5 Contemporary Shoreline Processes

5.1 Water Level Variations

5.1.1 Astronomical Tide

The tides within Moreton Bay are mesotidal and predominantly semi-diurnal. The tidal planes for the Brisbane Bar Standard Port and relevant Secondary Place are shown in Table 5-1. The astronomical mean spring tide range at Beachmere, Toorbul and Donnybrook is 1.72m, 1.62m and 1.53m respectively.

Table 5-1 Study Area Tidal Planes in metres above Lowest Astronomical Tide (Maritime Safety Queensland, 2012)

Location	Time Difference (min)		Highest Astronomical Tide	Mean High Water Springs	Mean High Water Neaps	Australian Height Datum	Mean Sea Level	Mean Low Water Neaps	Mean Low Water Springs
	HW	LW	(HAT)	(MHWS)	(MHWN)	(AHD)	(MSL)	(MLWN)	(MLWS)
Brisbane Bar	Standard Port		2.73	2.17	1.78	1.24	1.27	0.76	0.36
Beachmere	6	18	2.51	2.08	1.71	1.26	1.21	0.73	0.36
Toorbul	30	20	2.46	1.95	1.6	1.1	0.9	0.68	0.33
Donnybrook	60	56	2.36	1.88	1.55	1.12	1.11	0.69	0.35

5.1.2 Extreme Water Levels

Elevated water levels occur during storm tide events due to the combination of decreased atmospheric pressure, wind set-up and wave action. Storm tide levels represent still water levels due to the combination of storm surge and astronomical tide variations.

Design water levels throughout the study area were derived by Cardno Lawson Treloar (2009) as part of a regional storm tide risk assessment. Representative non-cyclonic and cyclonic design water levels for each study location are provided in Table 5-2 and Table 5-3. These design levels do not consider the influence wave processes or include any additional freeboard allowance. This information is important input to the short term erosion potential assessment presented in Section 6.5.

Table 5-2 Non-cyclonic Design Water Levels (Cardno Lawson Treloar, 2009)

Location	20yr (mAHD)	50yr (mAHD)	100yr (mAHD)
Deception Bay	2.0	2.1	2.1
Beachmere	1.8	1.9	2.0
Godwin Beach	1.8	1.8	1.9

Location	20yr (mAHD)	50yr (mAHD)	100yr (mAHD)
Sandstone Point	1.7	1.8	1.8
Toorbul	1.8	1.9	1.9
Donnybrook	1.9	2.0	2.0

Table 5-3 Cyclonic Design Water Levels (Cardno Lawson Treloar, 2009)

Location	20yr (mAHD)	50yr (mAHD)	100yr (mAHD)
Deception Bay	1.9	2.0	2.2
Beachmere	2.0	2.2	2.3
Godwin Beach	1.9	2.0	2.2
Sandstone Point	1.8	2.0	2.1
Toorbul	1.7	1.8	1.9
Donnybrook	2.0	2.2	2.3

5.2 Wind Climate

The region experiences a seasonal wind climate. East to south-easterly trade winds dominate between April and September. During the summer months lighter east to north-easterly sea breezes are observed. November to April is generally accepted to be the tropical cyclone season. Tropical cyclones and east coast low pressure systems often bring destructive wind to the region, generating storm surges and extreme waves.

A long term average wind rose based on recorded data from Bureau of Meteorology (BOM) Spitfire Channel weather station (station number 40927) is provided in Figure 5-1 and shows the directional spread of wind speed at the northern entrance to Moreton Bay. This weather station is positioned on a beacon over water and therefore the wind speeds are expected to be higher than those observed at land based locations. Small changes to wind direction would also be expected as the winds move over the local terrain.

The variation in wind climate for the summer (December to February), autumn (March to May), winter (June to August) and spring (September to November) is shown in Figure 5-2 through Figure 5-5. The wind roses confirm that the wind climate at Spitfire Channel is consistent with the regional description, namely:

- The dominance of winds from the south easterly sector; and
- North easterly winds occur seasonally, predominantly during summer and spring.

