2. Study Area Coastal Assessments

2.1 Introduction

The shape and nature of the coastline within the study area is the product of a number of natural processes, including those relating to geomorphology, tidal currents, wind and wave climate, sea level, sediment movement and ecology. Each of these aspects have been considered below:

2.2 Geomorphology

The evolution of Bribie Island and Pumicestone Passage is complex and the result of significant sea level fluctuations that have occurred in the recent geological past. Importantly, tidal movements continue to heavily influence the Bribie Island shoreline. The following summary of the geomorphological history of the study area draws on the work of Armstrong (1990), Grosser (1995) and Jones (1992).

During the Pleistocene highstand (140,000 to 120,000 years before present), the sea level was 4 to 6 m higher than at present, and the coastline generally consisted of sand dunes backed by sand plains and peaty swamps, interspersed with occasional rocky headlands. In the vicinity of southern Pumicestone Passage, the coastline was approximately 3km west of its current location, and comprised beach ridges abutting Jurassic Landsborough Sandstone.

As sea level had been rising prior to this time, the shoreline was still adjusting to higher sea levels, resulting in erosion of the coastline. This allowed large volumes of sediment to be transported elsewhere along the coastline. In the vicinity of Caloundra, longshore transport was from north to south.

As these sediments were transported south, they fell out of suspension as they neared the northern end of Moreton Bay due to the growing influence of the concurrently forming Moreton Island and North Banks on the wave climate. These sediments became the basis of Bribie Island, and were located east of Bribie Island's current position. Pumicestone Passage at this time was wide, and as Bribie Island developed, ebb and flood tide deltas formed at the northern and southern ends of the passage, which strengthened the island's formation.

The Pleistocene lowstand (120,000 to 18,000 years before present) saw local sea levels fall to about 180 m below present levels. During this time, Bribie Island further developed into a strand plain. As the tidal inlet at the southern end of the Passage was still wide, sediment deposition into the ebb tide delta continued. By the time sea level had reached its lowest point, the main drainage line was the ancestral Elimbah Creek and the Pumicestone Passage area comprised a coastal plain.

Sea levels rose rapidly (estimated at 13 mm/year) during the Holocene Transgression (18,000 to 6,500 years before present). The ancestral Elimbah Creek mouth became progressively flooded, forming Pumicestone Passage. The increased water depths caused larger waves to impact on the coastline, resulting in increased erosion. Due to the gentle slope of the continental shelf, small changes in sea level resulted in large lateral shoreline movements. The eroded sediment was transported southwards and deposited on the southern end of Bribie Island and also carried by tides where it was deposited into Pumicestone Passage.

As sea levels continued to rise, Bribie Island and Pumicestone Passage migrated westwards. Sediments eroded from the eastern (ocean) shoreline of Bribie Island were ultimately distributed onto the southern and western sides of the islands, resulting in “roll-over” of the barrier island.

Sea levels ceased rising about 6,500 years ago (the Holocene Stillstand) when they reached approximately 0.4 to 1m above current levels. By 3,000 years before present they had stabilised at current levels. During this time, significant southward growth of Bribie Island occurred. This caused the longshore transport of sediments to bypass the southern inlet to Pumicestone Passage, instead depositing in ebb and flood delta deposits in the northern part of Moreton Bay. The reduced tidal currents from lower sea levels resulted in increased settling of fine fluvial sediments in the inter-tidal area and consequent expansion of vegetation such as mangroves.

Accordingly, on the western (mainland) side of Pumicestone Passage, the shoreline is generally muddy as the tidal currents are small. Conversely, the eastern (Bribie Island) side of Pumicestone Passage has sandy shorelines in the vicinity of the high energy tidal channels. The stability of the western shoreline of Bribie Island is therefore heavily influenced by the position of the tidal channels.

If sea levels continue to rise, it is expected that Bribie Island would continue to prograde southwards. Constriction of the southern inlet to Pumicestone Passage would further develop, and the northern inlet of Pumicestone Passage at Caloundra would widen due to scouring from increased tidal currents. The western shoreline of Bribie Island would recede as inundation progresses.

If sea levels stabilise, muddy sediments would continue to deposit within Pumicestone Passage, causing further reduction in tidal currents. Pumicestone Passage would likely evolve into an intertwined network of muddy channels with sandy deltas at each end.

2.3 Wind climate

The wind climate for the study area is based on wind records from the Bureau of Meteorology for the Inner Reciprocal Marker located in the northern part of Moreton Bay approximately 8km north-east of Redcliffe Jetty. The data recorded at this site was found to be more suitable than the Brisbane Airport site as it provided a more consistent and representative data set for the generation of waves that affect the study area. Figure 2 shows the annual wind climate in the form of a wind rose. The analysis is based on 7 years of continuous data (2 recordings/hour) between 2002 and 2009. The data has also been analysed seasonally and plots for the Summer, Autumn, Winter, and Spring seasons are shown in Figure 3 to Figure 6.

