbar migration. A sandbar crest at approximately 2 m below AHD is apparent in the 2011 profile.
- The upper beach profile to the immediate south of Mudjimba Island (ETA544) appears relatively stable however offshore from 2 m below AHD the profile has steepened slightly between 1993 and 2011. A reef with crest at 10 m below AHD is located approximately 1,300 m offshore (chainage 3,700m) and is part of the rocky feature that forms Mudjimba Island. The relatively minor change at this location is expected to be due to the control provided by Mudjimba Island.
- Profile ETA546 (approximately inline with the southern extent of the existing airport runway) shows upper beach accretion between 1974 and 1993. An offshore bar with crest at approximately 2 m below AHD is evident in the 2011 profile. The onshore bar migration has caused a steepening of the offshore profile offshore to a depth of 10 m below AHD. A reef with crest at 12 m below AHD is located approximately 1,650 m offshore (chainage 3700 m) and is also part of the rocky feature that forms Mudjimba Island.
- The 1974 profiles ETA548, ETA550, ETA554 and ETA 558 show a pronounced offshore sand deposit between depths of 5-15 m below AHD. This sand deposit can be seen moving onshore in the 1993 and 2011 profiles suggesting a general accretive trend. The 2011 profiles show a sandbar crest at approximately 2 m below AHD.
- The northern most location (ETA562) also shows onshore sandbar migration between the1993 and 2011 profiles. The reef extending from the Point Arkwright rocky headland is present in the offshore area.