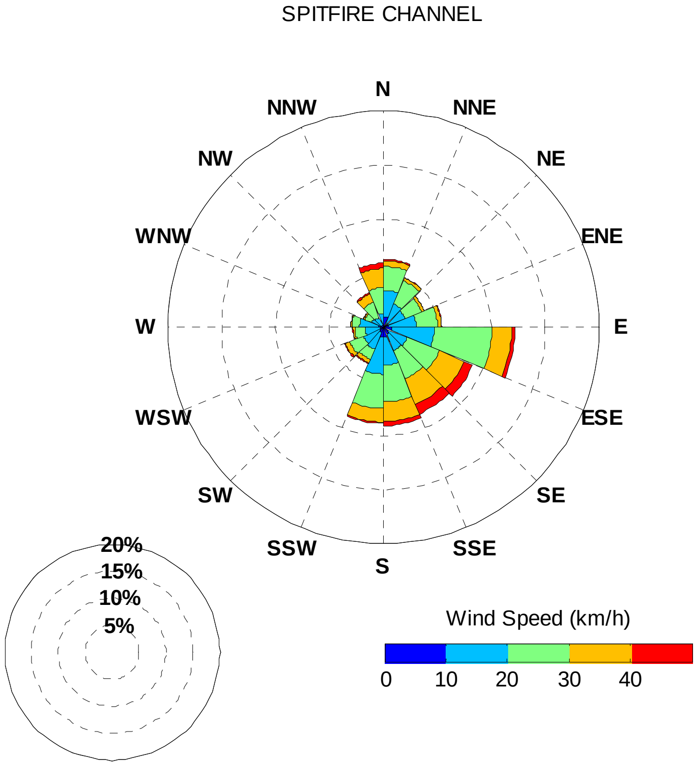

Figure 5-1 Long Term Average (2002 – 2011) Wind Rose – Spitfire Channel All Data

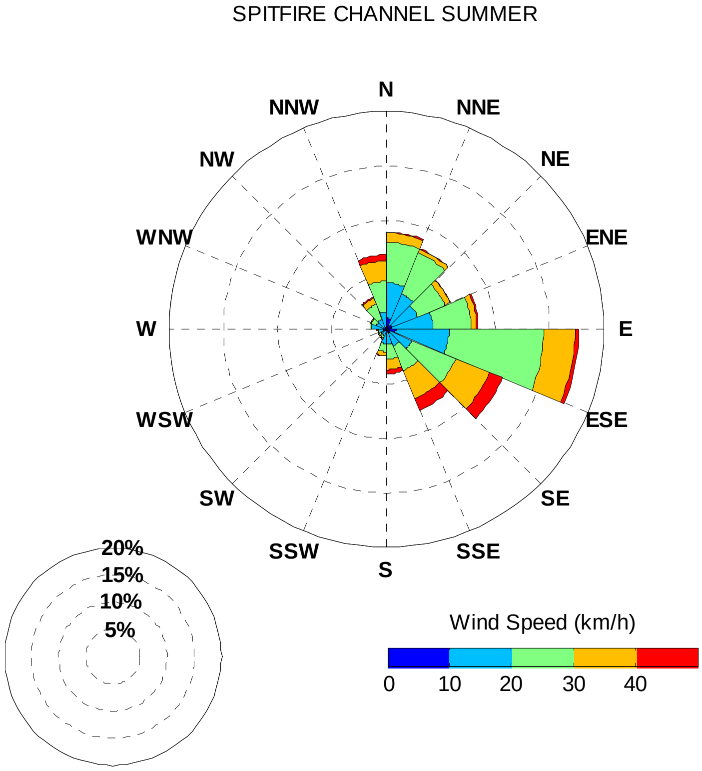

Figure 5-2 Long Term Average (2002 – 2011) Wind Rose – Spitfire Channel Summer Data

SPITFIRE CHANNEL AUTUMN

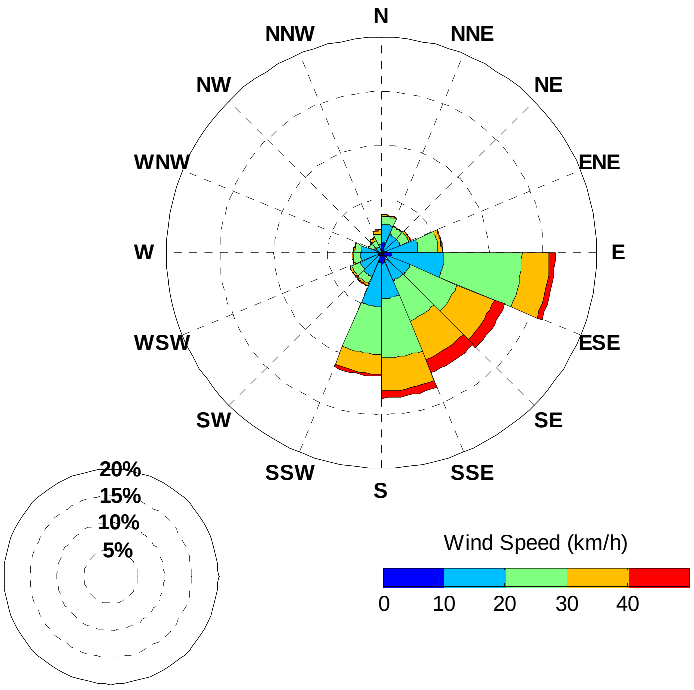

Figure 5-3 Long Term Average (2002 – 2011) Wind Rose – Spitfire Channel Autumn Data

SPITFIRE CHANNEL WINTER

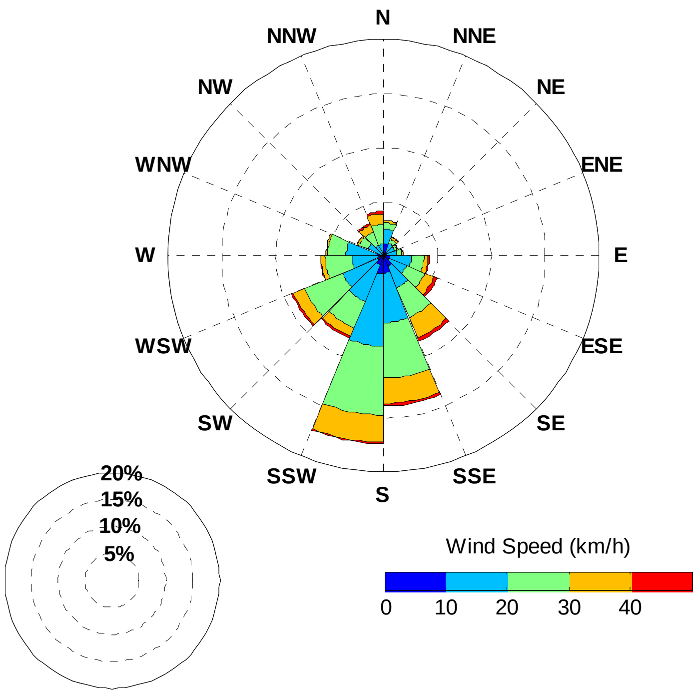

Figure 5-4 Long Term Average (2002 – 2011) Wind Rose – Spitfire Channel Winter Data