Figure 2 Wind Rose – Inner Reciprocal - Marker – Full Year

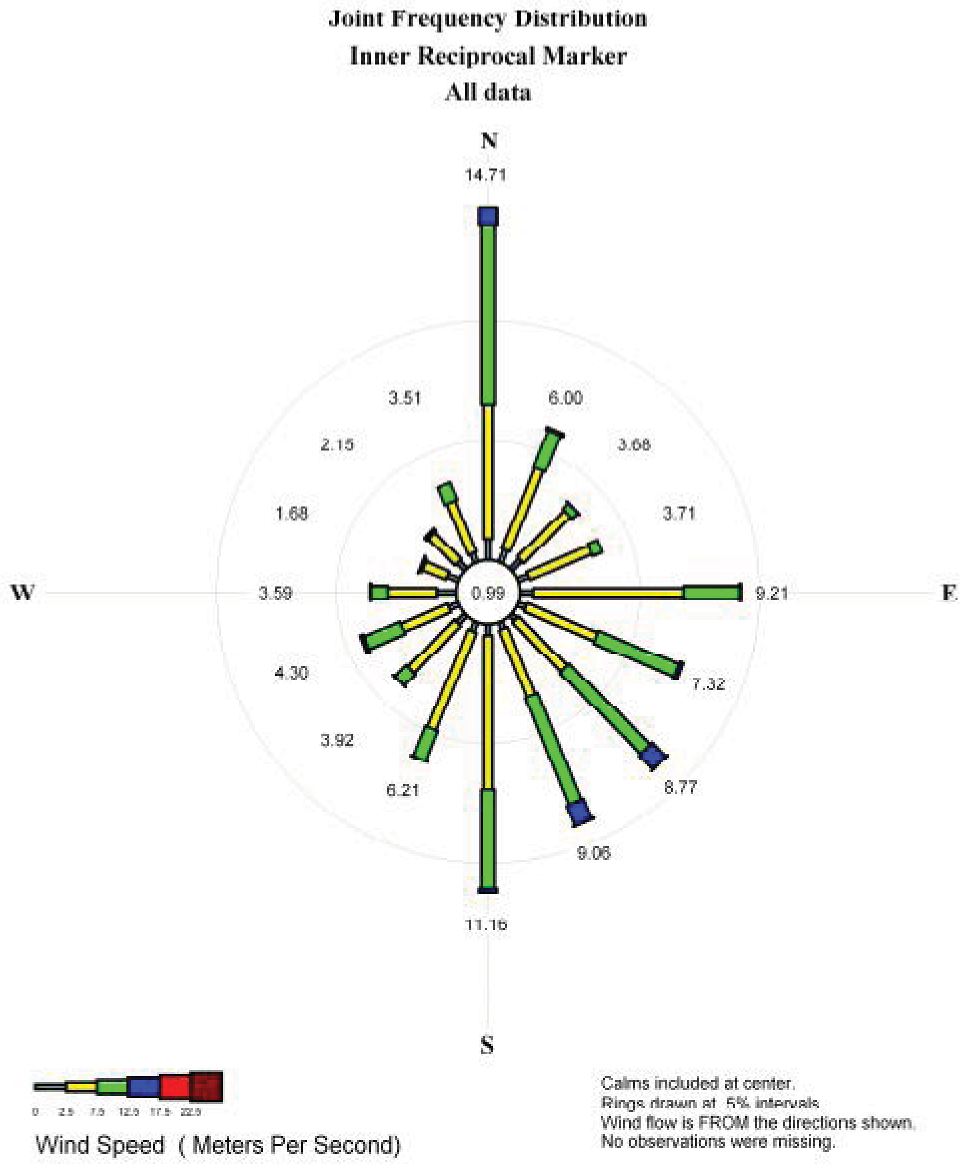


Figure 3 Wind Rose – Inner Reciprocal - Marker - Summer Season

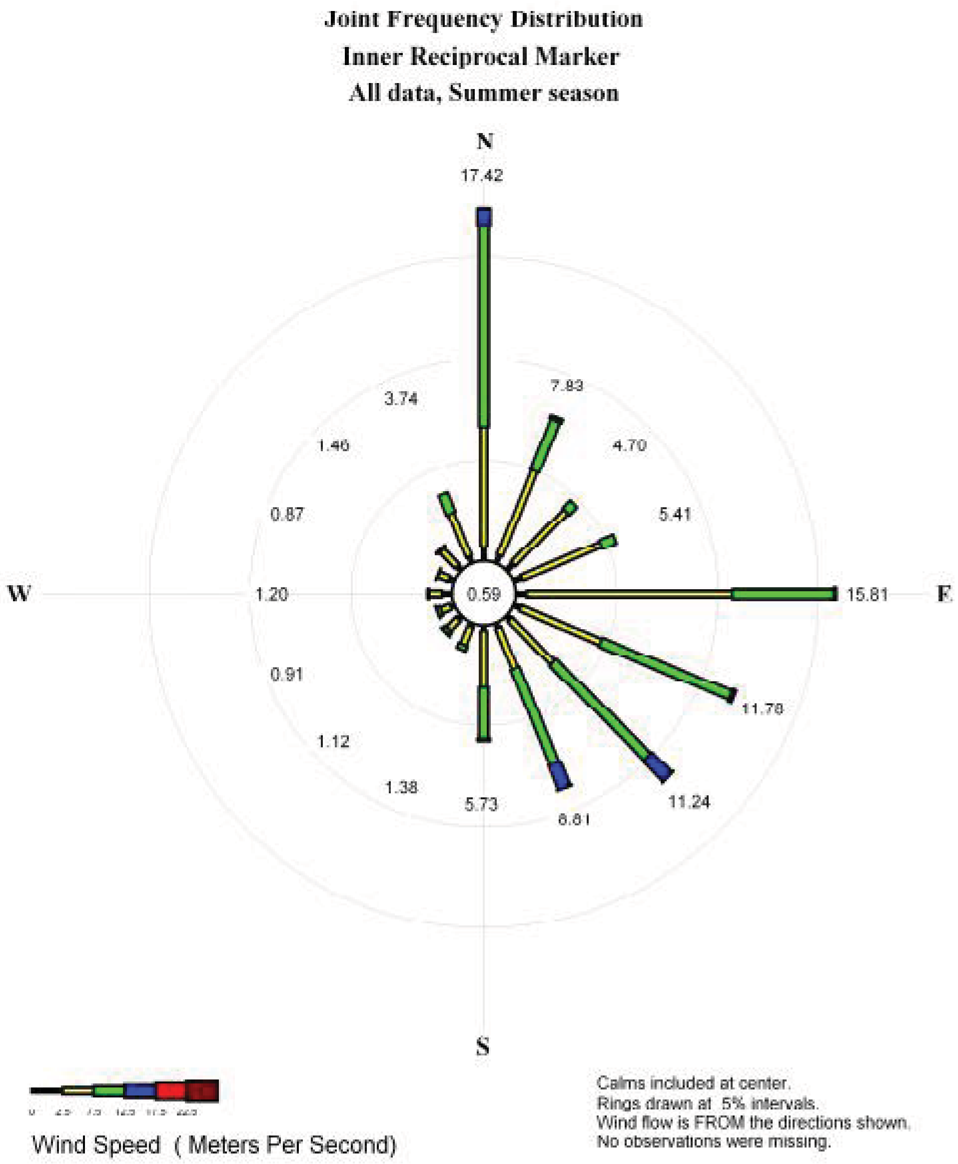
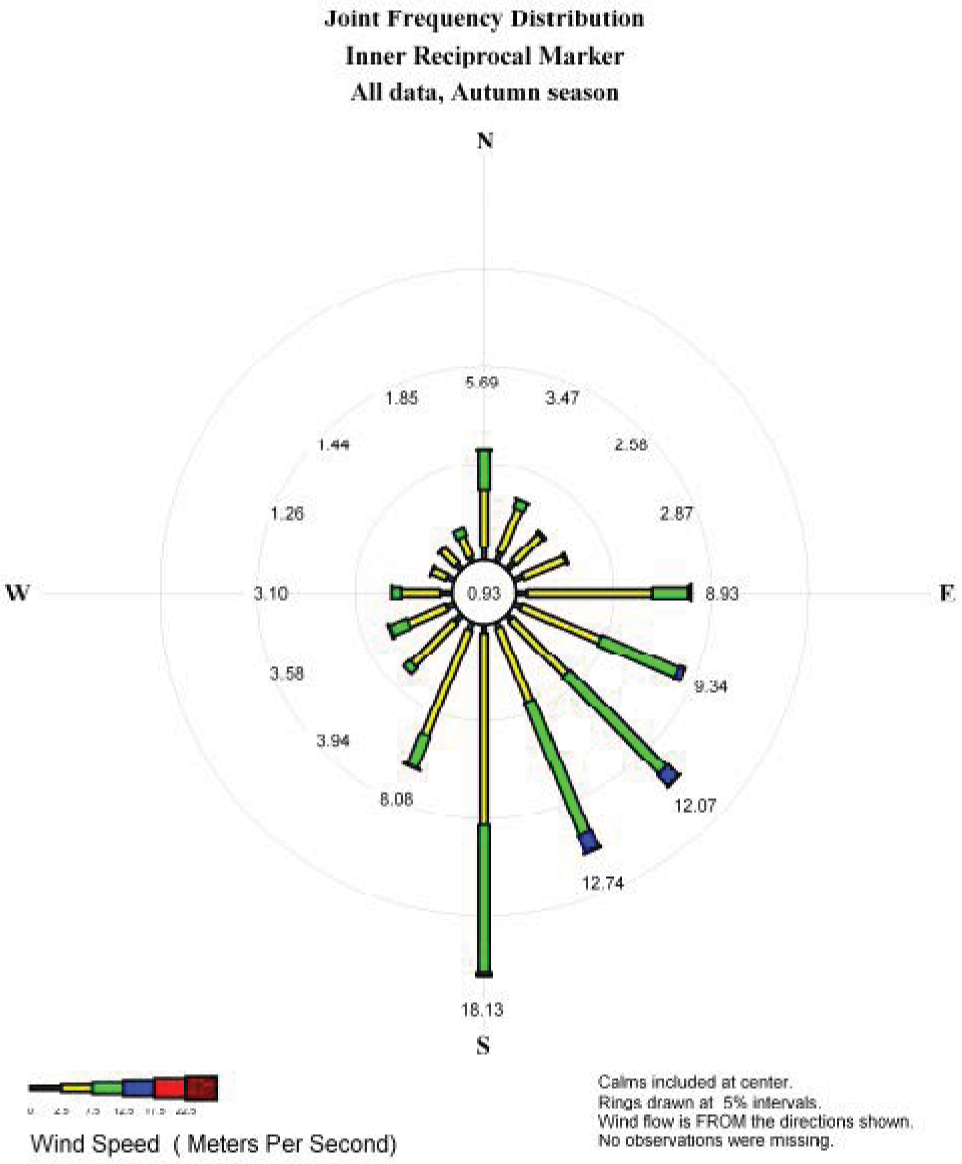


Figure 4 Wind Rose – Inner Reciprocal - Marker - Autumn Season



Calms included at center.
Rings drawn at 5% intervals.
Wind flow is FROM the directions shown.
No observations were missing.

Figure 5 Wind Rose – Inner Reciprocal - Marker - Winter Season

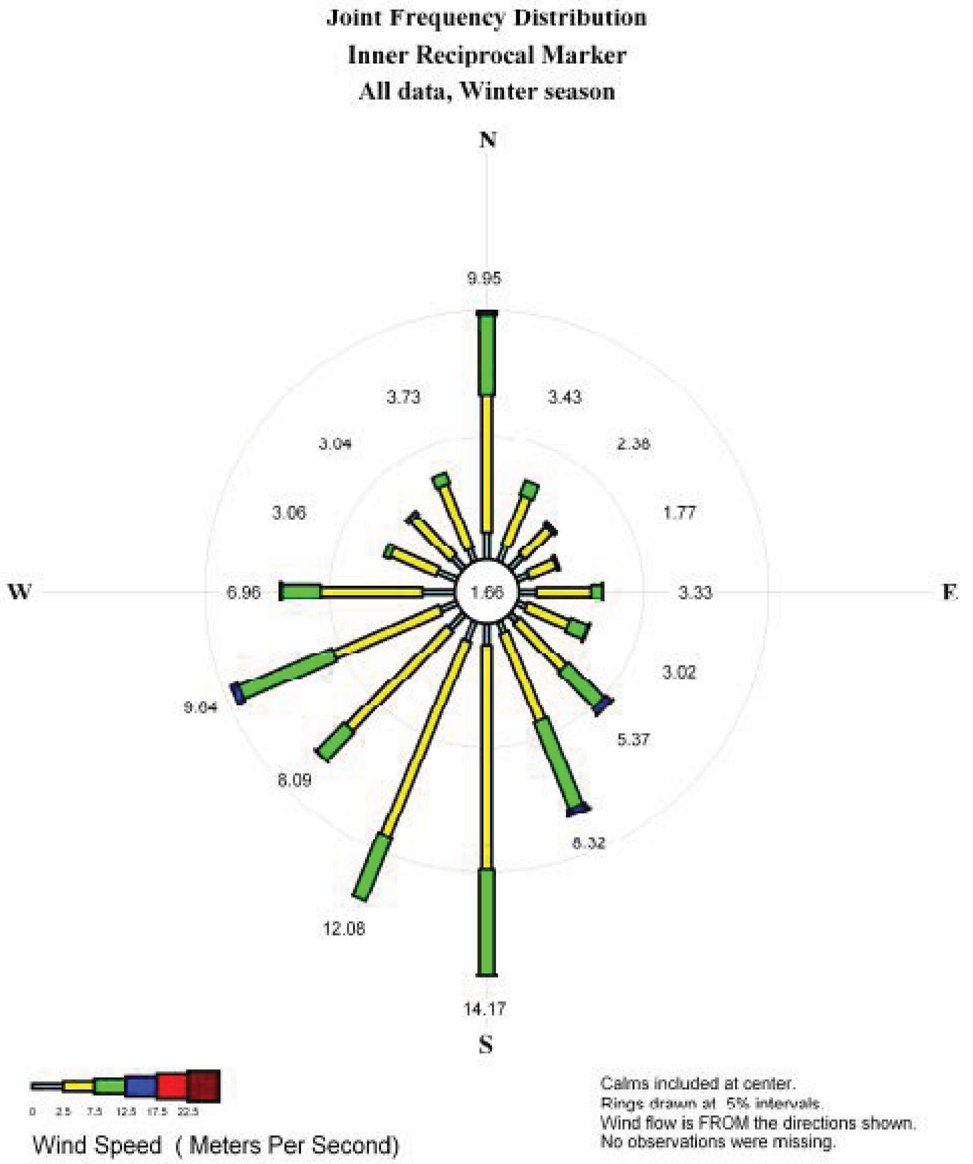
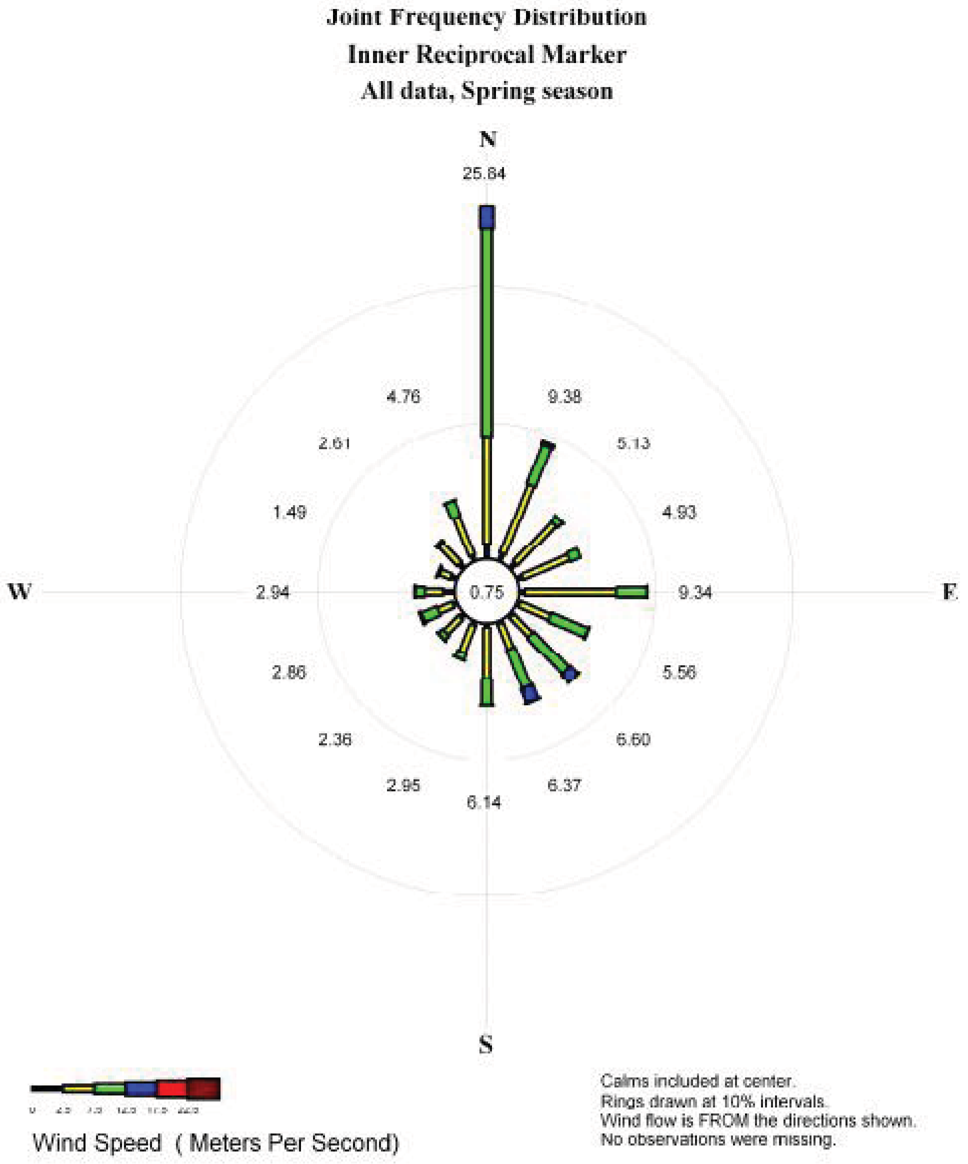