Figure 4.3c: Beach protection authority ETA profile locations

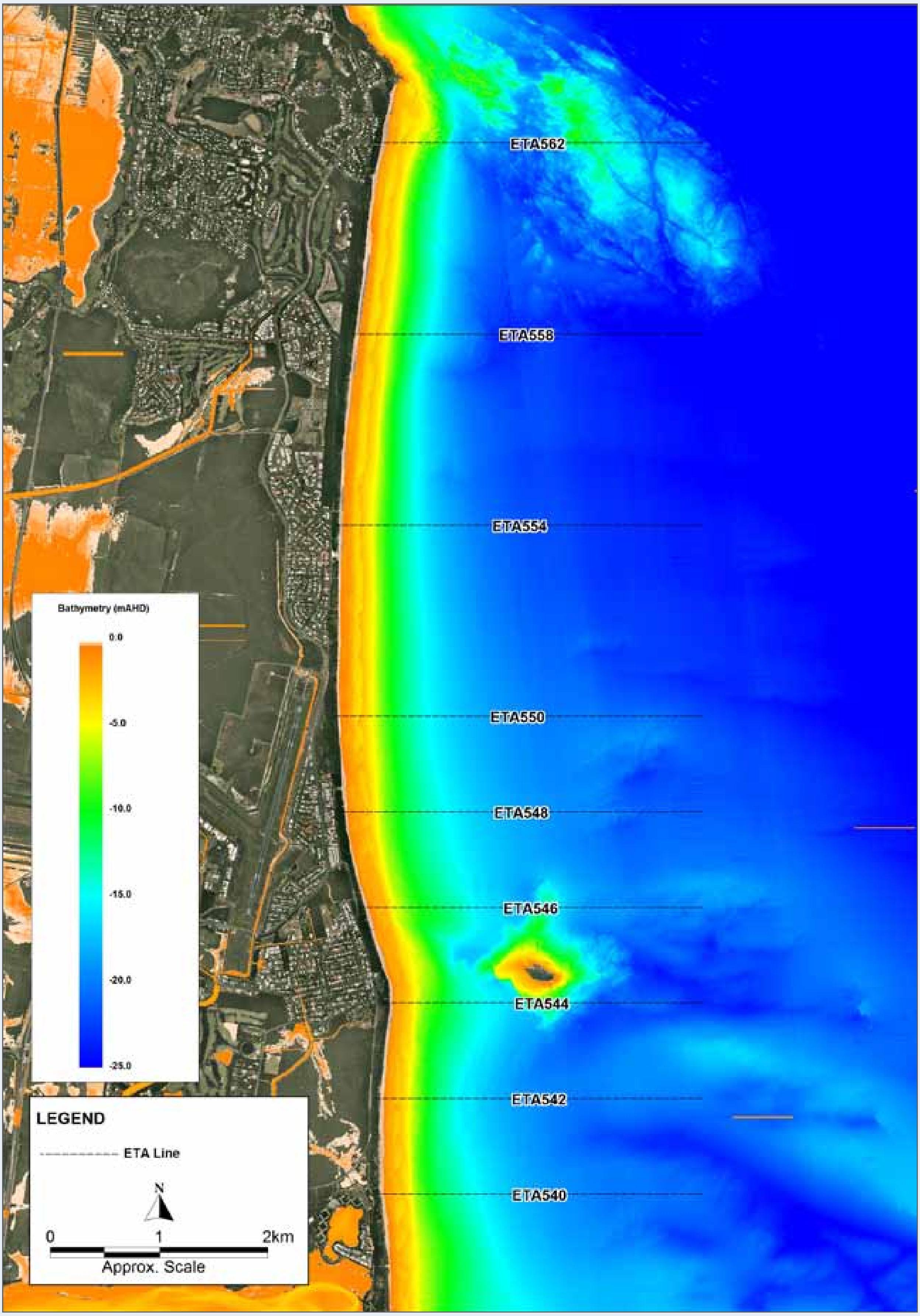


Figure 4.3d: ETA540 beach and offshore profiles

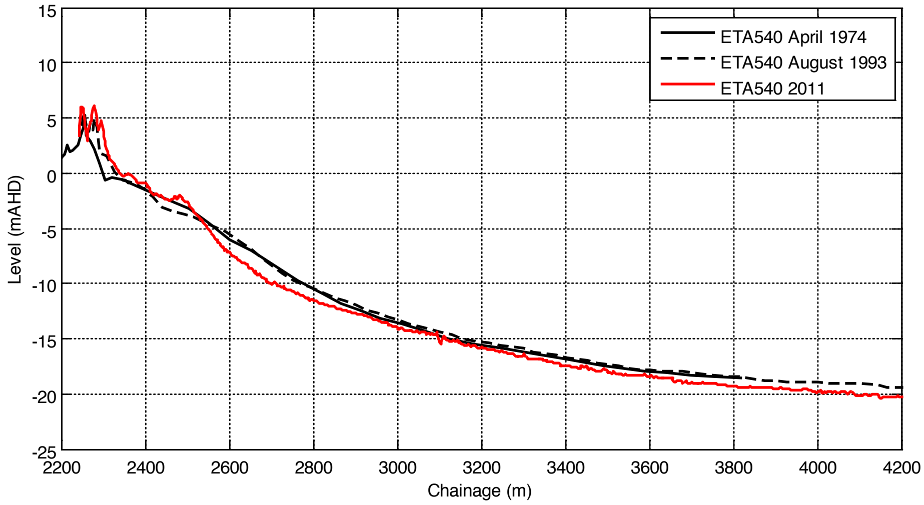


Figure 4.3e: ETA542 beach and offshore profiles

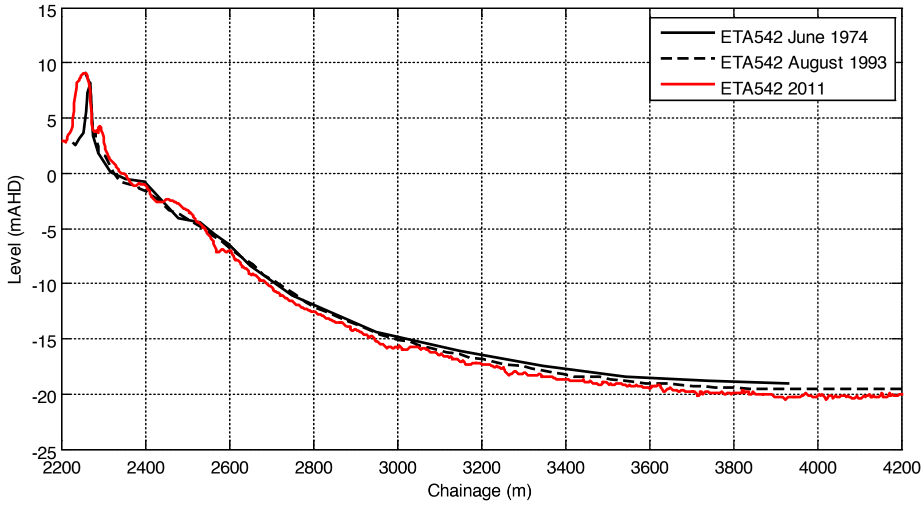


Figure 4.3f: ETA544 beach and offshore profiles

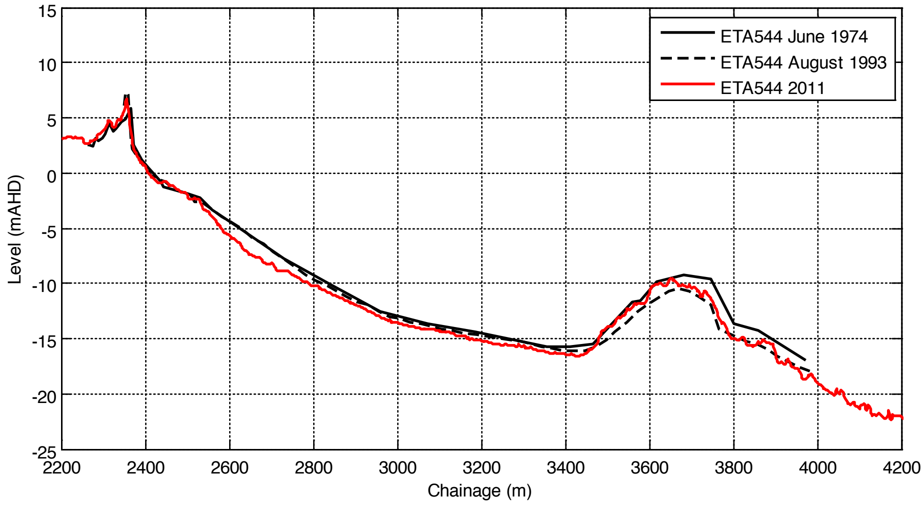


Figure 4.3g: ETA546 beach and offshore profiles

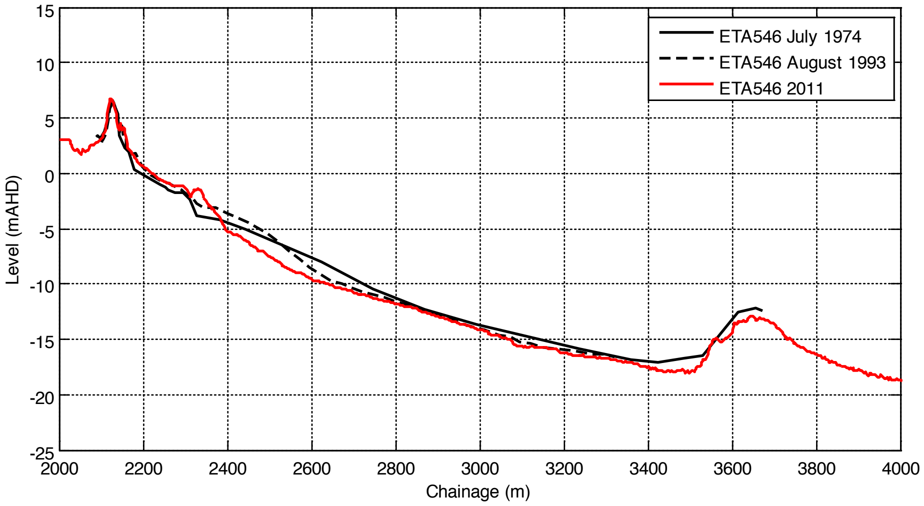


Figure 4.3h: ETA548 beach and offshore profiles

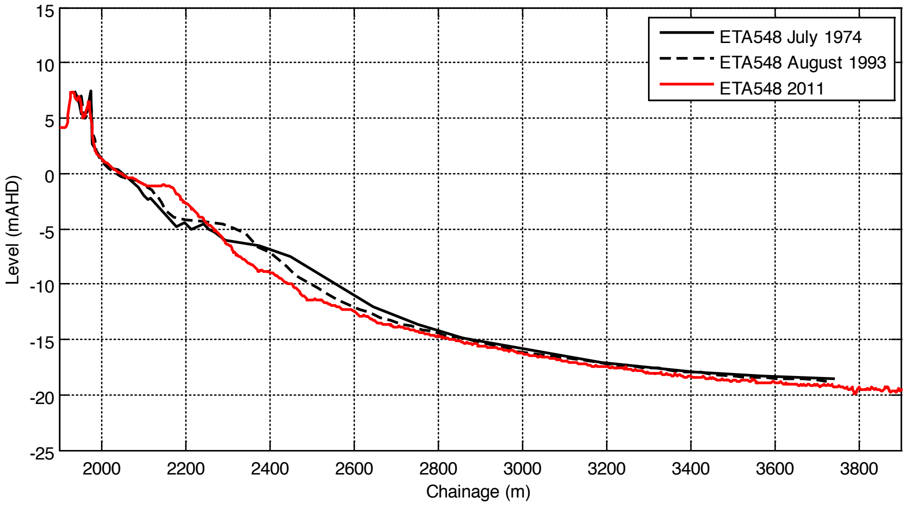


Figure 4.3i: ETA550 beach and offshore profiles

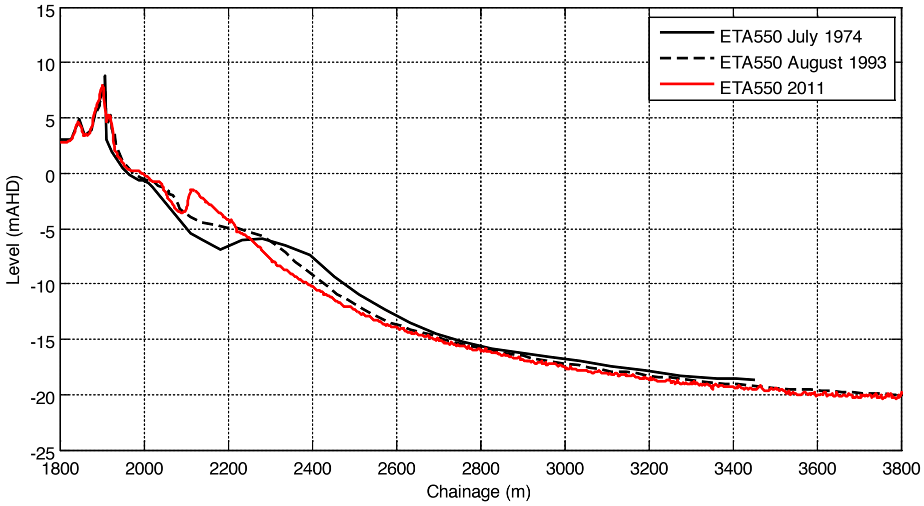


Figure 4.3j: ETA554 beach and offshore profiles

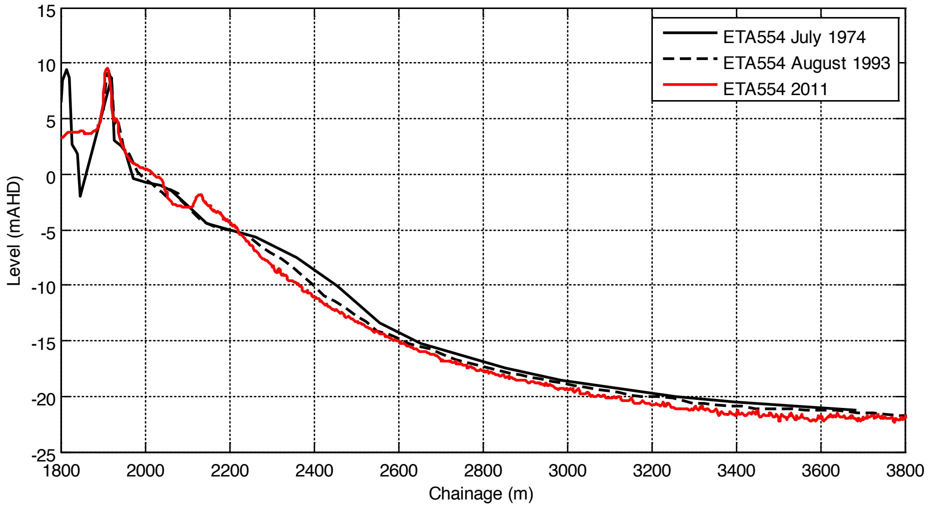


Figure 4.3k: ETA558 beach and offshore profiles

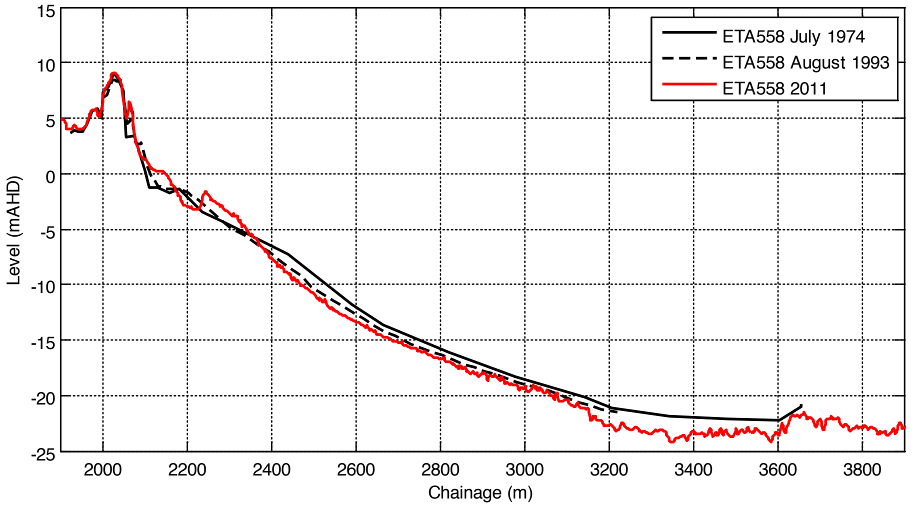
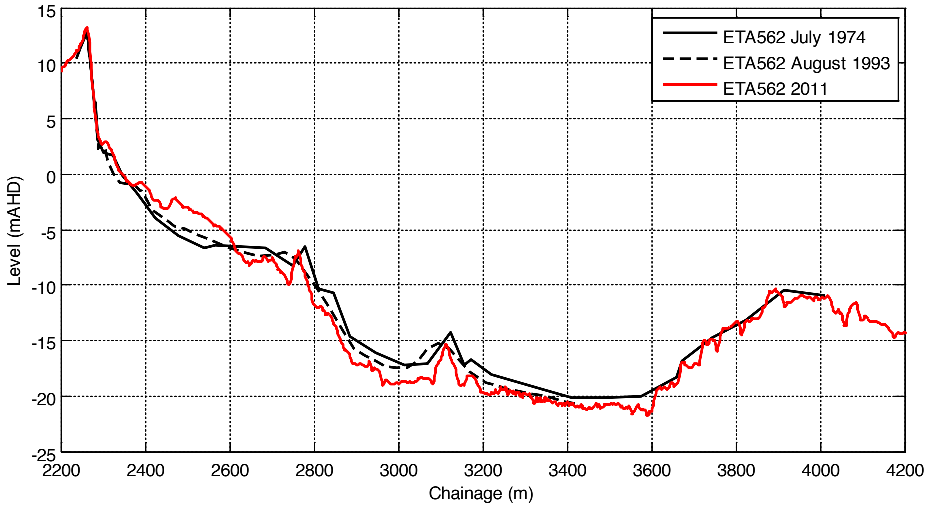


Figure 4.3l: ETA562 beach and offshore profiles



4.3.6.2 Recently observed erosion (ex-Tropical Cyclone Oswald)

A trend of erosion has been recently observed at many Sunshine Coast beaches since the 2011 bathymetric survey. The erosion trend has not been quantified however site inspections of the coastline following ex-TC Oswald (January 2013) confirmed significant erosion throughout the study area. A scarp approximately 3 m high and exposed coffee rock is visible in **Figure 4.3m** and **Figure 4.3n**. It is expected that the material eroded from the upper beach and dune system has been deposited offshore and will gradually move onshore if, on average, conditions that promote accretion (i.e. low wave energy) occur in the following years.

Water level and wave data recordings during ex-TC Oswald are presented in **Figure 4.3o** and **Figure 4.3p**. The water level data at Mooloolaba suggest a residual tide (storm surge) peak close to 0.5 m and a recorded water level (storm tide) close to Highest Astronomical Tide (HAT) occurred. This water level is approximately 1.25 m lower than the 100 year ARI water level report by Hardy et al. (2004) suggesting the study area is vulnerable to significantly higher extreme water levels than that experienced during ex-TC Oswald.

A maximum wave height (H_{max}) of 10.5 m was recorded by the Mooloolaba buoy during ex-TC Oswald. This is the largest wave measured since the 2005 directional wave buoy installation. The recorded significant wave height conditions with a peak of approximately 5.5 m are significantly smaller than the 100 year ARI wave conditions (Hsig ≈ 9.5 m) estimated by Hardy et al. (2004). It is notable that the peak wave conditions occurred from the east to north-easterly directional sector which the study area (and most other Sunshine Coast beaches) is particularly exposed to. Significant historical coastal erosion events along the Sunshine Coast are expected to be associated with waves from this sector.

Simple storm erosion estimates suggest the storm tide and wave conditions associated with ex-TC Oswald are likely to have removed 50,000 – 100,000 m^3 of sand from the upper beach and dune system at Marcoola. As discussed above, this material is not lost from the sediment budget but simply relocated to the nearshore area and is expected to migrate onshore under prevailing, low energy conditions. Nevertheless, the shoreline remains vulnerable to a subsequent extreme event and further setback while in an eroded state.

Figure 4.3m: Study area beach erosion following ex-TC Oswald looking north from ETA550 (photo taken 08/02/2013)

Figure 4.3n: Study area beach erosion following ex-TC Oswald looking south from ETA550 (photo taken 08/02/2013)

Figure 4.3o: Recorded, predicted and residual tide at Mooloolaba storm tide gauge during ex-TC Oswald (data provided by DSITIA)

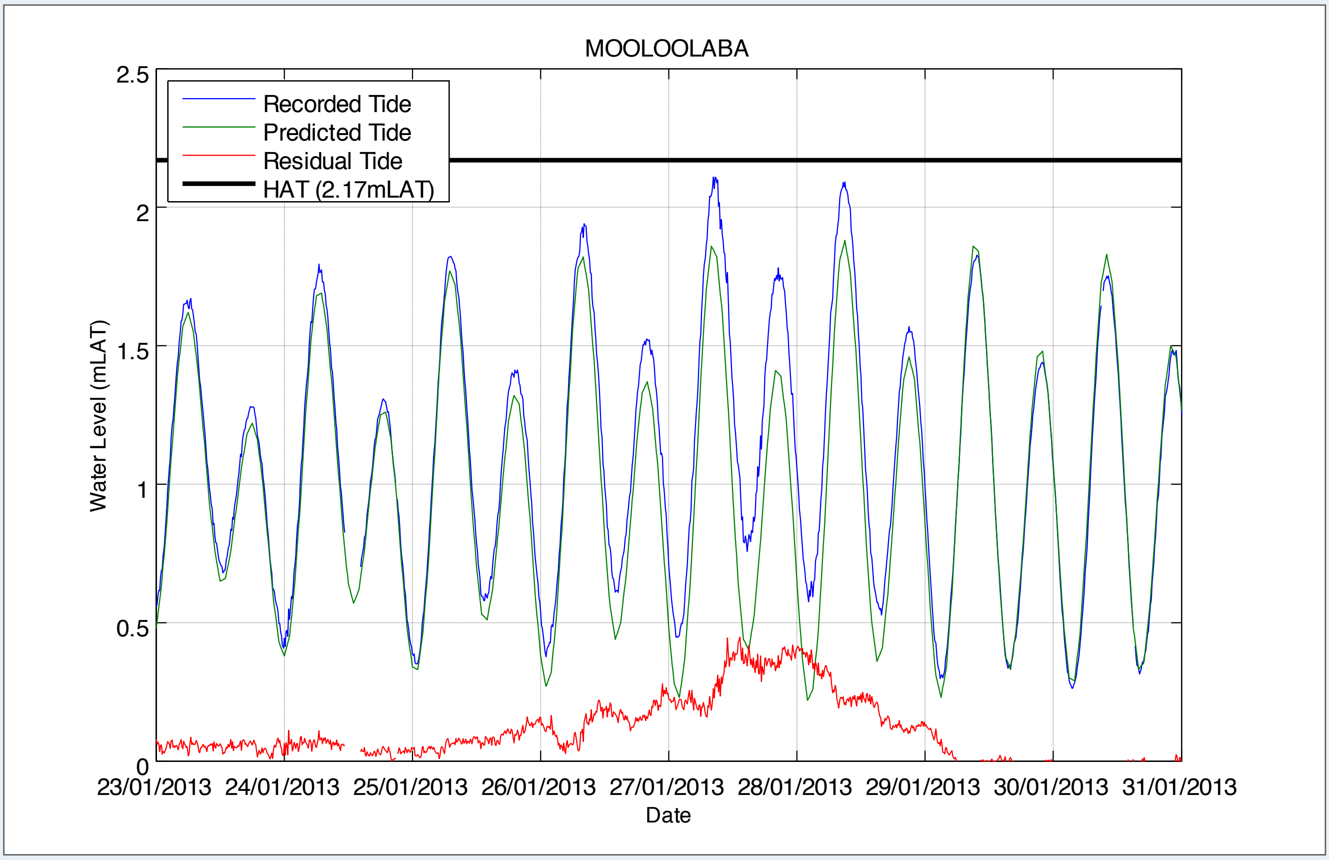
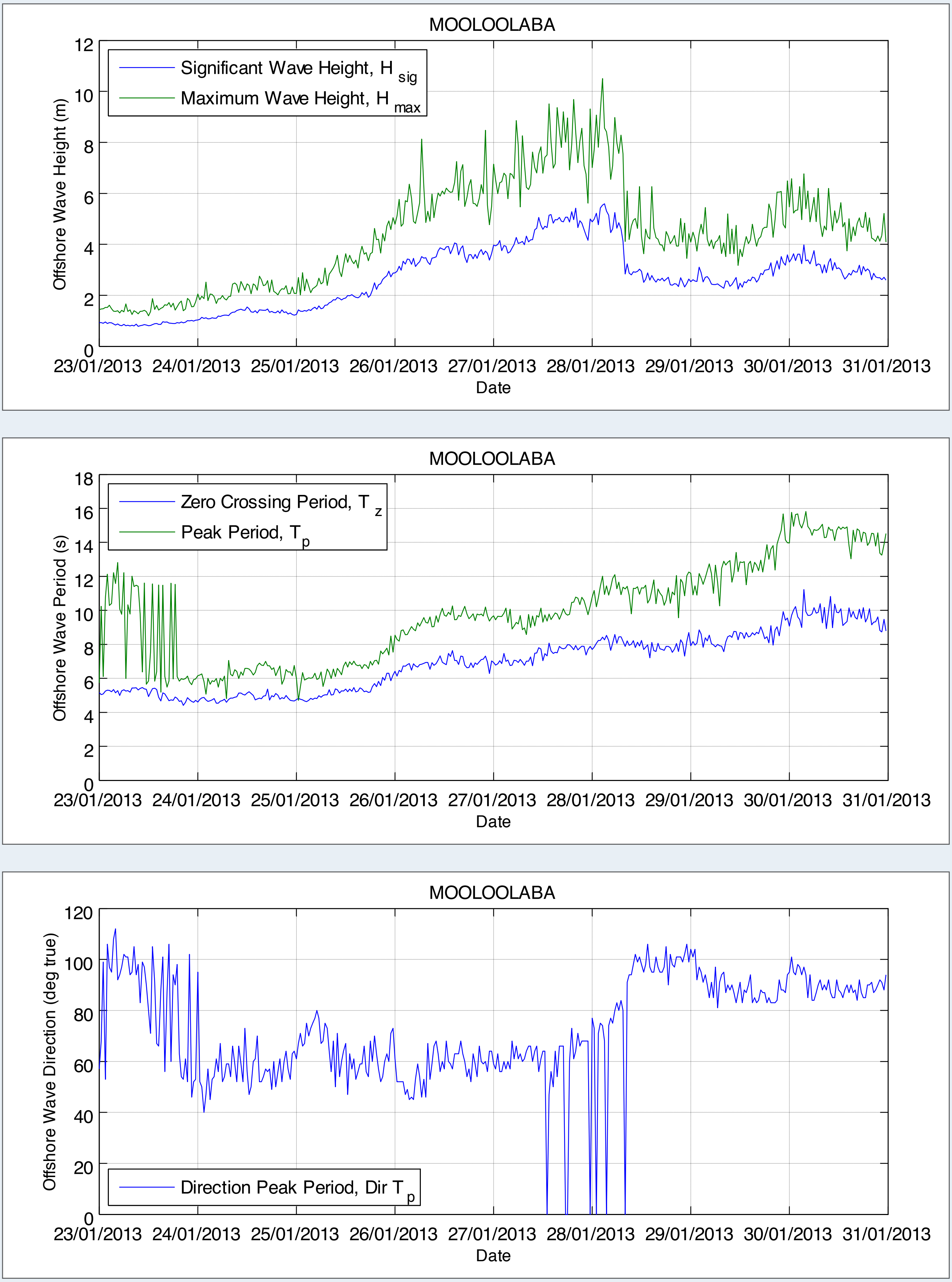