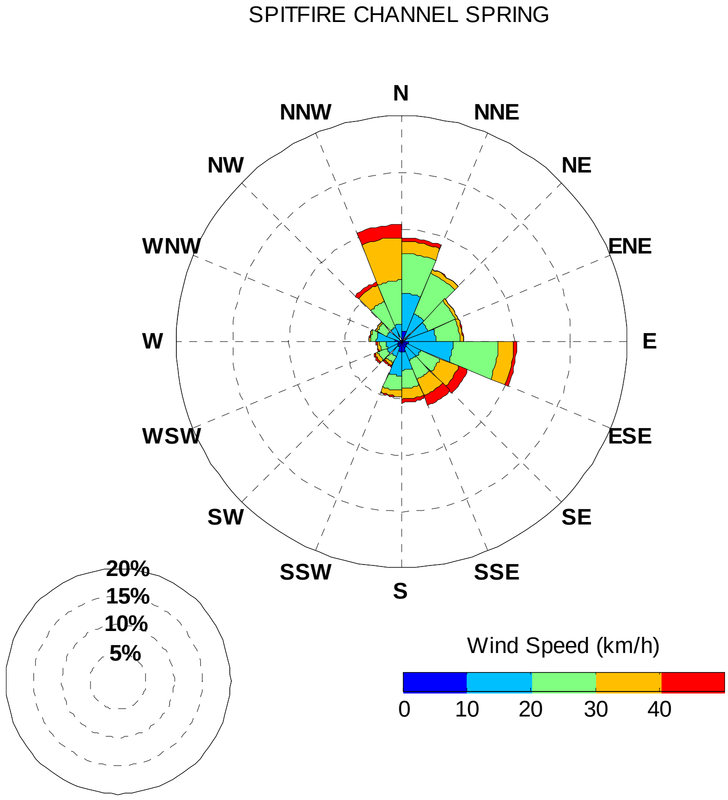

Figure 5-5 Long Term Average (2002 – 2011) Wind Rose – Spitfire Channel Spring Data

5.3 Wave Climate

Moreton Bay is sheltered from the prevailing southerly “swell” waves by North Stradbroke and Moreton Islands. The northern sections of the study area are further sheltered by Bribie Island. The ocean swell energy that enters Moreton Bay and reaches the bay shorelines is substantially attenuated by the processes of refraction, diffraction, bed friction and breaking across the shallow shoals at the bay entrance. The shorelines within the bay are generally most affected by the locally generated “sea” waves.

Knowledge of the wave climate along the South East Queensland open coast and within Deception Bay is derived from observation and calculation of wave conditions by hindcasting techniques based on winds in the region. As described in WBM (2005), previous studies have shown:

- The ocean wave climate (open coast outside of the bay) is of moderate to high energy, with median significant height about 1.3 metres and extreme wave heights (typically generated by tropical cyclone conditions) up to 8 metres.
- Both longer periods (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 open ocean swell waves are predominantly from the southeast directional sector.

- North to northeast 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 southeast sector swell waves.
- Moreton Bay is dominated by waves generated by winds from within the bay itself. The available fetch lengths and depths are limited and restrict wave development substantially compared to the ocean. Significant wave heights rarely exceed 1.5 to 2 meters. This is demonstrated in Figure 5-6 which shows a sample of Moreton Bay wave recordings from a buoy located approximately 10km offshore from the Redcliffe Peninsula.
- The height and direction of Moreton Bay waves are determined directly by the prevailing winds and are highly seasonal in nature. These small sea waves can develop quickly with the onset of stronger local winds and at certain times of the year substantial daily variability may be observed.
- A number of wave events with peak periods greater than 10s can be seen in Figure 5-6. It is likely that these events significant influence longshore sediment transport throughout the study area.