Figure 6 Wind Rose – Inner Reciprocal - Marker - Spring Season



Calms included at center.
Rings drawn at 10% intervals.
Wind flow is FROM the directions shown.
No observations were missing.

The yearly data wind rose (Figure 2) shows that the predominant winds are from the north and between the east and south with the strongest winds from the south–east. The wind rose for the Summer season (Figure 3) shows a similar pattern but with less winds from the southerly sector. Autumn winds (Figure 4) are predominantly from the south and south-east while in Winter (Figure 5) winds are mainly from the south to south-west and the north (10%). In Spring (Figure 6) winds from the north and north-east are the most common.

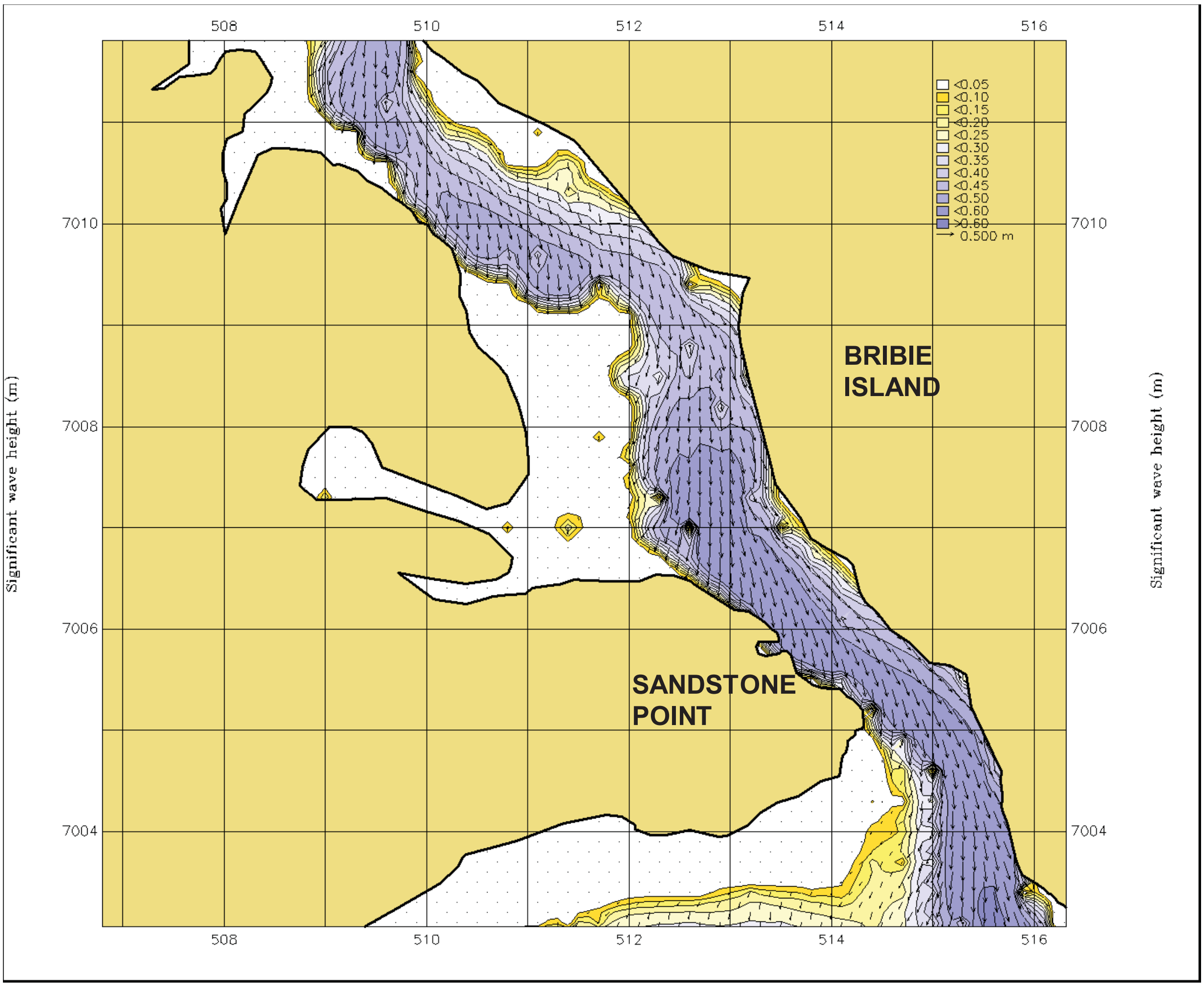
2.4 Wave climate

The wave climate was determined by using the wind climate as an input into a wave model that propagates the waves generated by the winds into the study area, taking into account wave refraction and shoaling and also generates waves from local winds at each location in the study area. The wave climate at any location can then be determined by combining the model results at that location with the percentage occurrence of the wind that generated the waves.

The wave model is an implementation of the SWAN model that computes random, short crested wind generated sea states in coastal regions and inland waters. The underlying hydrodynamics of the study area is based on a Delft-3D hydrodynamic model of the Moreton Bay area. A detailed description of the hydrodynamic and wave analysis is provided in Appendix A.

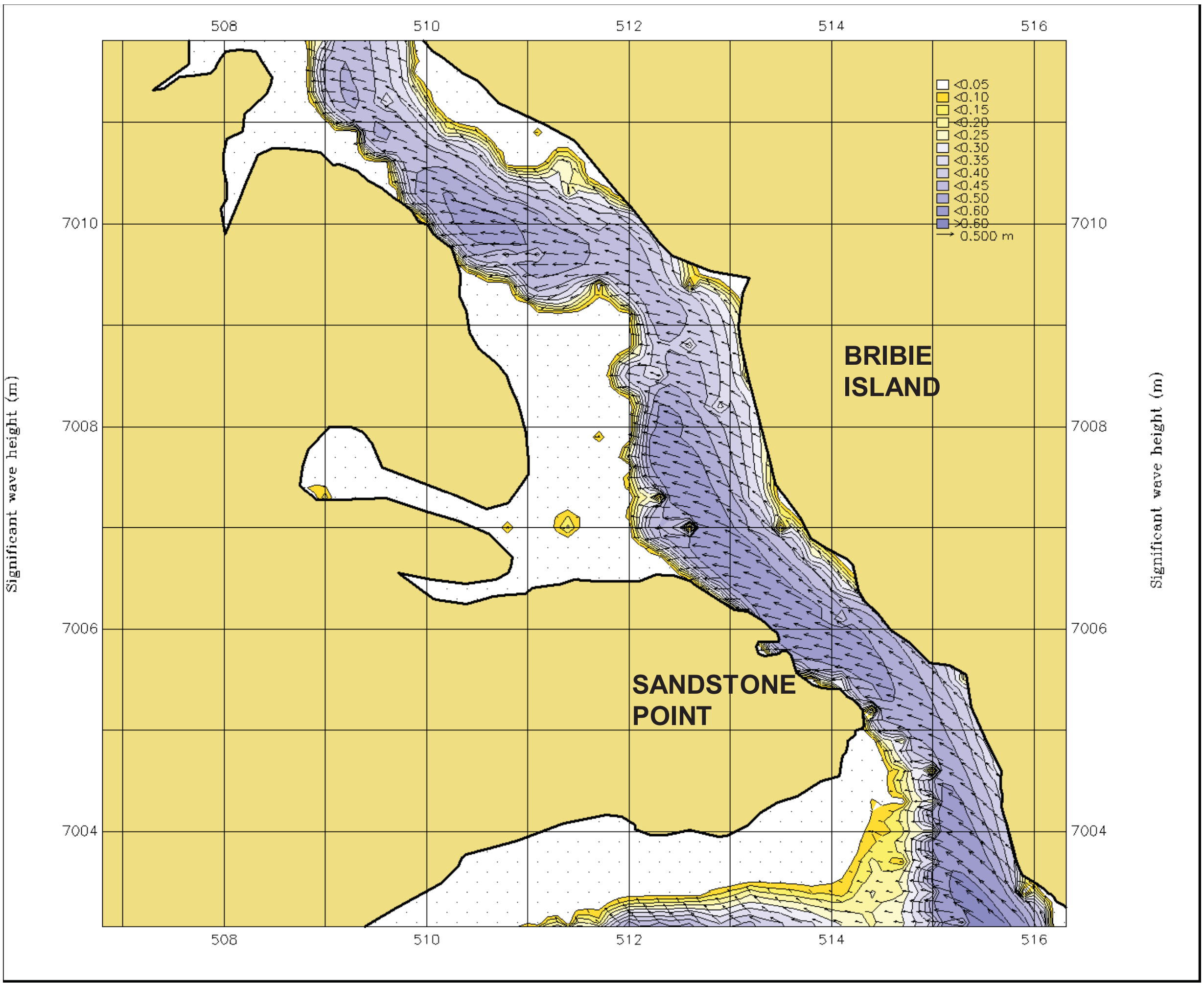
The wave model was run for 16 wind directions and 4 wind speeds. Examples of the wave patterns in the study area are shown on the following figures (Figures 7 to 10) for winds from the north, east, south, and west. The length of the arrows indicates the relative magnitude of the significant wave height; the direction indicates the direction of wave propagation.