Figure 4.3p: Recorded wave conditions offshore from the study area during ex-TC Oswald (data provided by DSITIA)



4.3.7 Baseline modelling

Baseline numerical modelling has been undertaken to aid the understanding of the existing coastal processes relevant to the study area and to help develop a basis to assess potential impacts of the Project.

Central to the baseline modelling exercises is a system of nested SWAN wave models used to transform offshore wave conditions to the nearshore area. Development and validation of the wave modelling system is provided in **Section 4.3.7.1** with the prevailing and design nearshore wave climates described in **Section 4.3.8** and **Section 4.3.9**.

Outputs from the wave modelling assessments form the key inputs for estimates of longshore sediment transport rates (**Section 4.3.10**) and design storm erosion potential (**Section 4.3.11**). Results of the baseline modelling exercises are considered in assessing the potential impacts of the Project described in **Section 4.5**.

4.3.7.1 Modelling system development and validation

The nearshore wave conditions were predicted using SWAN models of the study area. SWAN is a third generation spectral wave model that estimates wave parameters in coastal regions from given wind, wave and current conditions (Booij et al. 1999). SWAN is developed by Delft University of Technology and is widely used as a coastal engineering tool.

The SWAN input parameters employed in this study are considered to be realistic and are based upon previous experience with similar models. Default values for the whitecapping dissipation coefficient and wave steepness parameter were used for the Komen et al (1984) calculations. The bottom friction formulation of Collins (1972) was implemented with the default coefficient of 0.025. The first order Backward Space Backward Time (BSBT) scheme was used for the numerical propagation scheme. A mid-range refraction coefficient was chosen to achieve an accurate result without spurious oscillations.

A nested grid system was used to maximise wave model efficiency while minimising inaccuracies associated with the model boundary definitions. Following this approach, the finest-scale grid surrounds the nearshore area of interest and its boundary conditions are obtained from the encompassing coarser grid. The nested wave models included:

- Regional scale (500 m grid resolution) offshore model.
- Medium-scale (250 m grid resolution) Sunshine Coast model.
- Local-scale (50 m grid resolution) model representing the nearshore regions from Mudjimba to Point Arkwright.

The nested wave model extents are shown in **Figure 4.3q**.

The primary input to the SWAN model is bathymetric information. Bathymetry data was obtained from two sources (in order of preferred usage):

- Sunshine Coast Bathymetric LiDAR, Queensland Government (2012)
- Australian Bathymetry and Topography 250 m Grid, Geoscience Australia (2009).

SWAN uses offshore wind and/or wave boundary condition input to calculate the nearshore wave conditions within the study area. Both types of boundary condition input have been used for the wave assessment, including:

- Directional wave data recorded at the Brisbane Waverider buoy (operated by DEHP)
- Directional wind data from the BOM Cape Moreton Weather Station.

This approach ensures the dominating combination of sea/swell waves is resolved and later applied in the longshore sediment transport calculations.

<u>Wave Model Validation</u>

Two sets of nested wave models have been developed to calculate the wave climate within the study area:

A “swell state” model that uses recorded wave data from the Brisbane Waverider buoy as an input boundary condition. SWAN refracts the input waves to calculate the nearshore wave conditions within the study area.

A “sea state” model that uses the recorded wind data from Cape Moreton as a boundary condition. SWAN calculates the resulting wave height given the wind speed, direction and fetch length interacting with the model bathymetry.

The two systems of nested models were used to simulate concurrent time periods. From the model results, the dominant wave condition (sea or swell state) at any given nearshore location within the study area was obtained.

Estimates of wave height and direction were validated with recorded data from the Mooloolaba Waverider buoy (operated by DEHP) for a continuous period between July 2006 and April 2008. The wave recording locations are indicated in **Figure 4.3q**. The following wave model output validation is presented:

- A time series of wave height and direction recorded by the Mooloolaba Waverider buoy (**Figure 4.3r**).
- Wave height exceedance curves for Mooloolaba (**Figure 4.3s**).

The recorded wave data is generally well represented by the wave model and the modelling system is considered to be appropriate for baseline and subsequent impact assessments.

Figure 4.3q: Wave model extents and data recording locations

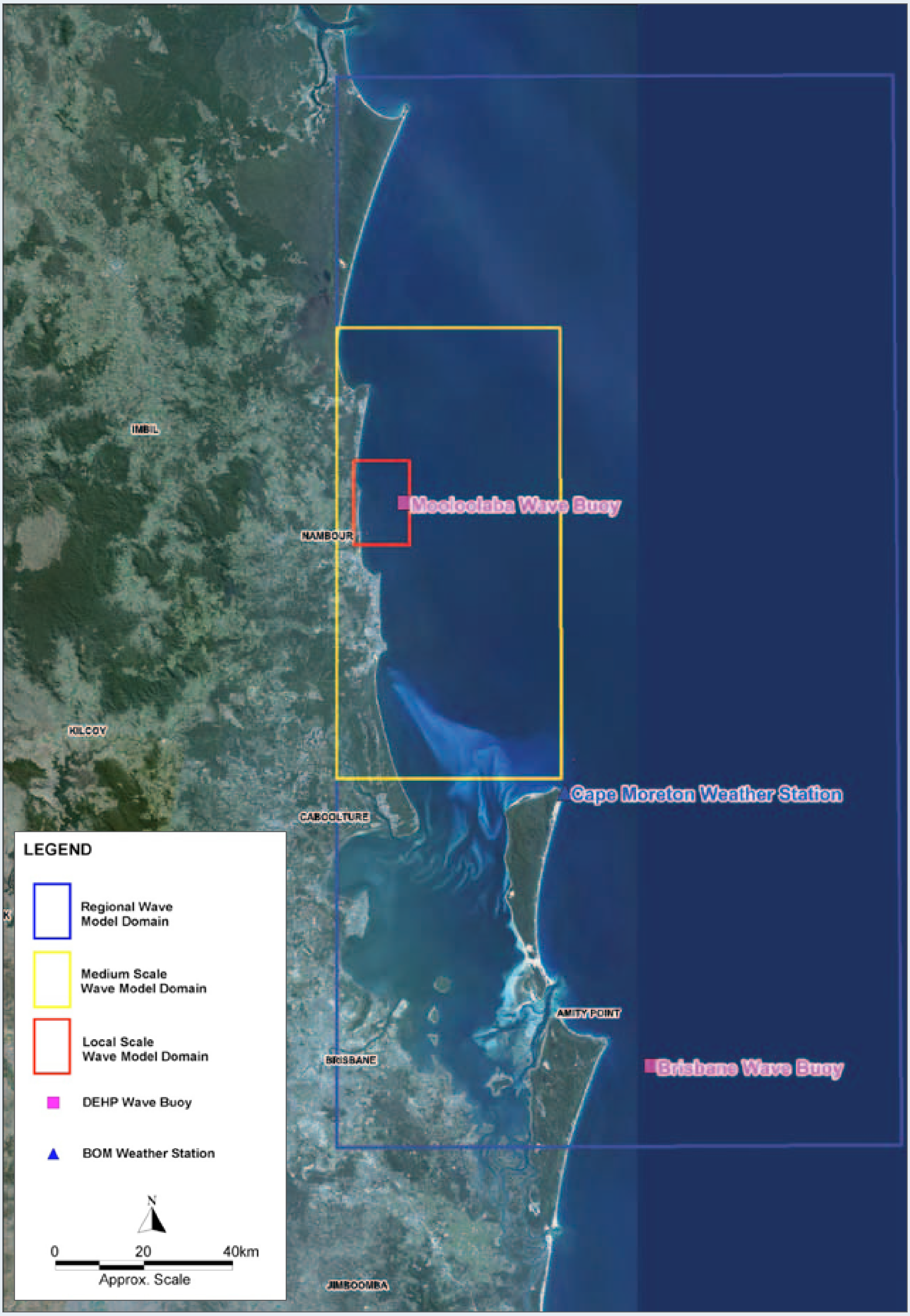


Figure 4.3r: Wave model validation with data recorded by the Mooloolaba wave buoy