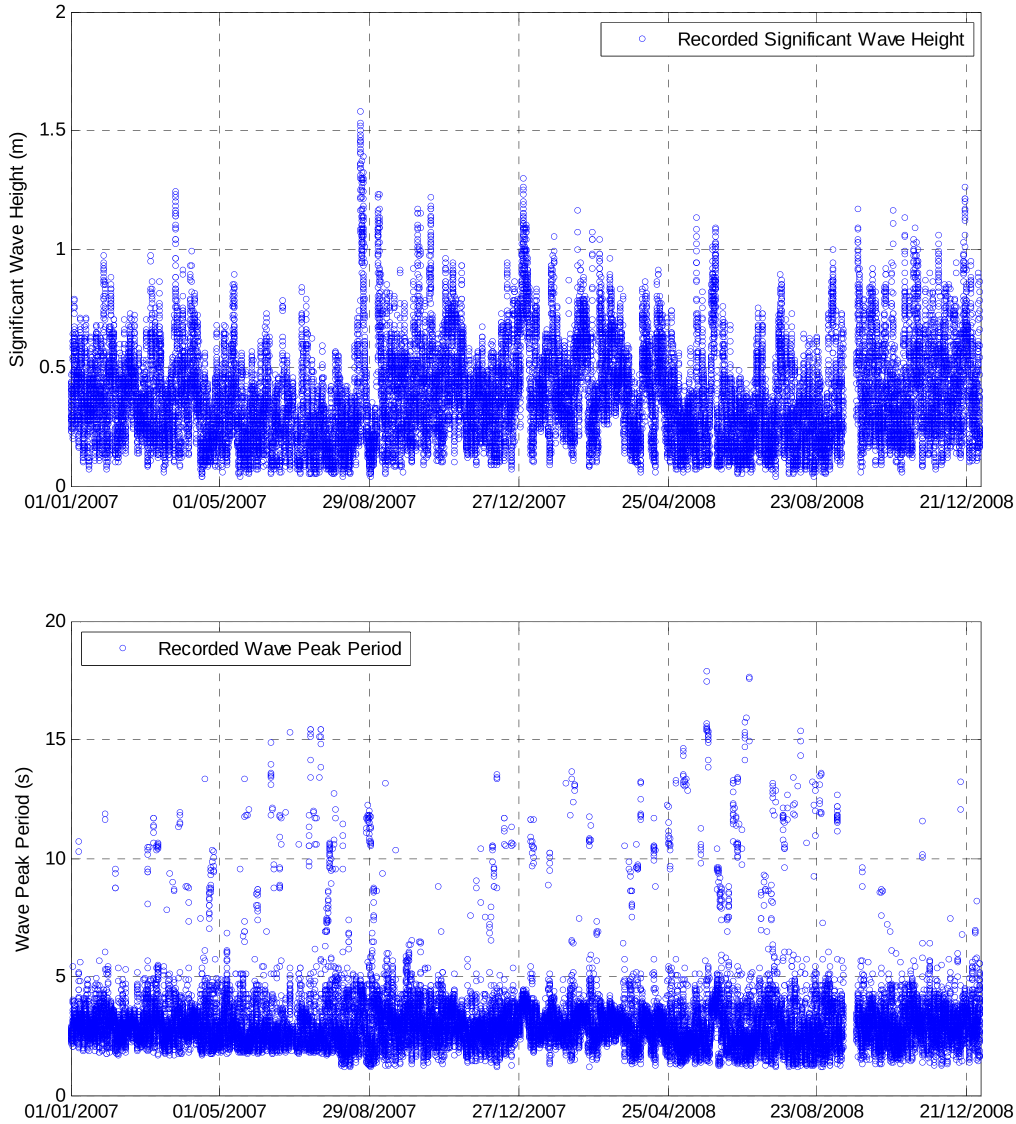

Figure 5-6 Moreton Bay Wave Buoy Recordings

5.3.1 Extreme Wave Climate

Design wave conditions throughout the study area were derived by Cardno Lawson Treloar (2009) as part of a regional storm tide risk assessment. Representative non-cyclonic and cyclonic design significant wave heights for each NMBSEMP study location are provided in Table 5-4 and Table 5-5. This information has been considered when developing inputs for the short term erosion potential assessment described in Section 6.5.

Table 5-4 Non-cyclonic Design Significant Wave Height (Cardno Lawson Treloar, 2009)

Location	20yr (m)	50yr (m)	100yr (m)
Deception Bay	0.7	0.7	0.7
Beachmere	1.0	1.0	1.1
Godwin Beach	1.0	1.1	1.2
Sandstone Point	0.9	1.0	1.1
Toorbul	0.5	0.5	0.5
Donnybrook	0.5	0.5	0.5

Table 5-5 Cyclonic Design Significant Wave Height (Cardno Lawson Treloar, 2009)

Location	20yr (m)	50yr (m)	100yr (m)
Deception Bay	0.9	1.0	1.0
Beachmere	1.1	1.2	1.2
Godwin Beach	1.3	1.3	1.3
Sandstone Point	1.0	1.1	1.1
Toorbul	1.1	1.1	1.1
Donnybrook	1.1	1.2	1.2

5.4 Sediment Supply

There has been a continual supply of marine sand to Moreton Bay throughout the Holocene period via the regional longshore sediment transport pathway that operates along the south eastern Queensland coast (Jones, 1992). This prevailing net-northerly sand transport has led to the formation of Stradbroke, Moreton and Bribie Islands which act as barriers to ocean swells and associated sediment transport within Moreton Bay.

Marine sand is transported to Deception Bay shorelines from Northern Passage (the northern entrance to Moreton Bay). In addition to marine sand, a supply of fluvial sand and mud is delivered to the study area from the Caboolture River which discharges to the south of Beachmere. A relatively smaller supply of sediment is also expected from the creeks that discharge to Pumicestone Passage.

Limited mixing occurs between sediments derived from the Caboolture River and Northern Passage (e.g. Flood, 1981). This is evident in the contrasting nearshore environments to the north and south of the Caboolture River entrance. To the south (toward the Deception Bay beach unit) the nearshore is dominated by tidal flats and mangroves. North of the entrance (toward the Beachmere beach unit) tidal sand flats and beach ridges are present. The sediments that form the Caboolture River delta are essentially derived from a mixture of the southerly directed longshore transport of sand from Beachmere and mud which settles from the suspended load of the Caboolture River.

5.5 Sediment Transport Mechanisms

Sediment transport within Moreton Bay is primarily driven by tidal currents and local wind waves. A net south westerly longshore transport of sand between Godwin Beach and the Caboolture River entrance has been previously reported (e.g. Flood, 1981). The Beachmere beach unit is most exposed to the prevailing south easterly wind conditions to which the nearshore bed forms and shoreline align (see Figure 5-7).

Figure 5-7 Offshore Bed Forms at Beachmere

Sand transport throughout Deception Bay can be generally described as a complex interaction between cross-shore and longshore processes. Understanding sand transport pathways forms a crucial component of the NMBSEMP and will directly guide the development of appropriate management strategies.

Conceptual descriptions of sediment transport modes on sandy beaches are provided below and consider shorelines without terminal structures. The influence of terminal structures on sediment transport under extreme conditions is also discussed. A conceptual diagram of the prevailing sediment transport pathways is provided in Figure 5-9.

5.5.1 Cross-shore Sediment Transport

Cross-shore sand transport is generally associated with:

- Erosion of sand from the upper shoreline 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; and
- Subsequent slow transport of the eroded sand back to the upper shoreline, often over many months or several years.

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

5.5.2 Longshore Sediment Transport

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 shoreline. 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.

Shoreline 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 (e.g. rivers or creeks) within the system or sand is removed from the active beach system; and/or
- 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 upper beach than was previously there.

As discussed above, south westerly longshore sand transport is evident between Godwin Beach and the Caboolture River entrance. This process has led to the interesting succession of sand spits that have developed on the tidal sand flats to the south of Beachmere discussed by Flood (1981). Over time, the net south westerly longshore transport has eroded the beach ridges and deposited sediment in a series of sand spits adjacent to the north bank of the Caboolture River. Several phases of erosion and deposition in the low lying mudflat areas has occurred and now support extensive mangrove habitat. Once mangroves become established in front of a spit, a new spit begins to form seaward of the trees. These processes can be seen in Figure 5-8.