Figure 7 Wave Height and Direction - Northerly Winds at 20m/sec



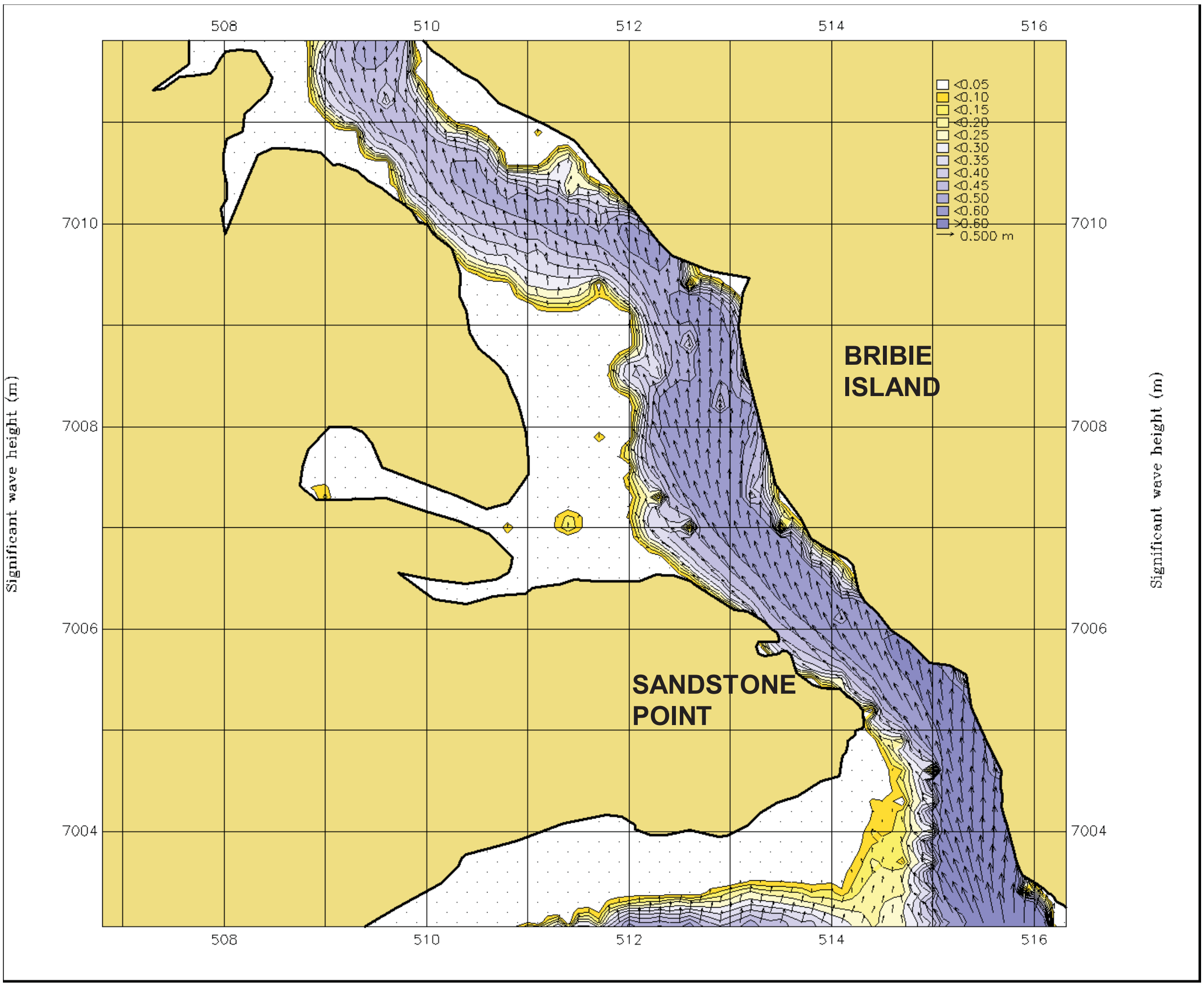
The northerly winds have the most impact on the Sandstone Point and Bongaree sections of the SEMP. Under these conditions longshore transport will be to the south. Note that the foreshore from Sylvan Beach to the Bribie Island Bridge is largely sheltered from the influence of northerly winds.

Figure 8 Wave Height and Direction - Easterly Winds at 20m/sec



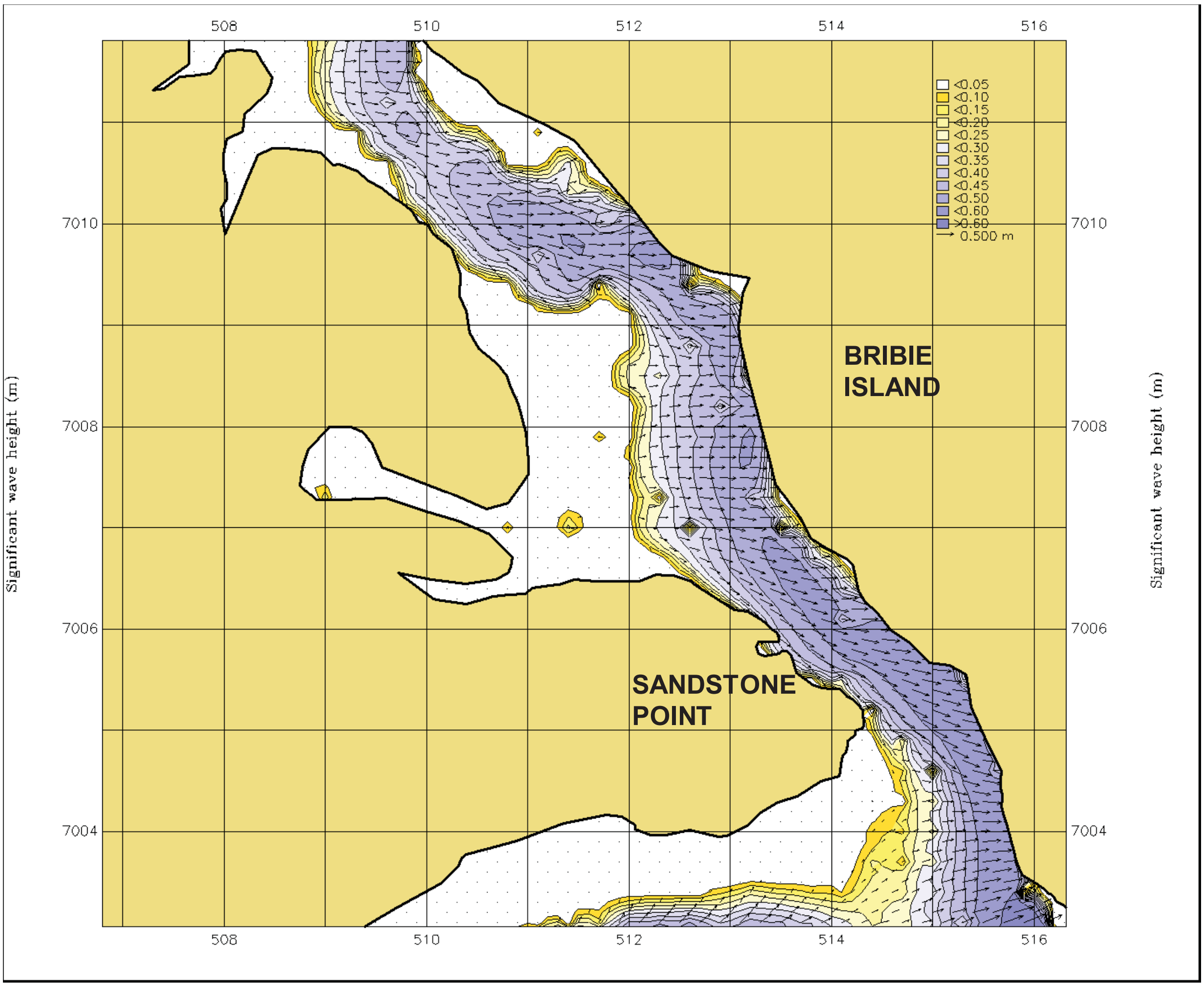
Easterly winds only affect the western side of the study area at Sandstone Point and will generate longshore transport of sand to the north. Elsewhere the winds from this direction are offshore. Within the passage the waves appear to be coming from the south-east due to the easterly waves in the top of Moreton Bay being refracted into the southern end of Pumicestone Passage.

Figure 9 Wave Height and Direction - Southerly Winds at 20m/sec



Southerly winds produce waves that propagate into Pumicestone Passage and refract into the shoreline resulting in significant longshore transport to the north in most places along the western foreshore of Bribie Island. Limited sheltering occurs at the Volunteer Marine Rescue base, Sylvan Beach and the southern part of Banksia Beach.

Figure 10 Wave Height and Direction - Westerly Winds at 20m/sec



Westerly winds are relatively unimportant in terms of longshore transport as wave heights are restricted by the short fetch across to the mainland and the alignment of the Bribie Island coastline means that the waves either meet or are refracted into the coast at right angles, reducing their potential influence on longshore sediment transport. The modelling shown above has been completed under high wind conditions, and it is worth noting that under normal wind conditions, the height of wind generated wave action is very small.

Longshore transport of sediment is described in further detail in Section 2.8.

2.5 Tidal water levels

The astronomical tide levels for the study area have been determined using published tide tables which provide derived tidal planes and predictions of high and low tide water levels. The 2010 Tide Tables published by Maritime Safety Queensland (MSQ, 2010) provide data for standard tidal planes for the study area (Table 1).

For this area, the Standard Port is the Brisbane Bar from which the tidal planes for secondary places are derived. The secondary places relevant to the study area are Bribie Beacon (South Point), Bongaree and Toorbul.

Table 1 Tidal Planes Lowest Astronomical Tide (LAT)

Tidal Plane	Brisbane Bar	Bribie Beacon (South Point)	Bongaree	Toorbul
	m (LAT)	m (LAT)	m (LAT)	m (LAT)
Highest Astronomical Tide, HAT	2.73	2.39	2.35	2.16
Mean High Water Springs, MHWS	2.17	1.91	1.87	1.71
Mean High Water Neaps, MHWN	1.78	1.57	1.53	1.41
Australian Height Datum, AHD	1.243	----	1.10	----
Mean Sea Level, MSL	1.27	1.09	1.06	0.93
Mean Low Water Neaps, MLWN	0.76	0.69	0.65	0.60
Mean Low Water Springs, MLWS	0.37	0.36	0.32	0.29
Lowest Astronomical Tide, LAT	0.00	0.00	0.00	0.00
Chart Datum, CD	0.00	----	----	----

From Table 1 it can be seen that the tidal range attenuates as the tide propagates northwards into Pumicestone Passage. The degree of attenuation between South Point and Toorbul, which approximate the southern and northern study area limits, is about 10%. The variation at most places in the study area will therefore be relatively small (<5%) and hence, for the purposes of referencing tidal levels in this report, the levels at Bongaree will be used. The levels at Bongaree to both the LAT datum and Australian Height Datum (AHD) are presented in Table 2.