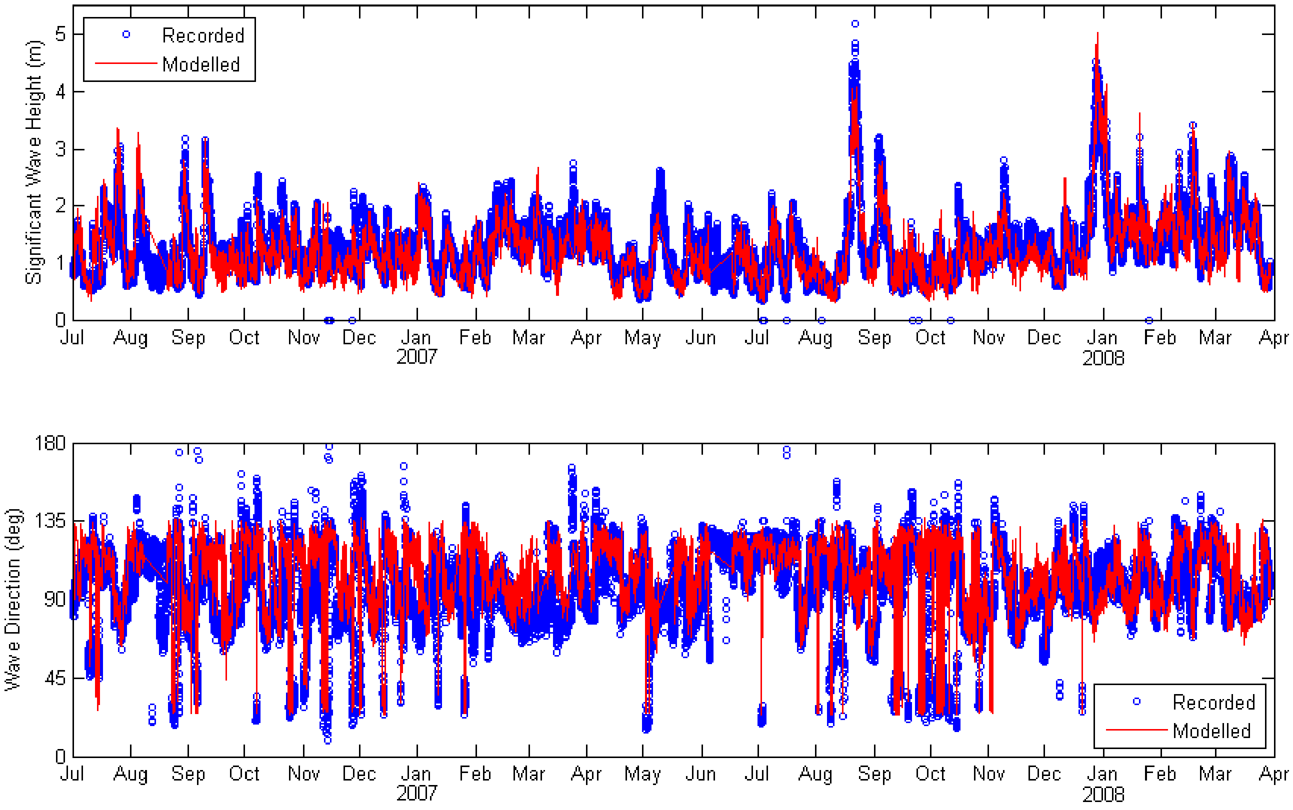
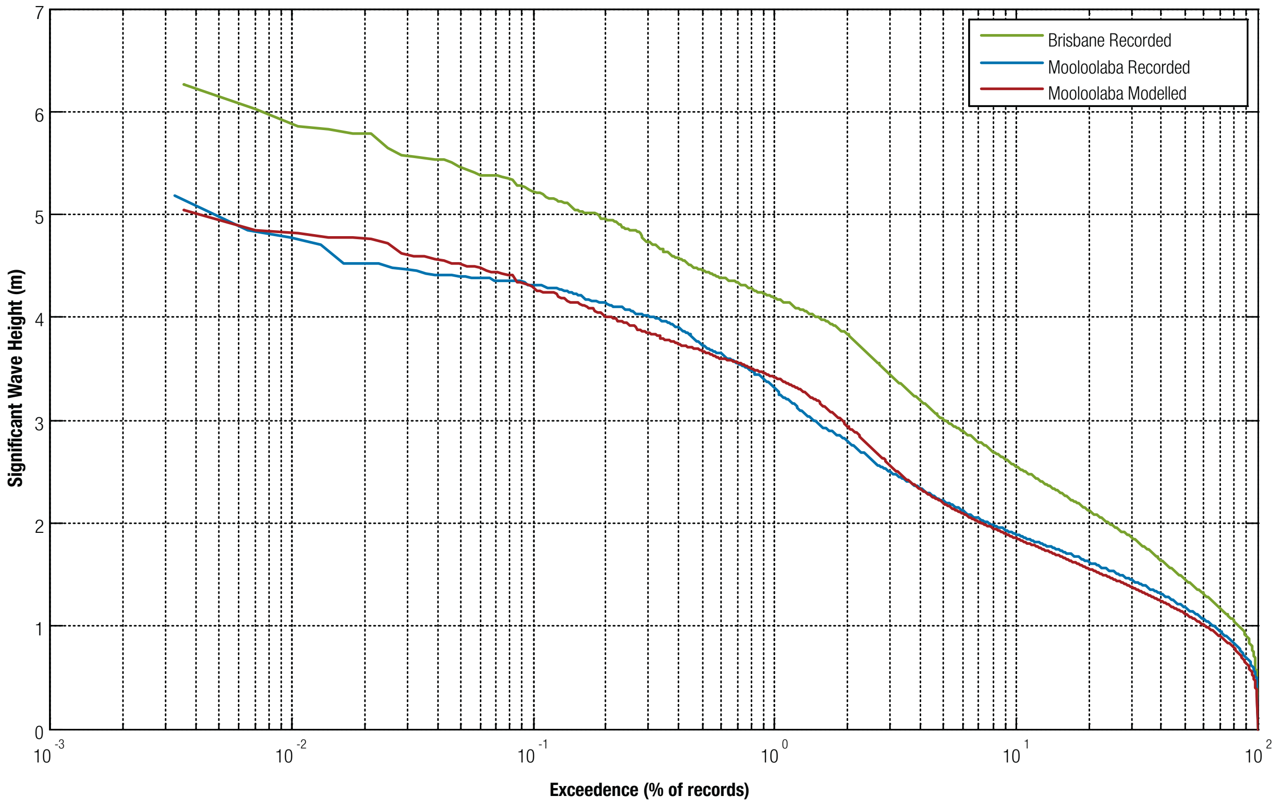


Figure 4.3s: Wave height exceedance model validation at the Mooloolaba buoy



4.3.8 Nearshore wave climate

The study area shoreline is exposed to wave conditions typically originating from the north-east through south-east. At the shoreline adjacent to the study area some nearshore modification of north-easterly waves, with respect to wave height and direction, is associated with Point Arkwright and the adjacent reef offshore. Moreton Island acts as a major coastal feature that shelters the southern Sunshine Coast (Caloundra to Maroochydore) from the prevailing south-easterly swells. This influence progressively decreases for the more northern Sunshine Coast beaches but is still relevant to the study area. More locally, Point Cartwright and Mudjimba Island also influences waves approaching the shore from the south-east.

An average nearshore wave climate has been developed for the study area using the nested wave modelling system described in **Section 4.3.7.1**. Model output has been extracted at three nearshore locations referred to as 250 m, 1,600 m and 3,600 m and indicated in **Figure 4.3t**. The anticipated dredge mooring and pipeline corridor footprint is also shown in **Figure 4.3t**. These temporary structures associated with the Project are not expected to significantly modify the wave climate and their location is simply shown for indicative purposes.

For each output location the nearshore wave climate is presented as a wave rose plot and summarised in a frequency recurrence table. Results of the wave climate modelling are summarised below:

- At the 3,600 m offshore location the prevailing wave climate is dominated by waves from the east to east - south-east with close to 70 per cent of all waves coming from this directional window (**Figure 4.3u** and **Table 4.3f**). For approximately 70 per cent of the time wave heights are between 1-2 m. Wave heights greater than 3 m occur rarely (approximately 1 per cent of the time) and are typically from the east-north-east direction. The larger wave events are typically associated with Coral Sea low pressure systems or tropical cyclones during the summer months.
- **Figure 4.3v** and **Table 4.3g** suggest little wave modification between the 3,600 m and 1,600 m offshore locations. This is due to the relatively deep water and mildly sloping, planar offshore bathymetry between the two locations.
- At the 250 m offshore location (**Figure 4.3w** and **Table 4.3h**) wave refraction causes the wave directional window to narrow and become more closely parallel with the bottom contours and shoreline alignment. The presence of Mudjimba Island and wave diffraction processes also influence the wave climate at the 250 m location. Wave energy dissipation associated with wave breaking causes a reduction in wave height. Nearshore wave heights are estimated to be less than 1.5 m more than 75 per cent of the time.
- The baseline wave modelling suggests the proposed dredge mooring and pipeline corridor is located within the nearshore zone where the significant wave transformation occurs. Pipeline construction and decommissioning operations will be difficult in this zone during energetic wave conditions and the preferred window for such works is likely to be during the winter months when milder wave conditions are expected. While in place, these temporary structures are not expected to significantly alter the nearshore wave climate at Marcoola Beach.

Figure 4.3t: Wave model output locations

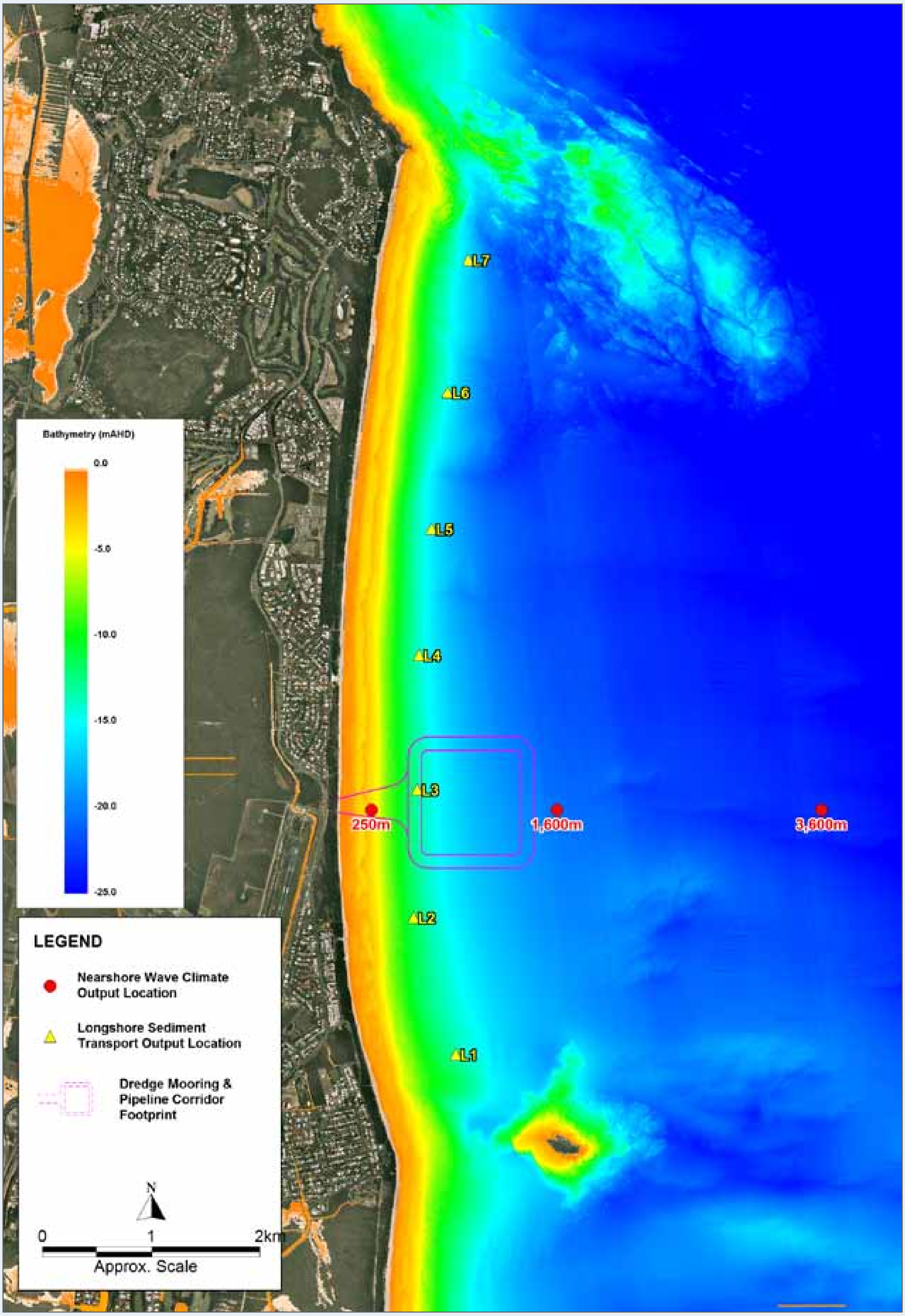


Figure 4.3u: Wave rose for Marcoola Beach 3,600 m offshore

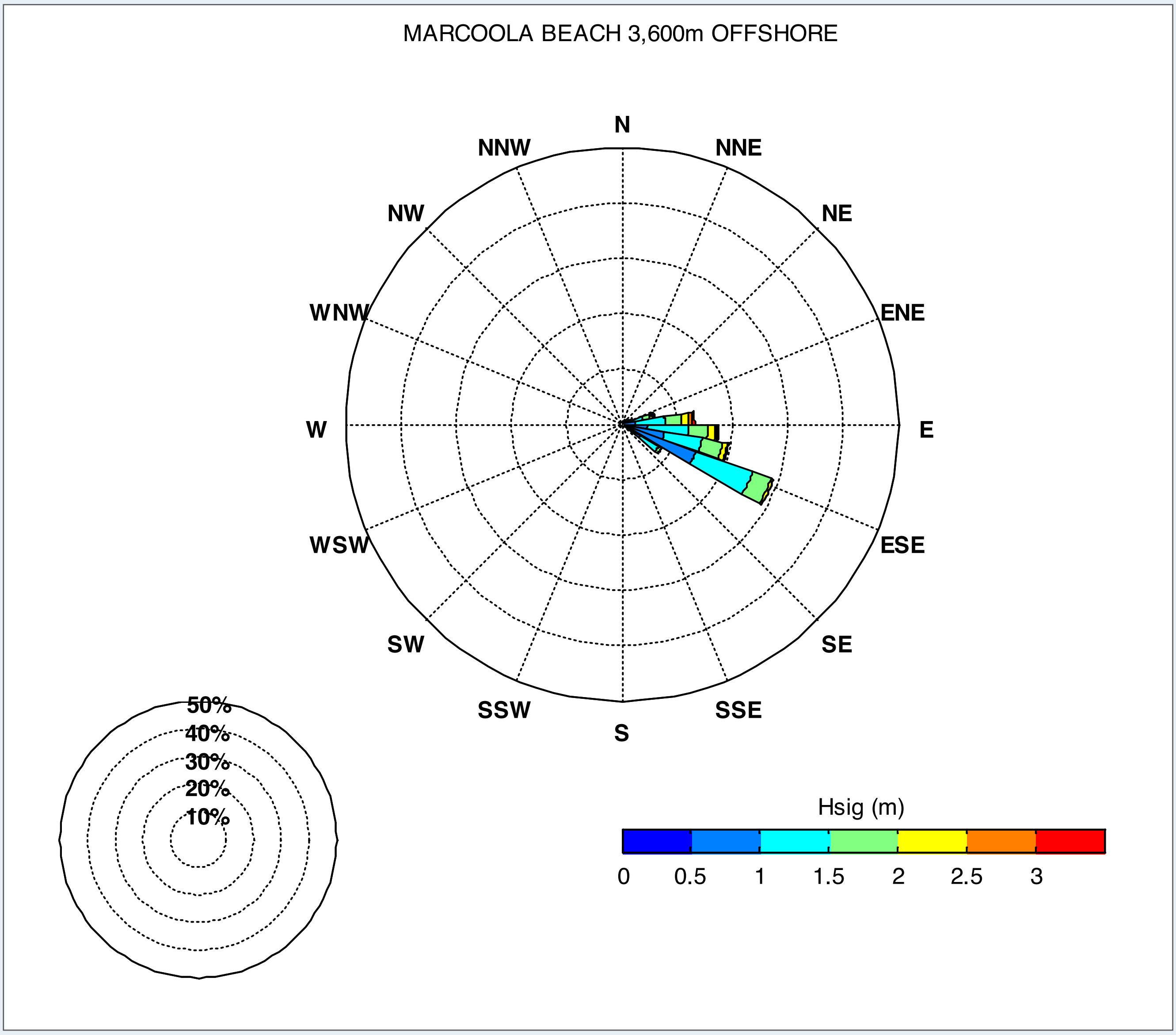


Table 4.3f: Wave frequency (per cent recurrence) table for Marcoola Beach 3,600 m offshore