Figure 5-8 Spit Development South of Beachmere between 1978 (left) and 2009 (right)

5.5.3 Shorelines with Terminal Protection

Natural sediment transport processes are interrupted on shorelines where erosion control strategies have been implemented. Revetment seawalls, such as those that are present at many locations throughout the NMBSEMP study area, are typically implemented to limit landward shoreline movements and therefore the cross-shore and longshore processes described above are impeded. The presence of a hard structure at the shoreline can cause local increases to current speeds, particularly during large storm wave events. This may cause an increase in sediment transport potential, leading to localised scour and in some cases complete undermining and failure of the structure.

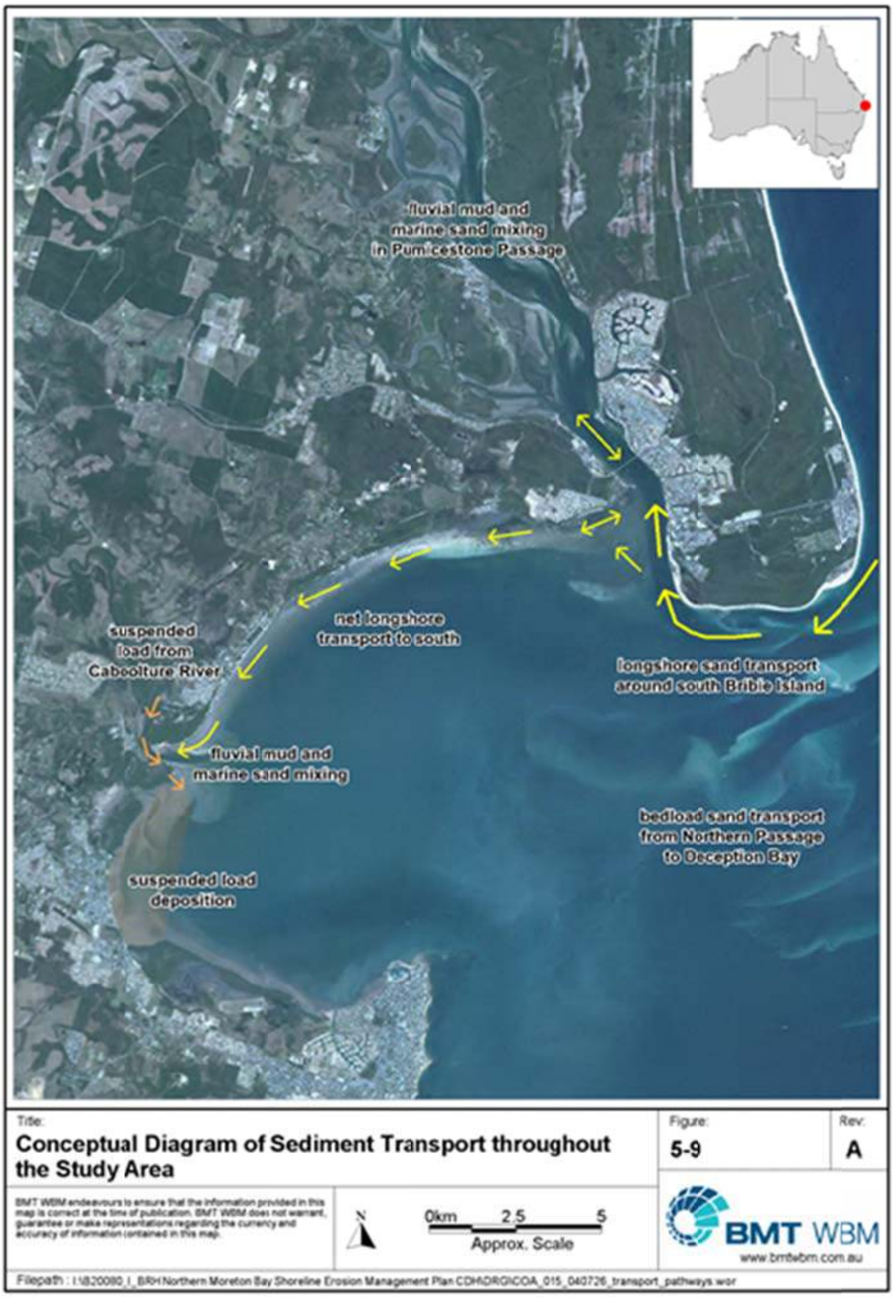

Figure 5-9 Conceptual Diagram of Sediment Transport throughout the Study Area

I:\B20080_I_BRH Northern Moreton Bay Shoreline Erosion Management Plan CDH\JPG\Figure5-9.jpg

5.6 Assessment of Historical Shoreline Erosion

Historical aerial photos of the NMBSEMP study area suggest a relatively stable shoreline alignment since the 1970s. This is primarily due to relatively low sediment rates and the addition of terminal shoreline structures to protect the urban development that expanded rapidly from 1960 to1980. Prior to urbanisation, Flood (1980) suggests a slowly eroding shoreline between Godwin Beach and Beachmere with sediment being transported to the south and depositing at the mouth of the Caboolture River.

Minor changes in shoreline position throughout the study area are not easily identified in the available historical aerial photography dating back to 1958. Example historical photos from 1978 and 2012 for each study area location are provided in Figure 5-10 through Figure 5-15. Formalisation of the shoreline with terminal structures has restricted significant landward recession associated with long term processes. Contemporary shoreline erosion problems are typically on a local scale and associated with episodic storm events rather than regional scale shoreline realignment. Typical examples of damage caused to shoreline structures following a significant storm event are provided in Section 5.6.1.