Table 2 Tidal Planes for Bongaree

Tidal Plane	Bongaree	
	m (LAT)	m (AHD)
Highest Astronomical Tide, HAT	2.35	1.25
Mean High Water Springs, MHWS	1.87	0.77
Mean High Water Neaps, MHWN	1.53	0.43
Australian Height Datum, AHD	1.10	0.00
Mean Sea Level, MSL	1.06	-0.04
Mean Low Water Neaps, MLWN	0.65	-0.45
Mean Low Water Springs, MLWS	0.32	-0.78

Tidal Plane	Bongaree	
	m (LAT)	m (AHD)
Lowest Astronomical Tide, LAT	0.00	-1.10
Chart Datum, CD	0.00	-1.10

2.6 Tidal Current

Information on tidal currents was derived from the hydrodynamic model developed for this project. A detailed description of the model used, calibration and verification of the model, and model results is provided in Appendix A. A brief summary of the results is provided as follows:

- The flood tide flows from south to north (i.e. propagating up from Moreton Bay into Pumicestone Passage), reaching a peak velocity of 0.8 m/s along the coast at Bellara and approximately 0.45 m/s in the vicinity of Banksia Beach. Flood tide current patterns for a large spring tide are shown in Figure A-5 in Appendix A.
- The ebb tide flows from north to south (i.e. from the middle reaches of Pumicestone Passage to the top end of Moreton Bay), reaching a peak velocity of 0.6 m/s at Bellara and 0.8 m/s offshore from Banksia Beach. Ebb tide current patterns for a large spring tide are shown in Figure A-6 in Appendix A.

The results presented provide a snapshot of the tidal currents and flow patterns for particular times in the tidal cycle. However, the model results can be interrogated to provide results for any time in the tidal cycle and detailed results for particular areas in the study area can be provided as required, for example, for the assessment of coastal management options that affect, or are affected by tidal currents.

2.7 Storm tide

The total seawater level experienced at a coastal, ocean, or estuarine site during the passage of a severe cyclone will be made up of relative contributions from a number of different effects, as depicted in Figure 11. The combined or total water level is then termed the storm tide, which is the absolute water level, referenced in this report to AHD. A description of the components of a storm tide is provided in GHD (2003) and is repeated here for clarity.

Components of a storm tide

(a) The astronomical tide

This is the regular periodic variation in water levels due to the gravitational effects of the moon and sun, which can be predicted with generally a very high degree of accuracy at any point in time (past and present) if sufficient measurements are available. The highest expected tide at any location is termed the HAT and occurs once each 18.6 year period, although at some sites tide levels similar to HAT may occur several times per year – in the study area this will be in January/February during the day and July/August at night. Tidal water levels for the study area are discussed in Section 2.5.

(b) Storm surge

This is the combined result of the severe atmospheric pressure gradients and wind shear stress of a severe weather event such as a tropical cyclone acting on the underlying ocean. The storm surge is a long period "wave" capable of sustaining above-normal water levels over a number of hours. The water travels with and ahead of the storm and may be amplified as it progresses into shallow waters or is confined by coastal landforms. Typically, the length of coastline which is severely affected by a tropical cyclone storm surge is of the order of 100km either side of the cyclone track although some influences may extend many hundreds of kilometres. The magnitude and real impact of the surge is affected by many factors such as storm intensity, size, speed and angle of approach to the coast and the coastal bathymetry.

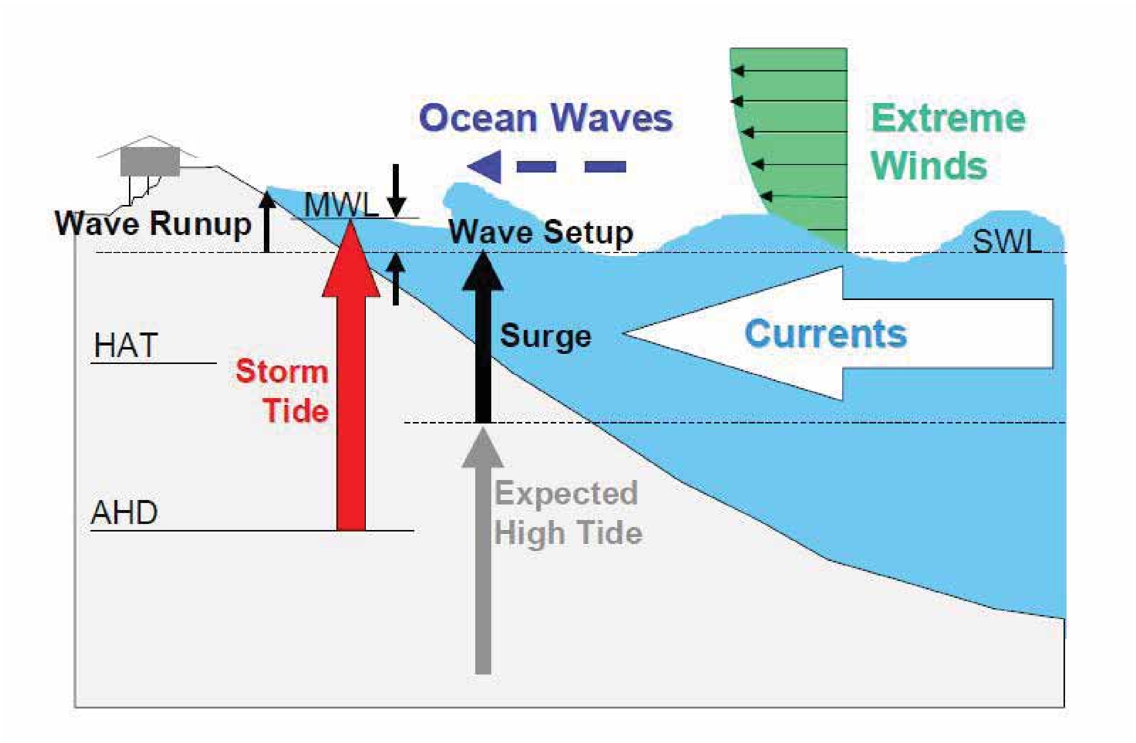
(c) Breaking wave setup

Severe wind fields also create abnormally high sea conditions and extreme waves may propagate large distances from the centre of a cyclone as ocean swell. As the waves enter shallower waters they refract and steepen until their stored energy is dissipated by wave breaking either offshore or at a beach. After breaking, a portion of the wave energy is converted into forward momentum which, through the continuous action of many waves, is capable of sustaining shoreward water levels which are above the offshore still-water level. This increase in still water level is known as breaking wave setup. However, because the study area is not exposed to the direct influence of ocean waves, wave setup will be negligible.

(d) Wave runup

Wave runup may cause localised impacts and erosion at elevations above that of the nominated storm tide level. The extent of wave runup is highly variable along a shoreline as it depends on the slope of the shoreline, shoreline porosity, vegetation, presence of structures, and the incident wave height and period. As above, because of the protected nature of the study area, this effect is negligible in the determination of storm tide levels.

Figure 11 Water Level Components of an Extreme Storm Tide (GHD 2003)



The Ocean Hazards Assessment Stage 3 Report (OHAR3) presents the work of a number of peak bodies in relation to the risk of inundation due to storm surge. The report addresses:

- Risks of inundation due to storm surge with the sea level at its present level; and
- Projections to the risk of inundation from sea levels accounting for the recommendations of the Intergovernmental Panel on Climate Change Assessment (IPCC) on Sea Level Rise.

The Ocean Hazards Assessment Stage 2 Report (OHAR2) presents a report on tropical cyclone-induced water levels and waves for Hervey Bay and the Sunshine Coast.

Notwithstanding the recommendations of the IPCC which have been included within the Ocean Hazards Stage 3 Report, the analysis in this report uses the storm surge projections without sea level rise and adds the sea level rise component assessed in Section 0. The closest site for which the Ocean Hazards Assessment Stage 2 Report quotes the storm tide statistics is Woorim on the eastern side of Bribie Island, and the closest site for which the Ocean Hazards Assessment Stage 3 Report quotes the storm tide statistics is Scarborough on the northern end of the Redcliffe peninsula (south of the study area).

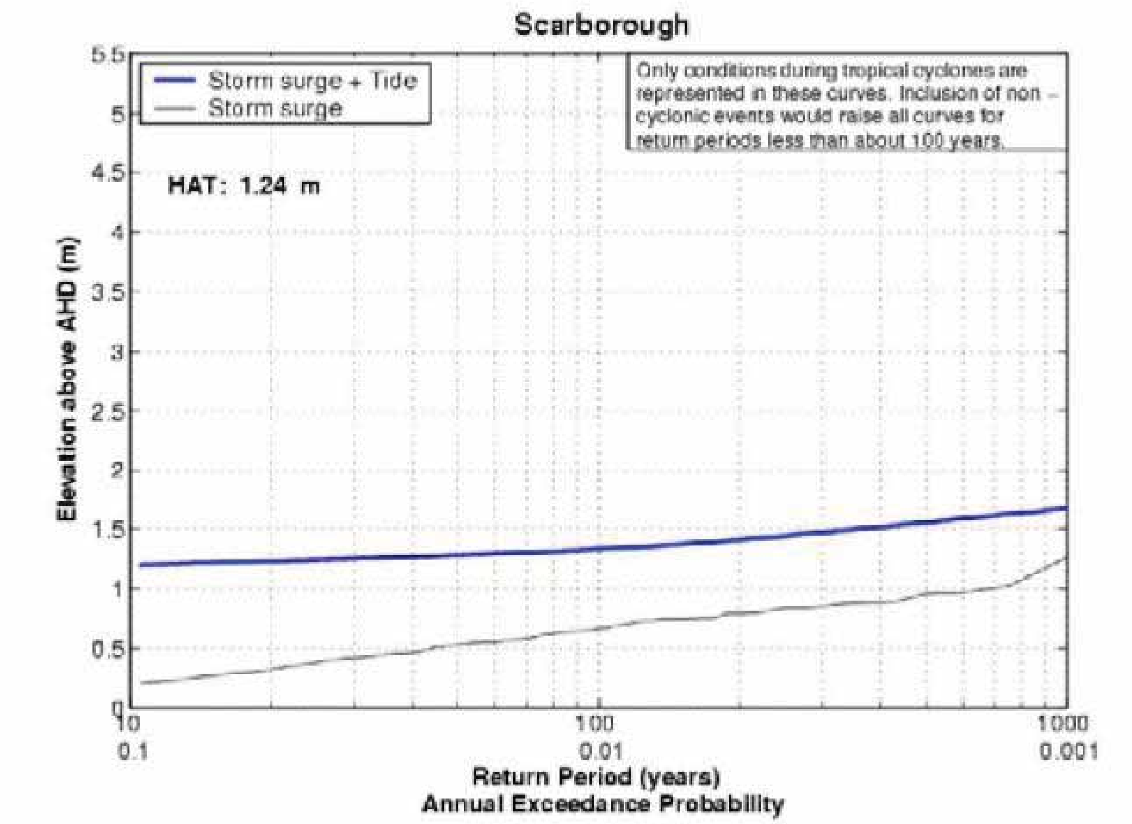
The recommendations of the Ocean Hazards Stage 2 and 3 Reports (OHAR2 and OHAR3) provide storm surge levels (not including the potential for sea level rise) for a range of extreme weather events with varying annual recurrence intervals (ARI's); a summary is contained in Table 3.