	Directional Bin (deg)														
Hsig Bin (m)	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**Total %**
0.5	0.54	0.30	0.13	0.09	0.15	0.11	0.04	0.09	0.17	0.20	0.33	0.61	0.22	0.00	2.97
1.0		0.09	0.15	0.20	0.24	0.52	0.87	1.35	2.39	4.34	7.49	13.63	3.71	0.09	35.06
1.5		0.02		0.24	0.43	0.48	0.80	2.52	5.21	7.49	6.90	10.90	3.82	0.07	38.88
2.0				0.02	0.09	0.07	0.20	1.22	3.04	3.54	3.76	3.54	0.63	0.02	16.11
2.5							0.07	0.48	1.32	1.30	0.89	0.46			4.52
3.0								0.17	0.61	0.39	0.26	0.02			1.45
> 3.0							0.02	0.26	0.41	0.26	0.04				1.00
TOTAL %	0.54	0.41	0.28	0.54	0.91	1.17	2.00	6.08	13.16	17.52	19.67	29.16	8.38	0.17	100.00

Figure 4.3v: Wave rose for Marcoola Beach 1,600 m offshore

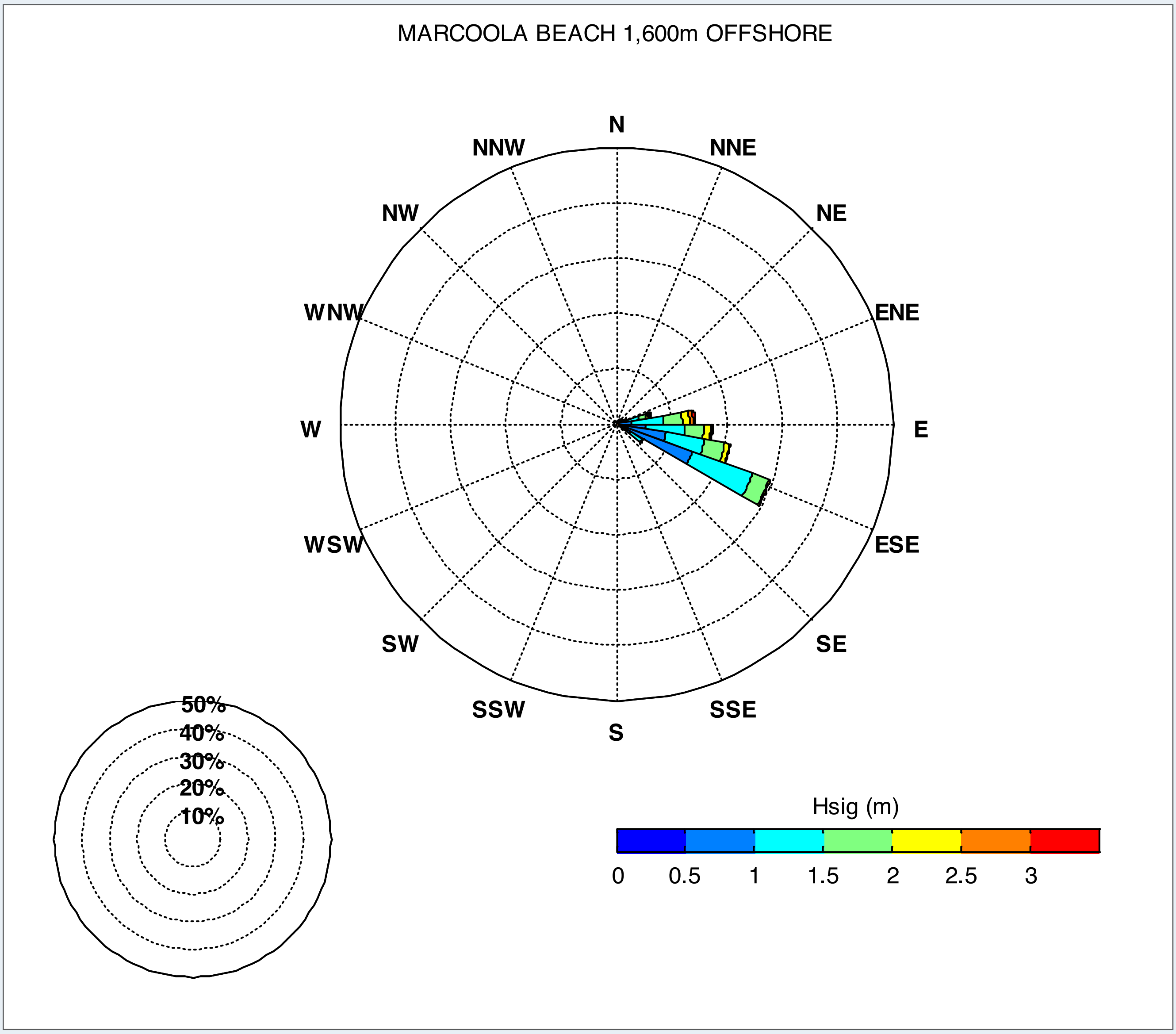


Table 4.3g: Wave frequency (per cent recurrence) table for Marcoola Beach 1,600 m offshore

	Directional Bin (deg)													
Hsig Bin (m)	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**Total %**
0.5	0.56	0.33	0.13	0.09	0.15	0.11	0.09	0.07	0.17	0.20	0.41	0.63	0.15		3.08
1.0		0.04	0.13	0.17	0.30	0.50	0.98	1.43	2.63	4.99	8.73	14.00	2.82	0.04	36.78
1.5				0.09	0.48	0.50	0.63	2.74	5.82	7.23	7.03	11.57	2.48		38.56
2.0					0.07	0.07	0.17	1.24	3.28	3.43	3.71	3.15	0.15		15.26
2.5							0.07	0.46	1.32	1.22	0.93	0.30			4.30
3.0							0.02	0.22	0.61	0.15	0.13				1.13
> 3.0								0.28	0.43	0.17					0.89
TOTAL %	0.56	0.37	0.26	0.35	1.00	1.17	1.95	6.43	14.26	17.39	20.95	29.66	5.60	0.04	100.00

Figure 4.3w: Wave rose for Marcoola Beach 250 m offshore

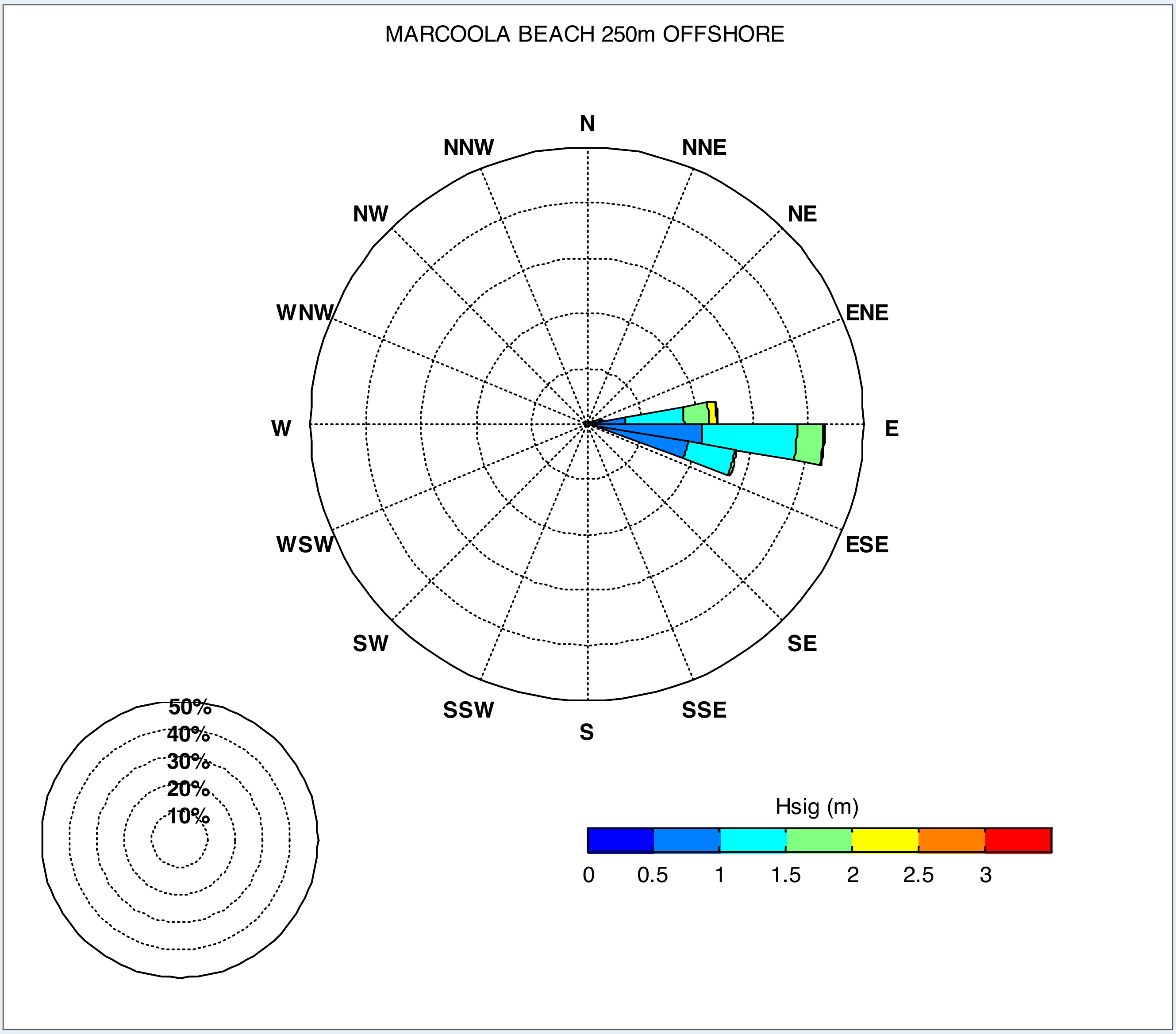


Table 4.3h: Wave frequency (per cent recurrence) table for Marcoola Beach 250 m offshore

Hsig Bin (m)	**Directional Bin (deg)**												
	0	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**Total %**
0.5	0.43	0.35	0.22	0.17	0.09	0.17	0.15	0.15	0.30	1.26	1.35	0.02	4.67
1.0			0.07	0.04		0.02	1.11	2.32	6.67	19.67	17.19	0.09	47.18
1.5							0.09	0.35	10.59	17.06	8.55		36.65
2.0								0.02	4.49	4.78	0.41		9.70
>2.5								0.02	1.54	0.24			1.80
TOTAL %	0.43	0.35	0.28	0.22	0.09	0.20	1.35	2.87	23.60	43.01	27.51	0.11	100.00

4.3.9 Design wave conditions

The design wave conditions for the Brisbane Waverider buoy reported by Allen and Callaghan (2001) have been used to estimate the equivalent nearshore design wave conditions for the study area. The system of nested wave models was used to transfer the design significant wave heights at the Brisbane Waverider buoy to the study area. Extreme wave model output was obtained at a location 3,600 m offshore from Marcoola Beach where the depth is approximately 17 m below AHD (indicated in **Figure 4.3t**).

As a conservative approach, a stationary water level of 1.5 m above AHD was adopted for the design wave assessment. This elevated water level is representative of design surge plus tide conditions previously reported by Hardy et al. (2004).

The result of the design wave assessment is presented in **Table 4.3i**. An offshore design wave height curve for Marcoola Beach and the Brisbane Waverider buoy (Allen and Callaghan, 2001) are provided in **Figure 4.3x**. The results of this assessment are used as input to storm erosion potential estimates provided in **Section 4.3.11**.

Rapidly changing wind fields, such as those associated with tropical cyclones, have not been considered in this wave assessment. In their detailed storm tide study, Hardy et al. (2004) simulated a very large population of synthetic tropical cyclones that represented approximately 3,000 years. For the Sunshine Coast, the average tropical cyclone induced 100 year ARI offshore (35 m depth) wave height is 9.4 m.

4.3.10 Longshore sediment transport rate prediction

Baseline estimates of longshore sediment transport rates are required to understand the potential for shoreline change associated with activities related to the Project. The proposed activity most likely to affect littoral processes is the temporary installation of the sand delivery pipeline. Without appropriate management, the interruption to longshore sand transport due to the presence of the pipeline on the seabed and beach face could potentially lead to undesired shoreline erosion and/or accretion at Marcoola Beach.