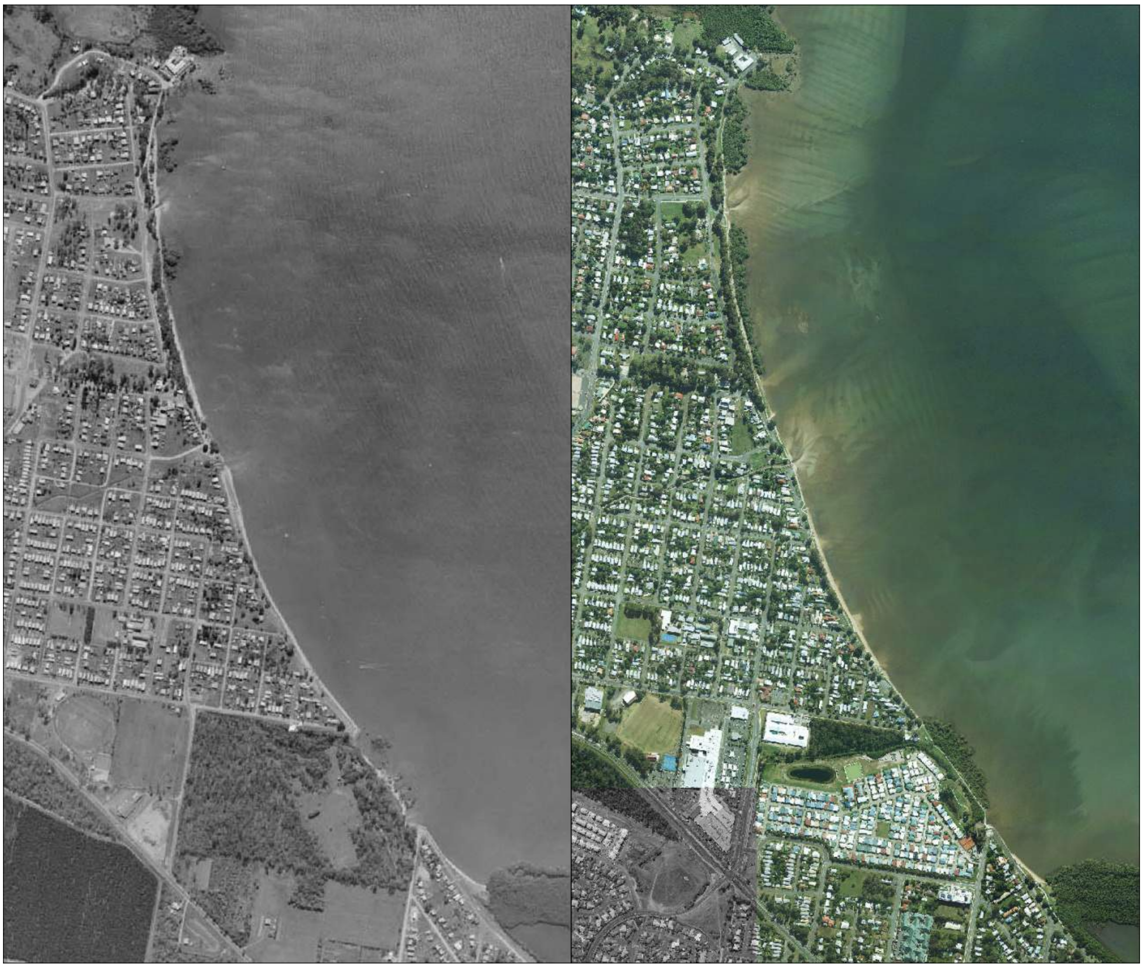

Figure 5-10 Deception Bay Shoreline Alignment in 1978 (left) and 2012 (right)

Figure 5-11 Beachmere Shoreline Alignment in 1978 (left) and 2012 (right)

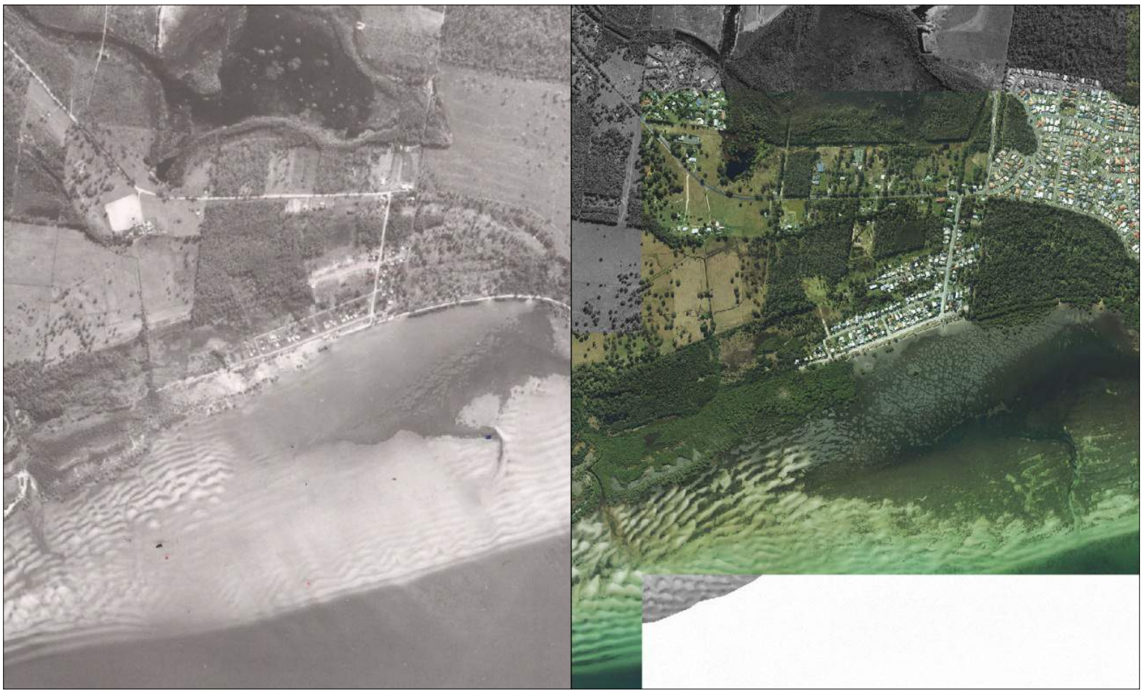

Figure 5-12 Godwin Beach Shoreline Alignment in 1978 (left) and 2012 (right)