Table 3 Storm Surge Levels

	Storm Surge Water Level (excluding Sea level Rise)		
	ARI 100 years	ARI 500 years	ARI 1000 years
Woorim HAT = 2.14 m LAT	2.40 m LAT 1.30 m AHD 0.26 m above HAT	2.43 m LAT 1.33 m AHD 0.29 m above HAT	2.60 m LAT 1.50 m AHD 0.46 m above HAT
Scarborough HAT = 2.41 m LAT	2.50 m LAT 1.33 m AHD 0.09 m above HAT	2.72 m LAT 1.55 m AHD 0.31 m above HAT	2.84 m LAT 1.67 m AHD 0.43 m above HAT

The water level frequency plot for Scarborough is shown in Figure 12.

Figure 12 Water Level Frequency – Scarborough (OHAR3)



Only conditions during tropical cyclones are represented in these curves. Inclusion of non - cyclonic events would raise all curves for return periods less than about 100 years.

Marine Modelling Unit, School of Engineering, James Cook University

Figure A48. Water level frequency: *Scarborough*

The tidal parameters for Scarborough and its location within Moreton Bay are similar to the study area and hence the storm tide characteristics for Scarborough provide a realistic estimate of storm surge levels in the study area. The resulting storm surge levels for Bongaree are presented in Table 4.

Table 4 Storm Surge Levels (excluding Sea Level Rise) - Bongaree

	Storm Surge Water Level (excluding Sea level Rise)		
	ARI 100 years	ARI 500 years	ARI 1000 years
Bongaree	2.44 m LAT	2.66 m LAT	2.78 m LAT
HAT = 2.35 m LAT	1.34 m AHD	1.56 m AHD	1.68 m AHD
	0.09 m above HAT	0.31 m above HAT	0.43 m above HAT

The water levels derived above are based on the best available information at the time and should be used with caution, particularly given to the study area location in relation to the nearest result location in the storm tide water level study. With time it is expected that later studies will recommend the adoption of different water levels as a result of more detailed analyses that are specifically focussed on this study area and with the benefit of more recent data on storm surges and sea level rise. However, by the nature of these studies that deal with predictions and risk of occurrences, the results should always be used with a degree of caution.

2.8 Sea level rise due to climate change

Sea level rise is an important component of coastal hazard assessment and is applied as an additional increment to tide and storm surge. Quantification of sea level rise will be related to the design life of the infrastructure under consideration.

The analysis of sea level rise draws on the 2007 Assessment Report 4 (AR4) by the Intergovernmental Panel on Climate Change (IPCC (2007)) and on the update report produced by the Antarctic Climate and Ecosystems Cooperative Research Centre in 2008 entitled *A post IPCC-AR4 Update on Sea Level Rise* (ACECRC (2008)).

The AR4 model projections (with a 90% confidence range) are for a sea level rise of 18 to 59cm by 2095 plus an allowance of another 10-20cm for potential dynamic response of the ice sheets at the poles. The potential dynamic response is the persistent, possibly accelerating, sliding of the ice sheets and outer glaciers over the bedrock, leading to a faster loss of ice.

The update by the Antarctic Climate & Ecosystems Cooperative Research Centre reviewed the 3rd and 4th Assessment Reports and concluded that the projections are similar, particularly for the upper limits.

Figure 13 Sea Level Rise Projections (extract from Antarctic Climate and Ecosystems Cooperative Research Centre Report)

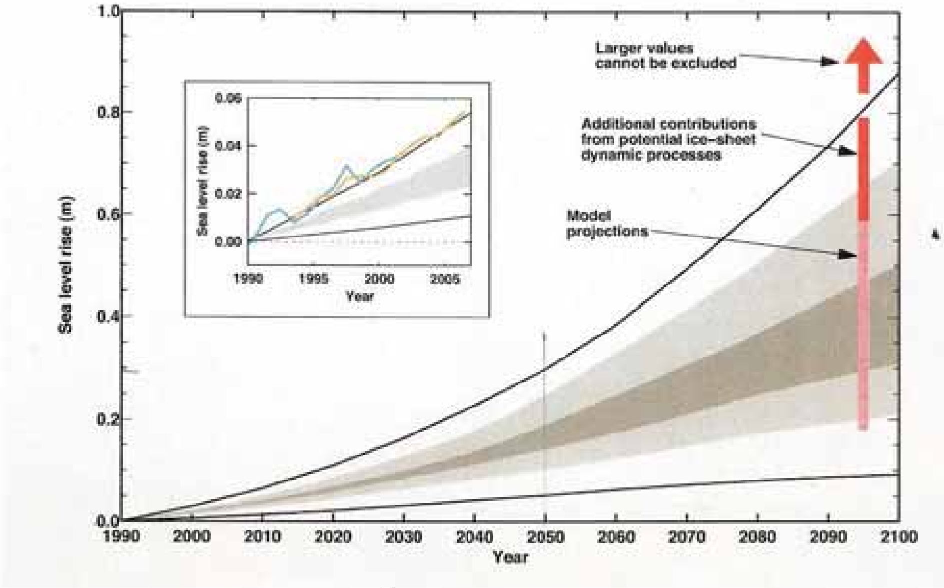


Figure 2.
TAR and AR4 projections of sea-level rise.[2,7]

The TAR projections are indicated by the shaded regions and the curved lines are the upper and lower limits. The AR4 projections are the bars plotted at 2095. The inset shows sea level observed with satellite altimeters from 1993 to 2006 (orange) and observed with coastal sea-level measurements from 1990 to 2001 (blue).

The base graph in Figure 13 is the 3rd Assessment Report (TAR) projections. The AR4 projections for 2095 are shown by the coloured bar and include a contribution for ice sheet dynamic processes. The outer black lines represent the full range of projections. The year 2100 projections of sea level rise (above 1990 levels) range from 9 to 88cm.

The inset graph in Figure 13 depicts actual sea level rise observed with satellite altimeters from 1993 to 2006 and observed with coastal sea level measurements from 1990 to 2001.

For coastal development, the key observations are:

- The observed sea level is currently tracking near the upper end of the IPCC projections from the start date of projections in 1990; and
- The simple statistical models are consistent with a sea level rise closer to the upper end of the IPCC projections.

Accordingly, the projections based on the upper limit curve should be used in design.

Another water level component that should be considered is the additional site specific sea level rise. For the east coast of Queensland this has been determined as 5cm (refer to Figure 10.32 in the Working Group Report *The Physical Science Basis* within AR4).

The recommended allowances for sea level rise are therefore:

- 0.84m for a design life of approximately 100 years; and
- 0.35m for a design life of approximately 50 years.

It should be noted that this sea level rise applies across the oceans and is not subject to the dynamic effects which cause the local amplification of tide and surge.

This is a technical assessment of sea level rise and can be used in design in the absence of regulatory levels set by government. Current recommendations of allowances for sea level rise in government policies are provided in the following section.

2.8.1 Government policies

The current State Coastal Management Plan 2001 recommends an allowance for sea level rise over a planning period of 50 years of 0.3m.

The draft revised State Coastal Management Plan recommends the following in the Draft State Planning Policy Coastal Protection for development not subject to a development commitment:

a) Planning period of 100 years;

b) Projected sea level rise of 0.8m by 2100 due to climate change;

c) Adoption of the 100 year average recurrence interval extreme storm event or water level; and

d) Allowance for an increase in cyclonic intensity by 10% due to climate change.

For development subject to a existing development commitment, the sea level rise component is scaled back in proportion to the planning period for the development, such that, for example, the projected sea level rise to be used for a 50 year life is 0.3m.

The State Government Centre for Climate Change, in their report on Climate Change in South East Queensland Region, advises that the 1-in-100-year storm tide event is projected to increase by 0.44m at Wellington Point in Moreton Bay. This increase is made up of 0.30m sea level rise, the effect of a 10% increase in cyclone intensity and frequency, and a 130km southerly shift in cyclone tracks. The Climate Change report uses the Ocean Hazards Assessment Reports (OHAR3) as the basis of its assessment.

2.8.2 Water levels for future planning

As indicated in Section 2.6, the analysis of water levels for future planning uses the storm surge projections without sea level rise and adds the sea level rise component assessed in Section 0. Using this methodology, the adopted future water levels for a 50 year and 100 year planning period for Bongaree have been derived and are presented in Table 5. For consistency with the Draft State Planning Policy Coastal Protection, the 50 and 100 year sea level rise values from the draft policy have been used in lieu of the more conservative derived values in Section 0 (i.e. 0.30m instead of 0.35m for 50 years and 0.80m instead of 0.84m for 100 years).

Table 5 Water Levels for Future Planning - Bongaree

Bongaree	**Planning Period**	
Water level for a 100 year ARI event	50 years Sea level rise 0.30m	100 years Sea level rise 0.80m
Above AHD	1.64	2.14
Above LAT	2.74	3.24

Bongaree	Planning Period	
Above HAT	0.40	0.89

2.9 Aerial photography and imagery analysis

Recent and historical aerial photographs and satellite imagery of the coastline were analysed for each section of the study area in order to identify changes over time. The main focus of analysis was the line of foreshore vegetation and the tidal limit of the shoreline.

Imagery was gathered for the following years in order to achieve a significant temporal representation, although this was dependent on available imagery and scales captured:

- 2009 Quickbird (satellite) imagery;
- 2007 aerial photography;
- 2003 aerial photography;
- 1999 aerial photography (Beach Protection Authority run at 1:12,000 scale);
- 1990 aerial photography (Beach Protection Authority run at 1:12,000 scale);
- 1982 aerial photography (Beach Protection Authority run at 1:12,000 scale);
- 1975 aerial photography (Beach Protection Authority run at 1:12,000 scale);
- 1958 aerial photography (black and white at 1:12,500 scale); and
- 1942 aerial photography (black and white).