The rate of longshore sediment transport between Mudjimba and Point Arkwright was estimated using methods originally described in the Shore Protection Manual (CERC, 1984). The so-called “CERC equation” relates the longshore transport to the wave energy flux at the wave breaker location:

Equation 1

$$Q_l = K(EC_n)_b \sin\alpha_b \cos\alpha_b$$

Where Q_l is the volumetric rate of longshore sediment transport, K is a dimensionless constant[1], $(EC_n)_b$ is the wave energy flux evaluated at the breaker point and α_b is the wave breaker angle.

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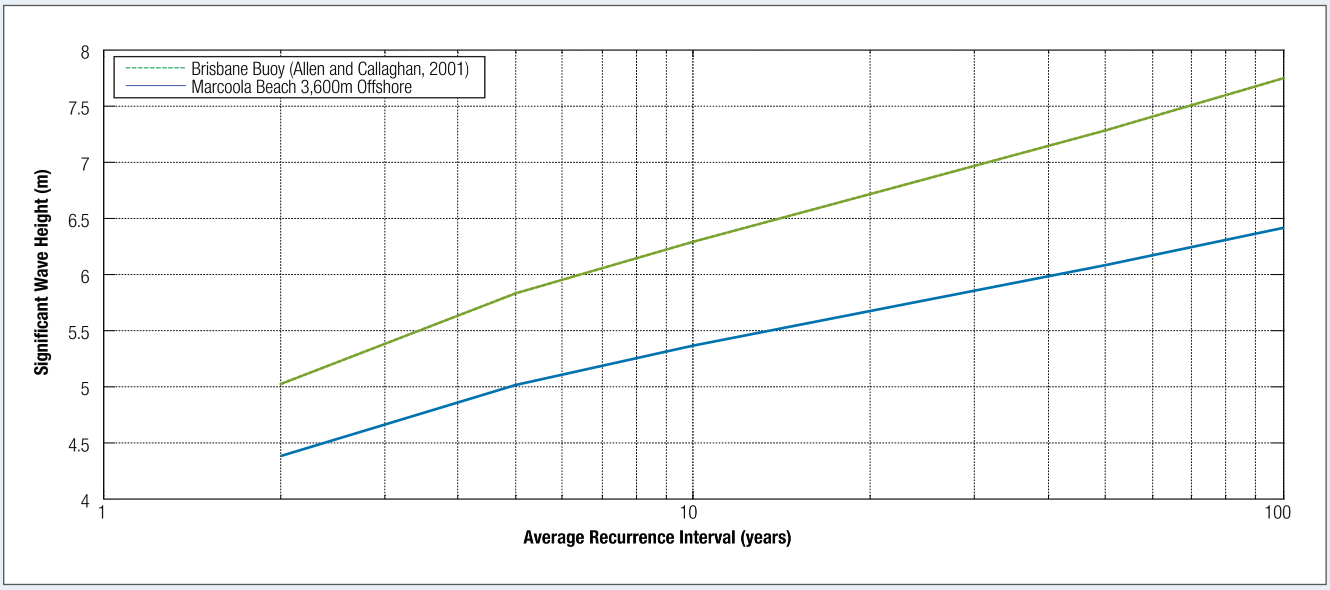
[1] Various methods exist to estimate the constant K. In this study a value of 0.14 has been used. This value was determined for a previous study using known annual transport rates at Gold Coast beaches (approximately 150 km south of the study area)

Table 4.3i: Design significant wave heights

	Significant Wave Height (m)		
Location	**20 year ARI**	**50 year ARI**	**100 year ARI**
Marcoola Beach 3,600m Offshore	5.7	6.1	6.4

Figure 4.3x: Significant wave height design curves



The SWAN wave model and linear wave theory was used to estimate the wave energy flux and the wave breaker angle at numerous locations within the study area. Daily wave energy flux estimates were obtained for the period 21/11/1996 to 01/07/2009. This period corresponds to the available directional wave data at the Brisbane Waverider buoy (necessary for the wave model boundary condition).

The net and gross wave-driven longshore sediment transport along the coast from Mudjimba and Yaroomba (south of Point Arkwright) was calculated using the CERC equation and the predicted inshore wave climate. The long-term average annual longshore transport rate at selected locations is summarised in **Table 4.3j**. **Figure 4.3y** shows the cumulative longshore sediment transport volume for the simulation period. It is noted that the reported transport rates represent transport potentials. Actual sand transport rates may be restricted by the availability of sand. For example, at locations where exposed rock exists on the beach or in surf zone from time to time, the actual longshore sand transport rates may be smaller than those predicted.

Results of the longshore sediment transport modelling are summarised below:

- There is a net southerly longshore sand transport potential within the study area near Mudjimba (locations L1 and L2). For this area the longshore transport direction is due to the presence of Mudjimba Island, the influence on the prevailing wave climate and the local shoreline alignment. Analysing the gross longshore sand transport potential, it is also noted that the total transport rate at Mudjimba (location L1) is substantially lower than the transport rates along the shoreline to the north. The lower transport potential has promoted the tombolo formation at this location.
- Between location L3 (offshore from the northern extent of the existing runway) and Yaroomba there is a net northerly sand transport potential that increases progressively from approximately 1,600 m^3/year to 17,000 m^3/year. This gradient in the average net annual longshore transport potential suggests that a long term trend of shoreline recession may be occurring (albeit at a slow rate).
- Despite the net northerly annual sand transport between locations L3 and L7, the cumulative sediment transport predictions in **Figure 4.3y** show periods of persistent southerly transport (e.g. early 2003, 2007 and 2008) during the summer months. The predicted southerly longshore transport events are attributed to short periods of wave energy from the north-east sector typically associated with Coral Sea east coast low and tropical cyclone events.

While the estimated longshore sand transport rates along Marcoola Beach are considered relatively low, any barrier to this process has the potential to influence shoreline morphology. The impact of the temporary sand delivery pipeline installation on longshore transport and proposed mitigation measures are considered in **Section 4.5**.

Figure 4.3y: Predicted cumulative longshore sediment transport for years 1997 to 2008. Positive/negative gradient indicates northerly/southerly transport direction

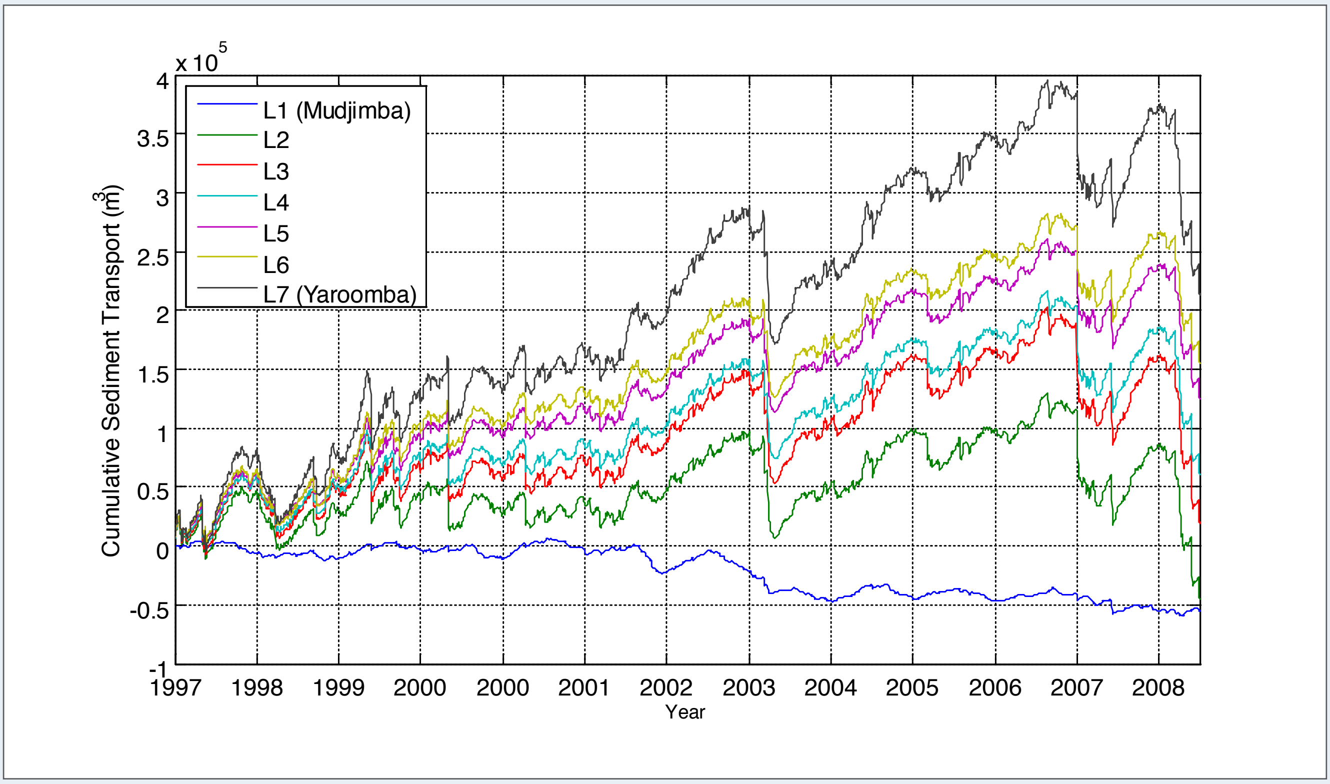


Table 4.3j: Annual longshore sediment transport rate potentials

Location	Alongshore Distance (m)	Mean Net Longshore Transport Potential (m^3/year)	Mean Gross Longshore Transport Potential (m^3/year)
L1 (Mudjimba)	1000	-4,382	55,325
L2	2000	-3,544	260,008
L3	3000	1,577	286,580
L4	4000	4,841	263,707
L5	5000	9,935	258,670
L6	6000	12,320	275,908
L7 (Yaroomba)	7000	16,959	365,782

4.3.11 Storm erosion potential

During construction and operation of the dredge pipeline the Project requires materials to be placed within the Coastal Hazard area as defined by the Coastal SPRP. Baseline short term erosion volume and width estimates have been completed at various locations along Marcoola Beach to measure the storm erosion potential.

Storm erosion occurs when increased wave heights and water levels result in the erosion of sand from the upper beach ridge. The eroded sand is taken offshore where it is deposited as a sand bar located in the vicinity of the wave break area. After the storm event the sediment is slowly transported onshore, often over many months or several years, rebuilding the beach.

The potential for short-term storm erosion due to severe wave and elevated sea water levels (storm tide conditions) has been predicted using the simple cross-shore equilibrium profile model of Vellinga (1983). The assessment adopted inputs considered appropriate for the study area, including:

- Nine initial beach profiles (ETA profile locations indicted in **Figure 4.3c**) extracted from a DEM created from a 2011 topographic/bathymetric survey and sediment characteristics.
- 50 year ARI wave conditions (refer **Table 4.3i**).
- 100 year ARI storm tide including wave setup conditions (obtained from Hardy et al, 2004).

It is noted that the likelihood of the 100 year ARI storm tide event coinciding with 50 year ARI wave conditions at Marcoola Beach remains uncertain however is considered a particularly rare event. It is assumed that the probability of this event occurring in any given year is less than one per cent.

Figure 4.3z provides an example of the predicted storm profile at Marcoola Beach (location ETA550). **Table 4.3k** summarises the predicted storm erosion volume and width at the nine ETA profile locations. The calculations assume that the upper beach and dune system consist of sand only and therefore the estimates are likely to be conservative in areas where coffee rock and/or dense dune vegetation exist. Cross-sectional figures showing the predicted storm erosion profile for each section are provided in **Appendix B4:A**.