Figure 5-13 Sandstone Point Shoreline Alignment in 1978 (left) and 2012 (right)

Figure 5-14 Toorbul Shoreline Alignment in 1978 (left) and 2012 (right)

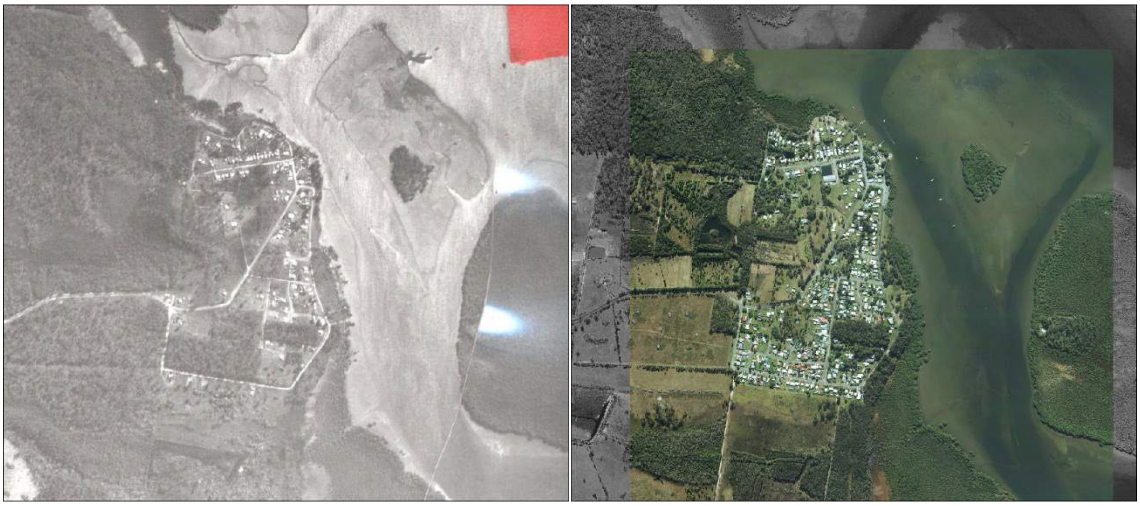

Figure 5-15 Donnybrook Shoreline Alignment in 1978 (left) and 2012 (right)

5.6.1 Recently Observed Shoreline Erosion

Typical shoreline erosion issues were observed throughout the study area following the wave and storm tide event associated with ex-Tropical Cyclone (TC) Oswald (January 2013). Examples of notable erosion and seawall damage that occurred within the Deception Bay and Beachmere beach units are shown in Figure 5-16. Damaged shoreline structures compromise public safety and are an ongoing maintenance issue for Council.

Figure 5-16 Recently Observed Shoreline Erosion: (a) Sink Hole and (b) Seawall Failure at Captain Cook Parade, Deception Bay; (c) Exposed Shoreline Fill and (d) Closed Beach Access at L & M Lehman Park, Beachmere

Water level and wave data recordings during ex-TC Oswald are presented in Figure 5-17 and Figure 5-18. The water level data at Mooloolaba (approximately 50km north of the study area) suggest a residual tide (storm surge) peak close to 0.5m and a recorded water level (storm tide) close to Highest Astronomical Tide (HAT) was observed. It is assumed that similar conditions were experienced throughout the NMBSEMP study area.