Imagery was initially checked for inaccuracies in the geographic rectification process, with any significant errors corrected through rectification to the 2009 Quickbird imagery. The Beach Protection Authority photography was obtained as rectified images and showed some errors when compared with the later imagery. It should be noted that slight errors in locations of features may occur between years, images and resolution scales.

The seaward extent of vegetation (including foredune vegetation and mangroves) and the upper tidal limit of the shoreline were digitised as lines in ArcGIS. The upper tidal limit was estimated through visual assessment of the high tide mark, however due to the scale and resolution of some images and the differences in tide levels at the time of photography capture, these shorelines are estimates only. This data was then analysed to identify patterns in shoreline changes over time. The results of this analysis are provided in each study area chapter.

2.10 Sediment transport

2.10.1 Sediment transport types

The movement of sediment along and across a sandy beach is one of the most important factors to be considered in a study of coastal processes, particularly in terms of foreshore erosion and the effects of erosion mitigation works on the coastal environment. The transport of sand under wave action falls into two categories:

- Longshore transport caused by waves breaking at an angle to the beach alignment; and
- Cross shore transport that usually occurs under storm conditions causing erosion of the dunes and foreshore.

Sand movement along a coastline can also be transported by tidal currents, forming flood and ebb tide sand shoals.

Longshore transport can be calculated from knowledge of the wave climate, the coastline shape and bathymetry, and the sediment size. For this study, the wave climate has been determined from the wind climate using a mathematical wave model to calculate the wave conditions at various locations in the study area.

The determination of cross shore transport requires knowledge of the beach profile, water levels, and wave heights and periods. These calculations are usually associated with studies to evaluate the buffer requirements for erosion under certain storm conditions. Calculations for particular areas, where required, will form part of Stage 2 of the SEMP.

An overview evaluation of sand transport under tidal currents for the various locations in the study area has been carried out using aerial photography and the findings are contained in Chapters 3 to 9.

The results of the assessment of the longshore transport in the study area are presented in Section 2.10.2.

2.10.2 Longshore transport

Using the wind climate and wave modelling details, the following parameters have been calculated for locations along the foreshore, on an annual and seasonal basis.

1. Average potential sand transport to the north;
2. Average potential sand transport to the south; and
3. Average potential net transport.

The locations at which the calculations were carried out are shown on Figure 14.

The longshore transport calculation uses the relationship derived by Kamphuis (1991).

A sediment grain size of 0.3mm has been used for all sediment from transport calculations and is based on the sediment size of sand at Woorim. This is considered to be a reasonable assumption given the movement of sand from Woorim to the southern end of Bribie Island and then into Pumicestone Passage. For the purposes of this study a small variation in the sediment size will not affect the overall longshore transport results to a significant extent, as testing of the formulation indicates that for a variation of 0.1mm in sediment grain size (0.2mm and 0.4mm). the variation in sediment transport is -8% to +3% respectively, compared with the calculations for 0.3mm.

The longshore transport described above does not include the influence of tidal currents on the movement of sand in the intertidal zone close to the coast. The net transport due to tidal currents is unlikely to be significant in this area as the tidal currents tend to be concentrated in the deeper areas offshore from the beach. Tidal currents have the greatest influence over the sand shoals that occur in Pumicestone Passage with wave induced transport being the predominant driver of sediment along the shoreline.

LEGEND

— Main Roads

● Location of Longshore Transport Calculation

1:24,000 (at A3)

0 0.125 0.25 0.5 0.75 1

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

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Longshore Transport Locality Plan

Figure 14

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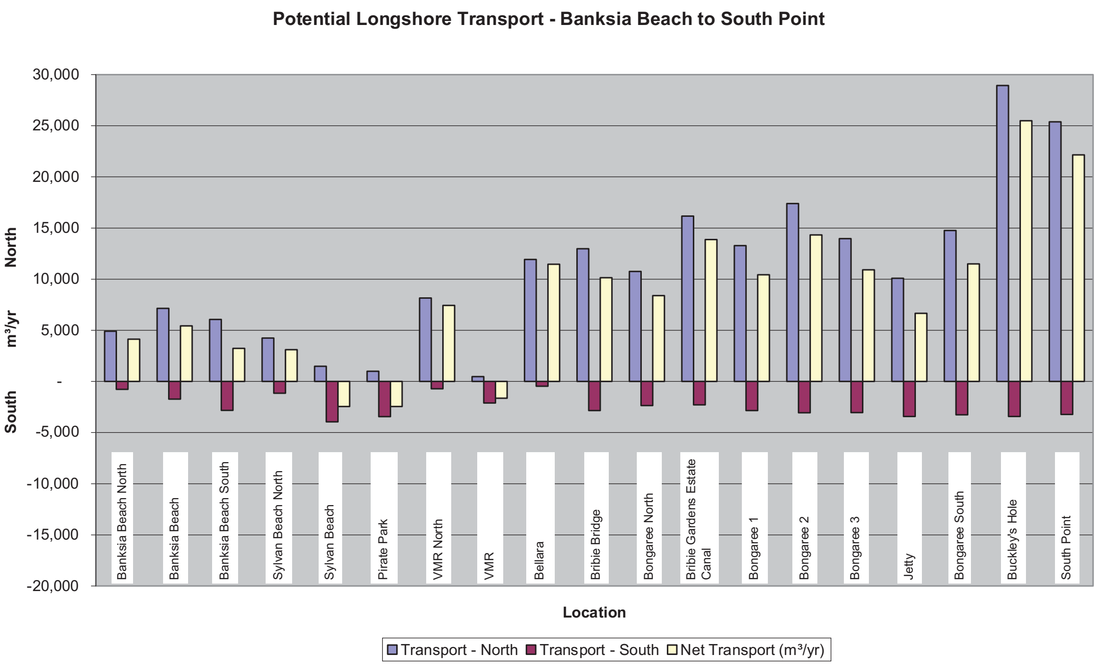
4-6 Innovation Parkway, Birtinya QLD 4575 **T** 61 7 5413 8100 **F** 61 7 5413 8199 **E** **W** www.ghd.com.au

Data source: MBRC, ROADS, 2009; Google Earth Pro, Image, 2009. Created by: S Potts

The graph in Figure 15 shows the annual transport at the locations between South Point and Banksia Beach and Figure 16 shows the same information for Sandstone Point (near the Bribie Bridge) to Turner's Camp. Note that transport to the North has been plotted as positive (above the zero line) and transport to the South is negative (below the zero line) in both figures.

The results are described as "potential" longshore transport because the volumes calculated represent the potential sand transport which will only be realised with a sufficient quantity of material available for transport and a sandy beach on which the transport can occur. In areas where these conditions are not met, such as where the recreational beach has already been eroded and the shoreline is protected by a revetment wall, the "potential" transport is not realised, which has implications on the sediment budget for an area and the long term beach stability.

Figure 15 Longshore Transport Results – South Point to Banksia Beach



From Figure 15 the following observations can be made:

1. The average annual net transport is to the north except at the lower end of Sylvan Beach;
2. Transport rates are highest at the southern end of the study area due to the exposure of this area to the prevailing south-easterly waves in Moreton Bay;
3. Transport rates at Bongaree Jetty are less than areas on either side of the jetty, leading to the conclusion that the sand build-up at the Jetty is caused by the combination of natural processes as well as the presence of the jetty and pontoons;

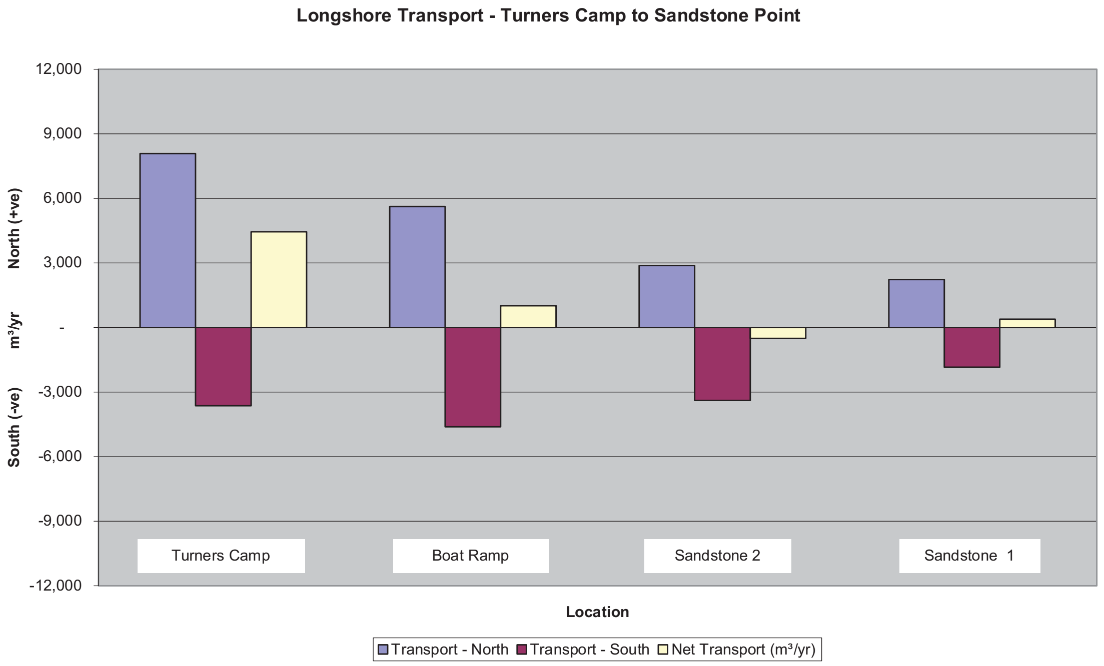
4. The embayment in which the voluntary marine rescue (VMR) and boating infrastructure are located is an area of low longshore transport and is probably a “sink” for sand being transported from the south;

5. The relatively higher transport rates at VMR North are due to the exposure of this area to waves propagating up Pumicestone Passage from the south with very little southwards transport due to the sheltering of this area from northerly waves;

6. The average net transport at Sylvan Beach is to the south due to its exposure to northerly waves. The orientation of the coastline in this area reduces the influence of the waves propagating up the passage from Moreton Bay resulting in the domination of northerly waves; and

7. The shoreline at Banksia Beach becomes progressively more exposed to southerly waves propagating up Pumicestone Passage and refracting to the east to break on the beach at an angle that maximises the potential transport. This effect is reduced at the northern section of this beach adjacent to Wrights Creek as the coastal alignment is further to the east which provides more shelter from northerly waves.

Figure 16 Longshore Transport Results – Sandstone Point to Turners Camp



From Figure 16 the following observations can be made:

1. The average annual net transport is virtually zero along the coastline between the Bribie Bridge and the entrance to Spinnaker Sound, due to small but equal transport volumes to the north and south.
2. The net transport at Turner’s Camp is to the north and this is supported by the extensive sand bank that has formed off the northern tip of this beach.