Figure 4.3z: Example of predicted storm erosion profile at Marcoola Beach (ETA550)

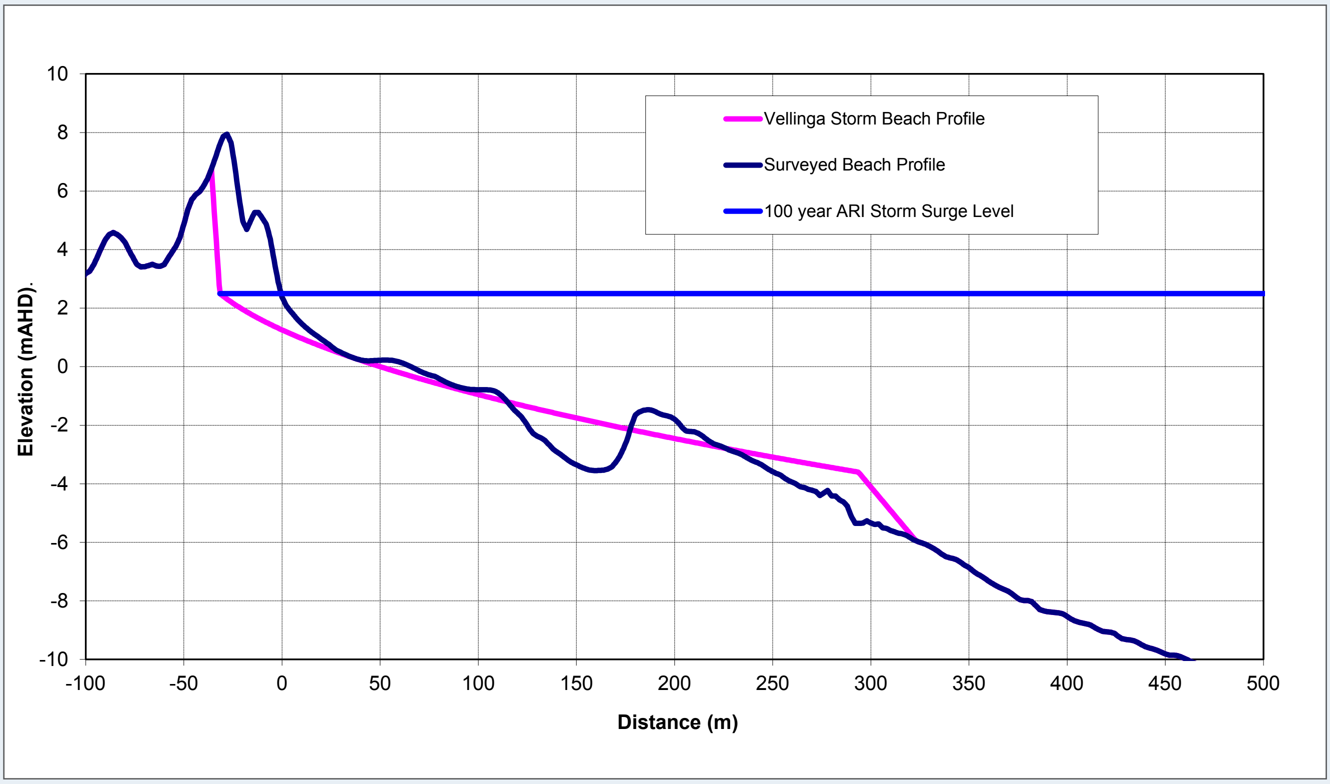


Table 4.3k: Summary of design storm erosion volumes and widths for Marcoola Beach

Profile Section	Design Storm Erosion Volume (m^3/m)	Design Storm Erosion Width (m)
ETA540	200	56
ETA542	279	55
ETA544	263	68
ETA546	264	48
ETA548	124	30
ETA550	139	32
ETA554	214	40
ETA558	249	46
ETA562	238	50
Average	219	47

The estimated design storm erosion volumes and widths are dependent on the volume of sand contained in the upper beach and dune system and therefore vary at each profile location. For the profiles considered in this assessment, the erosion volumes ranged between 139-279 m^3 per metre of shoreline, corresponding to a design erosion width (or “storm bite”) between 30-68 m. These results are considered as part of the impact assessment presented in **Section 4.5**.

4.3.12 Summary of baseline conditions

The various assessments of the existing coastal environment at Marcoola Beach assist the development of a baseline for which potentially impacting activities associated with the Project can be assessed. Specifically, the baseline assessments indicate:

- The offshore wave climate is of moderate to high energy, with a median significant wave height of 1.3 m. Swell direction is predominately from the east - north-east to south-east directions. The east - north-east sector waves are seasonal, predominantly during the spring through summer and are typically generated by local winds. These waves are typically of lower height and shorter period than the prevailing south-east sector swell waves. The exception is when an east coast low or tropical cyclone system develops in the Coral Sea and produces high-energy, north-easterly conditions.
- Marcoola Beach is within a region where large scale storm systems capable of generating a storm surge occur. The 100 year ARI storm tide level is estimated to be 2.5 m above AHD (Hardy et al., 2004) which is approximately 1.3 m above HAT.
- Historical beach profile data suggest a dynamically stable shoreline with episodic short term fluctuations in shoreline position associated with storm induced erosion events. Historical profiles between 1993 and 2011 show a general trend in onshore sandbar migration and slight steepening of the offshore profile.
- Simple storm erosion estimates suggest the storm tide and wave conditions associated with ex-TC Oswald are likely to have removed 50,000-100,000 m^3 of sand from the upper beach and dune system at Marcoola Beach. This material is not lost from the sediment budget but simply relocated to the nearshore area and is expected to migrate onshore under prevailing, low energy conditions.
- Baseline estimates of longshore sediment transport suggest relatively low sand transport rates with a residual to the north. It is noted that cumulative sediment transport predictions show periods of persistent southerly transport (e.g. early 2003, 2007 and 2008) during the summer months. The predicted southerly longshore transport events are attributed to short periods of wave energy from the north-east sector typically associated with Coral Sea east coast low and tropical cyclone events.
- Storm erosion estimates for Marcoola Beach suggest the erosion volumes between 120-280 m^3 per metre of shoreline, depending on the volume of sand contained in the upper beach and dune system. These volumes correspond to a design erosion width (or “storm bite”) between 30-68 m.

4.4
DESCRIPTION OF SIGNIFICANCE CRITERIA

A risk-based approach has been adopted in this environmental impact assessment. This is based on the identification of potential impacting processes and characterisation of the likely level of impact to the existing environment. The risk assessment process is described in Part A of this EIS.

For the purposes of the coastal processes chapter, impacts levels and risks were defined on the basis of the following:

- Significance of Impact – made up of assessment of the intensity, scale (geographic extent), duration of impacts and sensitivity of environmental receptors to the impact. **Table 4.4a** is a summary of the categories used to define impact significance.
- Likelihood of Impact – which assesses the probability of the impact occurring. **Table 4.4b** is a summary of the categories used to define impact likelihood.
- Risk rating – which assesses the level of risk for key impacting processes. The risk rating was generated from the Significance and Likelihood scores, based on the matrix shown in **Table 4.4c**.

Table 4.4a: Categories used to define significance of impact

Significance	**Description**
Very High	The impact is considered critical to the decision-making process as it would represent a major change to the physical processes at Marcoola Beach. This level of impact would be indicated by: • Very large changes to the natural physical processes at Marcoola Beach, such as major shoreline realignment or major changes to the wave climate or sediment transport patterns.
High	The impact is considered important to the decision-making process as it would a detectable change to the physical processes at Marcoola Beach. This level of impact would be indicated by: • Large changes to the natural physical processes at Marcoola Beach, such as shoreline realignment or major changes to the wave climate or sediment transport patterns.
Moderate	While important at a state or regional or local scale, these impacts are not likely to be critical decision making issues. This would be indicated by: • Moderate changes to the natural physical processes at Marcoola Beach, such as significant shoreline realignment or moderate changes to the wave climate and/or sediment transport patterns.
Minor	Impacts are recognisable/detectable but acceptable. These impacts are unlikely to be of importance in the decision making process. Nevertheless, they are relevant in the consideration of standard mitigation measures. This would be indicated by: • Minor changes to the natural physical processes at Marcoola Beach, such as subtle shoreline realignment or minor changes to the wave climate and/or sediment transport patterns.
Negligible	Minimal change to the existing situation. This could include, for example, impacts that are below levels of detection, impacts that are within the normal bounds of variation or impacts that are within the margin of forecasting error.

Table 4.4b: Categories used to define likelihood of impact

Likelihood Categories	
Highly Unlikely/ Rare	Highly unlikely to occur but theoretically possible
Unlikely	May occur during construction/life of the project but probability well <50%; unlikely but not negligible
Possible	Less likely than not but still appreciable; probability of about 50%
Likely	Likely to occur during construction or during a 12 month timeframe; probability >50%
Almost Certain	Very likely to occur as a result of the proposed project construction and/or operations; could occur multiple times during relevant impacting period

Table 4.4c: Risk ratings

		Significance				
Negligible		**Negligible**	**Minor**	**Moderate**	**High**	**Very High**
Likelihood	Highly unlikely	Negligible	Negligible	Low	Medium	High
	Unlikely	Negligible	Low	Low	Medium	High
	Possible	Negligible	Low	Medium	Medium	High
	Likely	Negligible	Medium	Medium	High	Extreme
	Almost certain	Negligible/ Low	Medium	High	Extreme	Extreme

The subsequent report sections present the impact assessment of the Project for the key coastal environment issues identified in the baseline section which are:

- Waves
- Shoreline and beach system.

Key assumptions and limitations of the impact assessment are outlined and discussed where relevant.

4.5
ASSESSMENT OF POTENTIAL IMPACTS AND MITIGATION MEASURES

Works and activities associated with the proposed delivery of up to 1.1 M m^3 of sand (fill material) for construction airport expansion will induce temporary changes to the beach system, including:

- Removal of dune vegetation
- Dune profiling
- Interference to longshore transport processes.

The wave and longshore sediment transport modelling system described in **Section 4.3.10** was used to assess the significance and likelihood of the impacts.

4.5.1 Construction phase beach impact assessment

The Project requires up to 1.1 M m^3 of fill for construction of the new runway and associated infrastructure. Capital dredge material extracted from the Spitfire Channel Realignment area is the proposed fill material. Delivery to the airport reclamation site will involve pumping the fill (marine sand), mixed with water as a slurry, through a pipeline from a moored dredge vessel. Full details of the dredging, fill delivery and reclamation are provided in Volume A of the EIS.

The proposed construction activities have the potential to temporarily disturb natural coastal processes and the dune system within the study area, namely:

- Sand delivery pipeline section laydown and assembly
- Operation of the sand delivery pipeline
- Spilled sand from the dredger at the mooring/pump-out location.

In this section the anticipated impact of the above activities with regard to the natural processes is assessed. It is noted that the assessment is semi-quantitative and only estimates of impact significance and likelihood can be provided while the specific details of the equipment and methodology remains uncertain.

Pipeline assembly impact assessment

A steel pipeline for the delivery of fill material to the airport reclamation site is proposed to be assembled at Marcoola Beach. It is anticipated the pipeline will be assembled on the beach in sections up to 500 m length. One end of each length would be floated out to its proposed location using a tug and sunk into position. During assembly (and dismantling after pipeline operations) a small section of beach would be closed to public access for 3 to 4 weeks. **Figure 4.5a** shows the location of the proposed temporary infrastructure and coastal hazard area defined by DEHP.

A corridor of approximately 20 m width from David Low Way and across the existing dune system is required for the supply of pipeline and equipment to the beach. This will require significant modification and profiling the natural dune system. Within the corridor it is estimated that a 1,500 m^2 area of vegetated dune cover will be disturbed and the dune height temporarily reduced. During pipeline assembly, the area with a lower dune crest will have an increased vulnerability to wave overtopping and storm erosion. The timing of the assembly works would seek to avoid periods of increased storm activity (typically during the summer months) that may generate extreme water levels (storm tide) and wave conditions that promote coastal erosion. The dune system would be re-established and managed after the dredging and sand delivery operations.

Below the MHWS level, the potential disturbance areas are considered high energy environments (i.e. beach, surf zone and nearshore) that are comprised of highly mobile sands influenced by wind, waves and currents, and subject to regular natural physical disturbance events (e.g. storm-related wave-induced erosion). Given the dynamic nature of the area, the physical characteristics would be expected to rapidly recover (i.e. local beach morphology and sediment characteristics within range of natural variation) on completion of the beach construction works.

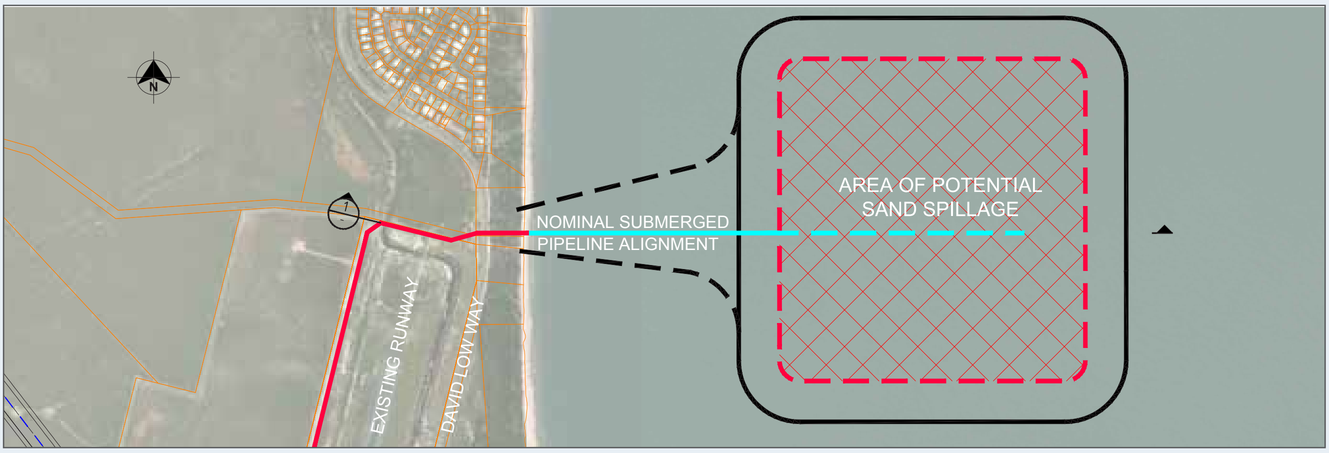
Pipeline operation and littoral processes impact assessment

In the pipeline assembly area the sand delivery pipeline will be coupled in two or three parts, and then hauled by tug into a position that is perpendicular to the shoreline and placed on the seabed and beach face. On completion of sand pumping activities, the pipeline will be manoeuvred back onto the beach and disassembled.

While the pipeline is in place, it may produce a temporary barrier to local longshore sediment transport processes. It is anticipated the fully assembled pipeline would be in place for up to 33 weeks, depending on the dredger type and sand pumping rates. The baseline longshore sediment transport assessment presented in **Section 4.3.10** shows a weakly net northern longshore sand transport direction at the proposed pipeline location (refer location L3 in **Table 4.3j**). Net annual longshore transport rate volume estimates suggest up to approximately 130 m^3 of sand may accumulate on the southern side of the pipeline per month that it is in place. It is noted that periods of persistent southerly sand transport are also expected during the summer months (as demonstrated by the cumulative longshore transport estimates in **Figure 4.3y**) and under these conditions accretion on the northern side of the pipeline would be expected.