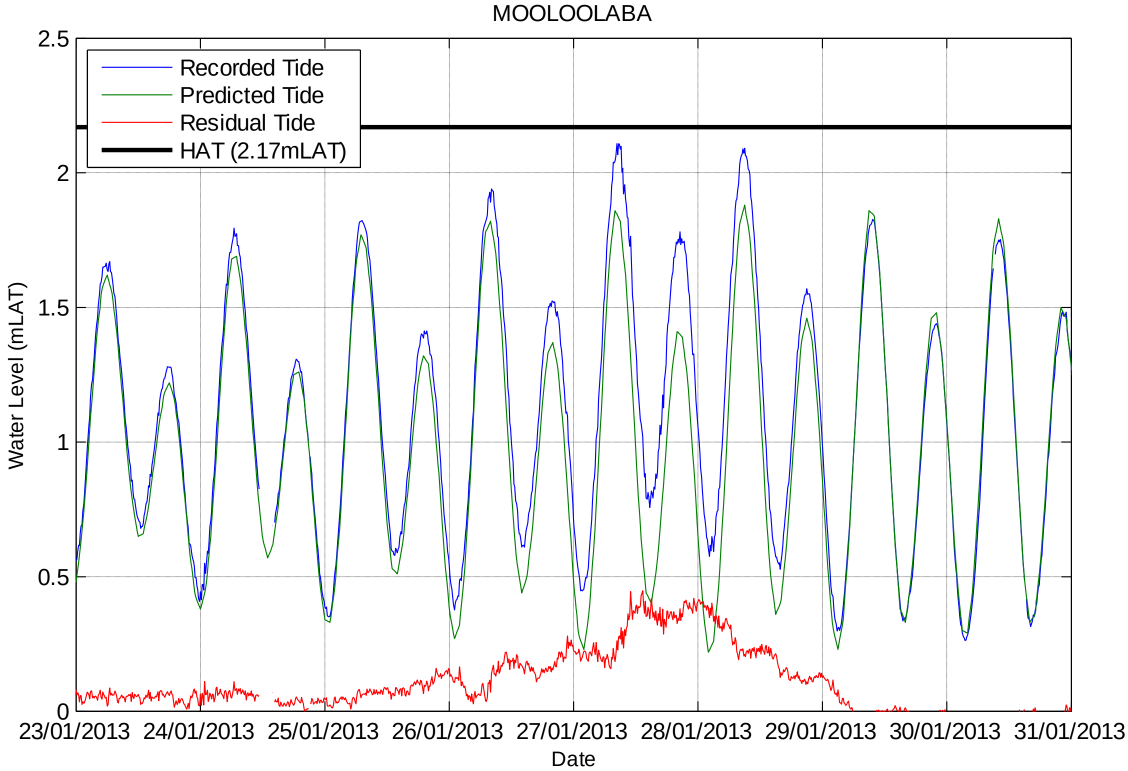

Figure 5-17 Recorded, Predicted and Residual Tide at Mooloolaba Storm Tide Gauge during ex-TC Oswald (data provided by DSITIA)

A maximum wave height (Hmax) of 10.3m was recorded by the Northern Moreton Bay buoy (located approximately 10km offshore from Bribie Island) during ex-TC Oswald. This is the largest wave measured since the installation of the instrument in 2010. The recorded significant wave height conditions with a peak of approximately 5.5m are much larger than the waves experienced at the study area shoreline. Wave energy dissipation due to wave refraction and wave breaking causes a reduction in wave height as waves propagate to the shoreline. It is notable that the peak wave conditions occurred from the east to north-easterly directional sector, allowing waves developed offshore to enter Moreton Bay.

The data recorded during ex-TC Oswald is used to inform a storm wave assessment presented in Section 6.3.3.

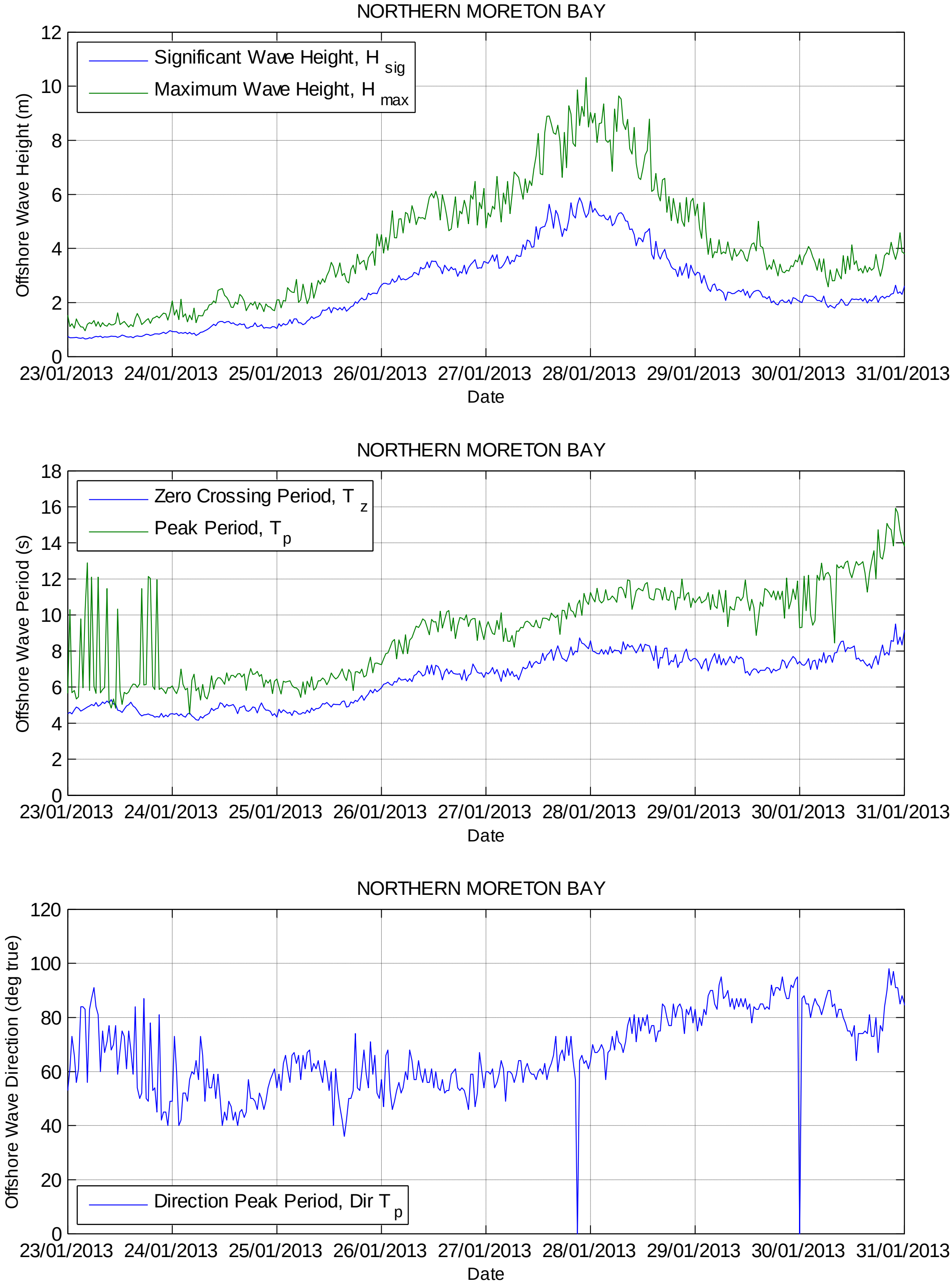

Figure 5-18 Recorded Wave Conditions Offshore from Bribie Island during ex-TC Oswald (data provided by DSITIA)