Figure 4.5a: Proposed temporary infrastructure, construction footprint and coastal hazard areas

Figure 4.5b: Indicative dredge mooring, potential sand spillage area and pipeline alignment (Source: AECOM, 2013)



A reactive mitigation strategy can alleviate any moderate impacts to longshore sediment transport associated with the temporary pipeline installation. This would include regular weekly inspections and assessment of accumulated sand volumes and a commitment to manually relocate the material (using a small excavator) to the active beach if an excessive volume had accumulated.

Spilled fill material (marine sand) impact assessment

During sand pumping, it is anticipated that a quantity of marine sand will be spilled from the moored dredger. The amount of spilled material will depend on the specific vessel selected to undertake the work, with older dredgers typically losing more material than newer models (AECOM, 2013).

The dredge mooring location is dependent on the vessel size and draught and is expected to be at least 500 m offshore from Marcoola Beach. While the vessel is moored its orientation will be largely dictated by the prevailing wind, current and wave conditions. Consequently, the area of potential sand spillage is relatively large and is indicated by the 850 m by 900 m area in **Figure 4.5b**.

The sea bed elevation across the potential spill area ranges between approximately 13 – 22 m below AHD. The historical beach and offshore profiles presented in **Section 4.3.6.1** suggest very little morphological change at depths greater than 15 m below AHD. It is therefore anticipated that any spilt material will only become mobile under relatively extreme wave conditions and will eventually integrate into the local sediment budget. It is expected that the maximum total spillage at the mooring location could temporarily decrease depths locally by 1 – 2 m during sand pumping operations (refer Chapter A4, Project Description).

It is noted that if the accumulated spill is excessive (i.e. causing a navigational hazard) it will be re-dredged. If required, this work is expected to have a negligible impact on coastal processes and water quality since the re-dredging works would occur infrequently for short periods (up to a few hours).

Potential impacts on water quality from normal operations of the dredge whilst at the pump-out locations, such as fuel leaks, release of liquid waste or other pollutant sources are addressed in the Dredge Management Plan (DMP) in Part E of the EIS.

Coastal erosion assessment results

Baseline storm erosion estimates provided in **Section 4.3.11** suggest an erosion width (or "storm bite") potential between 30 – 68 m along Marcoola Beach.

The potential for short-term storm erosion due to severe wave and elevated sea water levels (storm tide conditions) has been estimated at the proposed pipeline corridor following the methodology described in **Section 4.3.11**. The impact assessment compares the erosion associated with the existing dune/beach profile (extracted from a DEM created from a 2011 topographic/bathymetric survey) and the developed profile that accounts for a temporary reduction in dune height to 4 m AHD during the sand delivery operations.

The results of the Vellinga (1983) storm erosion assessment for the existing and developed cases are summarised in **Table 4.5a** and illustrated in **Figure 4.5c** and **Figure 4.5d**. The existing storm erosion potential width at the proposed pipeline corridor is estimated to be 30 m. For the developed case, with reduced dune crest elevation of 4 m AHD, the

Table 4.5a: Summary of design storm erosion volumes and widths at the pipeline corridor location

Profile Section	Design Storm Erosion Volume (m^3/m)	Design Storm Erosion Width (m)
Existing Case (2011 DEM)	123	30
Developed Case (4mAHD Dune Crest)	97	37

storm erosion potential width increases to 37 m AHD (approximately 20 per cent increase). This result reflects the reduced volume of sand contained in the upper beach and dune system which is balanced by an increase in landward erosion.

As noted in **Section 4.3.11**, the probability of the design erosion event occurring in any given year is expected to be less than one per cent. It is therefore assumed that the probability of this event occurring within a 33 week period (the assumed time required for sand delivery operations) is considerably less than one per cent. The risk of a significant erosion event is higher during the summer months and therefore the risk of enhanced coastal erosion associated with the Project can be further reduced if the works are undertaken in milder conditions typically present during the winter. It is noted that regardless of the season, any enhanced erosion is not expected to lead to long term impacts to the beach system and can be mitigated through an appropriate shoreline erosion management strategy if required.

Once sand delivery to site is completed the dune and vegetation will be re-established. It is noted that the disturbed section of dune may be more vulnerable to a severe erosion event while the vegetation matures. To minimise any potential long-term impacts associated with the construction phase of the Project, the area of re-established dune would need to be inspected following an erosion event. If additional shoreline setback is observed at the disturbed dune location then remedial works would be undertaken to attain a consistent dune/shoreline alignment.

Figure 4.5c: Pipeline corridor location – existing case

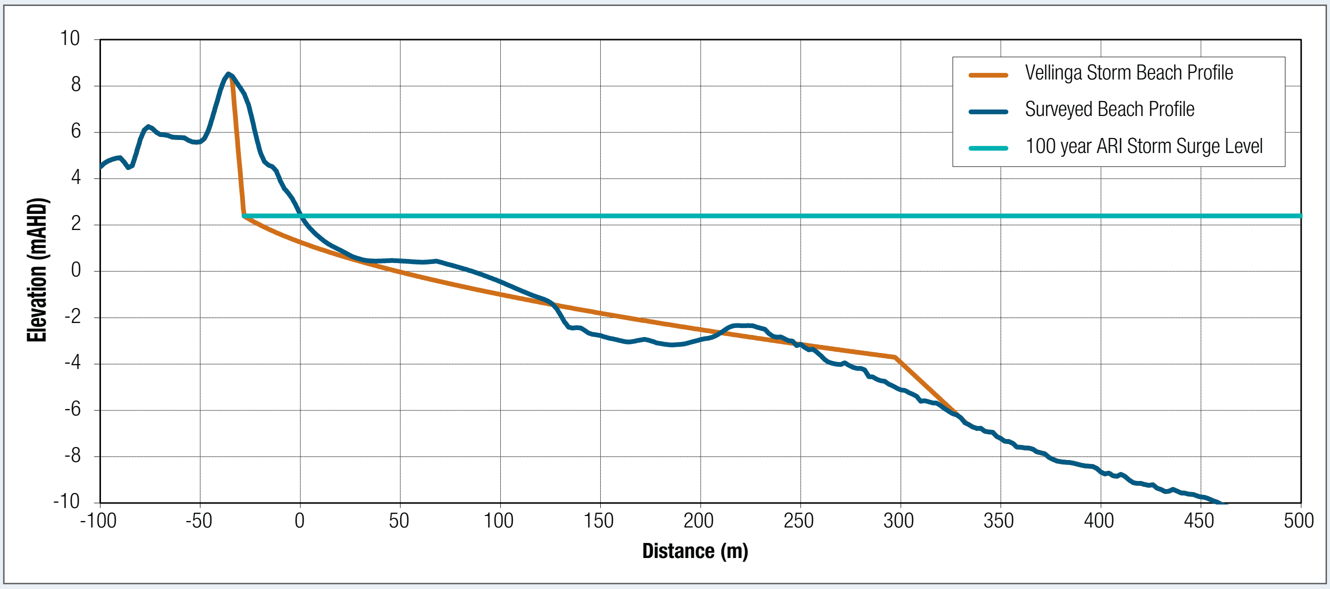
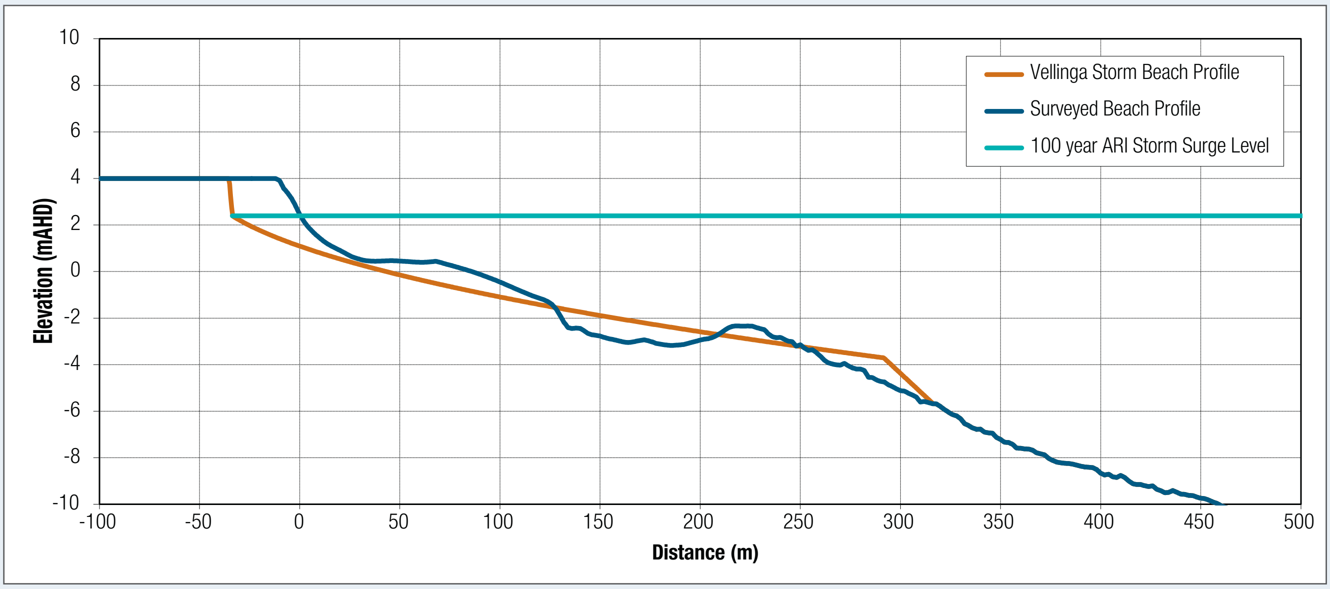


Figure 4.5d: Pipeline corridor location – developed case



4.6
IMPACT ASSESSMENT SUMMARY

The various coastal processes assessments have identified activities related to the Project that will require careful management to mitigate any undesirable impacts to the value of Marcoola Beach. Specifically, the modelling results and qualitative assessments show that:

- Within a corridor with an area of approximately 1,500 m^2 significant modification and profiling of the natural dune system is required to allow delivery of up 1.1 M m^3 of fill material for runway construction. The risk of long term impact to the dune system is considered low and will be mitigated by re-establishing the dune height and revegetating the corridor following sand delivery operations.
- The short term increased vulnerability to storm erosion within a 20 m corridor of disturbed dune is not expected to cause significant undesired impacts at other Marcoola Beach locations. It is considered highly unlikely for a design storm erosion event to occur during the proposed period of sand delivery operations.
- The assembly of the sand delivery pipeline will cause disturbance to a localised area of the beach. This will require sections of the beach to be closed for short durations for public safety reasons. Physical disturbance to the beach below the MHWS level associated with heavy machinery movements is expected rapidly recover under natural processes.
- The presence of the dredge delivery pipeline on the seabed and beach face for the duration of dredge material delivery operations will create a minor barrier to littoral sand transport. Net annual longshore transport rate estimates suggest up to approximately 130 m^3 of sand may accumulate on the southern side of the pipeline per month. Periods of sand accumulation on the northern side of the pipeline may also occur, depending on the wave climate experienced during the sand delivery operations. A reactive mitigation strategy can alleviate any moderate impacts to longshore sediment transport associated with the temporary pipeline installation. This would include regular inspections and assessment of accumulated sand volumes and a commitment to manually relocate the material (using a small excavator) to the active beach if an excessive volume had accumulated.
- During sand pumping operations a quantity of marine sand may be spilled at the dredge mooring location. This is expected to have negligible impact on coastal processes however it is noted that if the accumulated spill is excessive (i.e. causing a navigational hazard) it may need to be re-dredged.

The coastal processes impact assessments are summarised in **Table 4.6a** together with the identified anticipated risk and potential mitigation measures (where relevant). Based on the outputs of the risk assessment, all relevant risks to coastal processes that have been identified can be reduced to a low residual risk through a mix of existing controls (associated with the design of key infrastructure elements of the project) and through the proposed implementation of risk treatment measures.

4.7
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Table 4.6a: Impact assessment summary table

Coastal Processes	Initial assessment with mitigation inherent in the Preliminary design in place				Residual Assessment with additional mitigation in place (i.e. those actions recommended as part of the impact assessment phase)			
Primary impacting process	**Mitigation inherent in the design**	**Signif-icance of impact**	**Likeli-hood of impact**	**Risk rating**	**Additional mitigation measures proposed**	**Signif-icance of impact**	**Likeli-hood of impact**	**Residual risk rating**
Modification to wave climate at Marcoola Beach associated with temporary mooring and pipeline infrastructure	Minimal structure proposed for mooring	Negligible	Highly Unlikely	Low	Not required	Moderate	Highly Unlikely	Low
Change to sediment transport patterns at Marcoola Beach associated with dredge pipeline during project construction phase	Minimise duration of pipeline installation	Negligible	Likely	Negligible	Not required	Negligible	Possible	Negligible
Long term modification to sediment transport patterns at Marcoola Beach	Temporary pipeline installation completely removed following dredging and sand pumping activities.	Moderate	Highly Unlikely	Low	NA	Moderate	Highly Unlikely	Low
Modifications to dune crest height during pipeline installation and project construction phase. Temporary increased vulnerability to dune erosion and storm tide inundation.	Upon completion of dredge campaign dune area impacted will be reinstated	Minor	Possible	Low	Preference for works requiring dune crest elevation lowering to be completed during winter months when the severe coastal erosion and storm tide risk is low	Minor	Possible	Low