The seasonal variation of the longshore transport at the various locations is shown in the relevant figures in the following chapters for each part of the study area.

2.11 Ecology

The overall ecological characteristics of the study area are generally not considered to be of pristine value due to existing disturbances and ongoing use of the coastline. The foreshore mainly features park and recreation areas with large eucalypts and fig trees that provide some habitat and shelter for bird species and some mammals. There is little understorey in these areas and are dominated by mown grasses, which would provide minimal habitat and shelter for ground-dwelling species, such as amphibians, reptiles and small to large mammals. Additional key species that are commonly present in the foreshore reserves (either naturally occurring or planted) include:

- *Callitris columnaris* (coastal cypress pine);
- *Casuarina equisetifolia* (coastal she-oak);
- *Hibiscus tiliaceus* (cottonwood); and
- *Melaleuca quinquenervia* (coastal paperbark).

The foredunes generally consist of the following key species:

- *Canavalia rosea* (beach bean);
- *Carpobrotus glaucescens* (coastal pigface);
- *Hibbertia scandens* (snake vine);
- *Ipomoea pes-caprae subsp. brasiliensis* (goats foot morning glory vine);
- *Juncus* species;
- *Sesuvium portulacastrum* (sea purslane);
- *Spinifex sericeus* (beach spinifex);
- *Sporobolus virginicus* (marine couch); and
- *Vigna marina* (yellow beach bean).

Mangroves are present at some points along the shoreline, particularly at Wrights Creek, Banksia Beach, and Buckley's Hole. Mangroves are dominated by the species *Avicennia marina subsp. australasica* (grey mangrove) and *Rhizophora stylosa* (spotted mangrove).

However, there are some areas of the foreshore that have greater ecological value and provide significant habitat for fauna species. These include the lagoons at Banksia Beach (the Public Environmental Park) and Buckley's Hole. These wetlands are known to provide habitat and shelter for shorebirds and migratory birds. The Public Environmental Park at southern Banksia Beach has been protected with fencing and signage around the lagoon and bird roosting area along the beach. Buckley's Hole is also signed as a shorebird habitat and is located in the Buckley's Hole Conservation Park.

Significant shorebird roosting sites have been studied and detailed in the *Moreton Bay Regional Council Shorebird Habitat Mapping Project* (Milton *et al*, 2009). A variety of listed marine and migratory birds use these sites, as well as locally abundant and protected native species. There are three roosting sites mapped within the SEMP study area as detailed below:

- Kakadu Beach – the artificial sand mound on the beach adjacent to Kakadu Beach residential development in the Banksia Beach section of the shoreline (north of Solander Canal at the Public Environmental Park). This is a critical roost used by large numbers of shorebirds on king tides and there are records of the ‘rare’ beach stone-curlew nesting at this site. This area needrequires regular maintenance to retain its viability as a roost. Access is restricted by fences and signage; however it is reported to have one of the highest rates of disturbance than any other roost studied during the project (Milton *et al*, 2009).
- Buckley’s Hole – the freshwater lagoon that is intermittently used by migratory shorebirds. Access is limited by vegetation around the lagoon therefore disturbance is negligible (Milton *et al*, 2009).
- Buckley’s Hole sandbar – the beach sandspit adjacent to Buckley’s Hole lagoon, which is a critical king tide roost available on all tides. This site is signed as a shorebird roost however is heavily disturbed by beach visitors and fishers (Milton *et al*, 2009).

There is also a recognised shorebird roost at Dux Creek on the southern edge of the Pacific Harbours Canal Estate. These sites are shown on Figure 17.

Another significant habitat area that may be affected by coastal movements and human interference is the seagrass beds in the sub-tidal zone along the Sandstone Point study area. Seagrass species in this area include *Syringodium isoetifolium* and *Zostera muelleri subsp. capricorni* (eelgrass). The seagrass beds provide forage and shelter resources for a number of marine species, including sea cucumbers, crabs, molluscs, dugongs, fish and birds.

The protected and otherwise significant areas surrounding the western coastline of Bribie Island are shown on Figure 17. Areas of Pumicestone Passage and Moreton Bay as well as some intertidal areas of Bribie Island and the mainland are within the area of the Moreton Bay Ramsar wetland of international significance. The ecological values of this wetland area are protected under Commonwealth legislation. Large areas of Bribie Island, Pumicestone Passage and Moreton Bay are also listed in the Directory of Important Wetlands.

The Pumicestone Passage is also part of the Moreton Bay Marine Park and is included within the Conservation Park Zone. This zone places restrictions on the intensity of fishing, crabbing and collecting and prohibits netting and trawling. Along the intertidal zone from South Point to Wrights Creek is identified within the Habitat Protection Zone, which restricts only coral collecting and trawling. The Moreton Bay Marine Park Zoning Map is provided in Appendix B.

A declared fish habitat area is located from the southern extent of South Esplanade adjacent to Buckley’s Hole Conservation Park as well as north-west of Turner’s Camp along the western side of Pumicestone Passage (refer to the declared fish habitat area map in Appendix B). Areas along Sandstone Point are also classified as having coastal wetland vegetation communities (including closed mangroves and saltpan).

A small number of weeds were observed in the study area including declared pests such as *Bryophyllum delagoense* (mother-of-millions) and *Schinus terebinthifolius* (broad-leaved pepper tree), which tend to degrade the natural value of the parks and foredunes.

2.12 Cultural Heritage

Known sites of Indigenous cultural heritage are located on the mainland at:

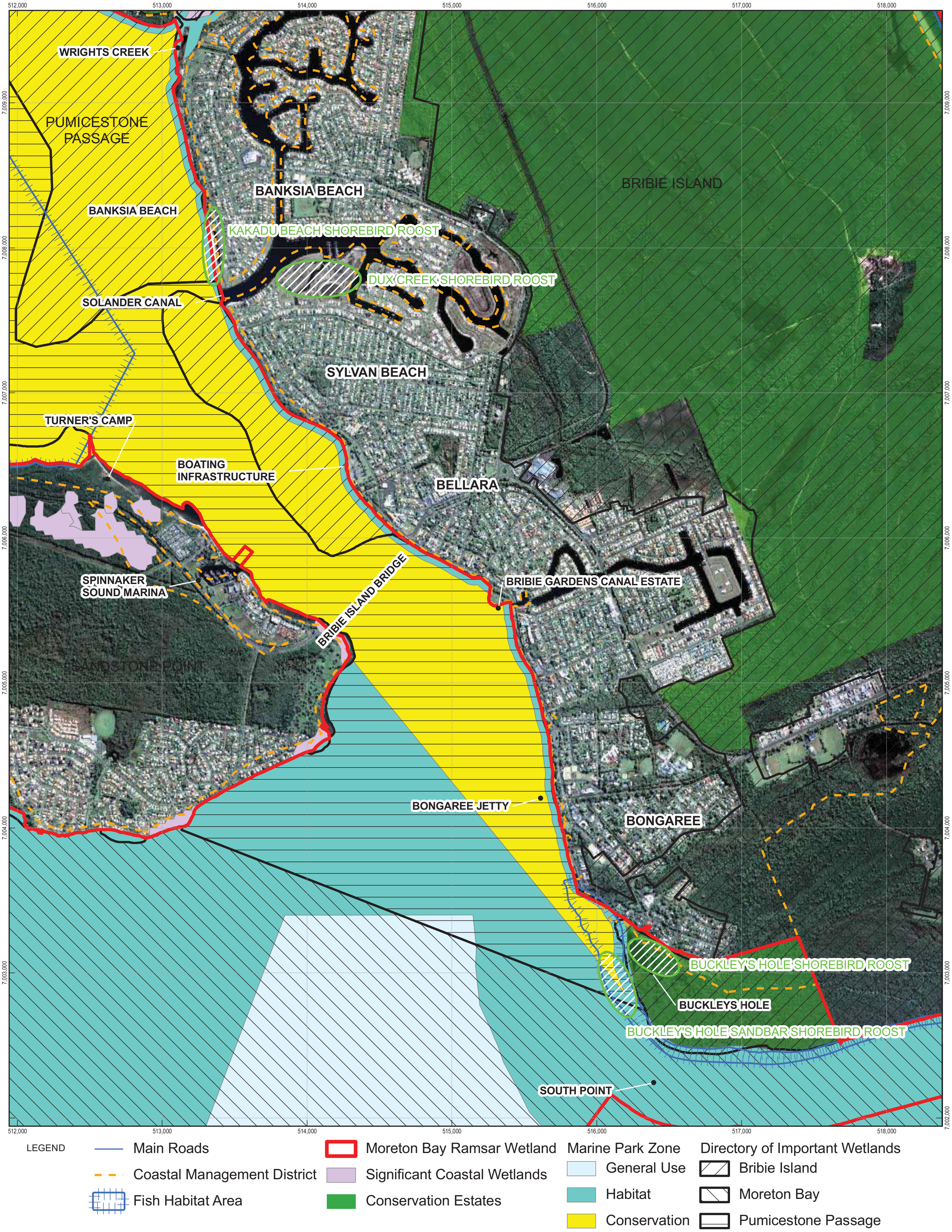
- Turner's Camp (a memorial statue in the park at the northern end of the Sandstone Point study area); and
- Kal-Ma-Kuta's grave site (in the centre of the road near the Turner's Camp Road turn-off).

Additional items and places of cultural heritage value are also present on Bribie Island and the surrounding areas. While this investigation has not sought to document each of these sites, it is worth noting that cultural heritage matters will be a necessary consideration for coastal management works proposed for the study area. Additional investigations involving consultation with the Aboriginal party for the area may be required prior to detailed design or construction activities occurring in the coastal zone. There may also be the need for additional studies into European heritage for some sites prior to the commencement of detailed design and construction works occurring.

2.13 Land Tenure

The land tenure along the foreshore of the study area varies across each of the coastal compartments included in this investigation (refer to Figure 19 for land tenures). The protected areas of South Point and Buckley's Hole area comprises National Park tenure. The foreshore either side of Bongaree Jetty, along the length of Banksia Beach and either side of Solander Canal, and between Spinnaker Sound Marina and Turner's Camp is reserve tenured land (largely under the trusteeship of Moreton Bay Regional Council). The foreshore is included in the esplanade road reserve tenure along the majority of Bellara and Sylvan Beach, which is also under the trusteeship of Moreton Bay Regional Council. The stretch of foreshore between Bribie Island Bridge and Spinnaker Sound Marina is freehold tenure. The Spinnaker Sound Marina and part of the Sylvan Beach boating infrastructure is a leasehold tenure.

The tenure of the land has significant bearing on the nature of approvals required for any coastal management works proposed for the area. Specific consideration of this matter has been given with respect to each management option proposed for the coastal compartments designated within this investigation and has been documented in Section 13 of this report.



Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

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Significant Coastal Areas

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Figure 17

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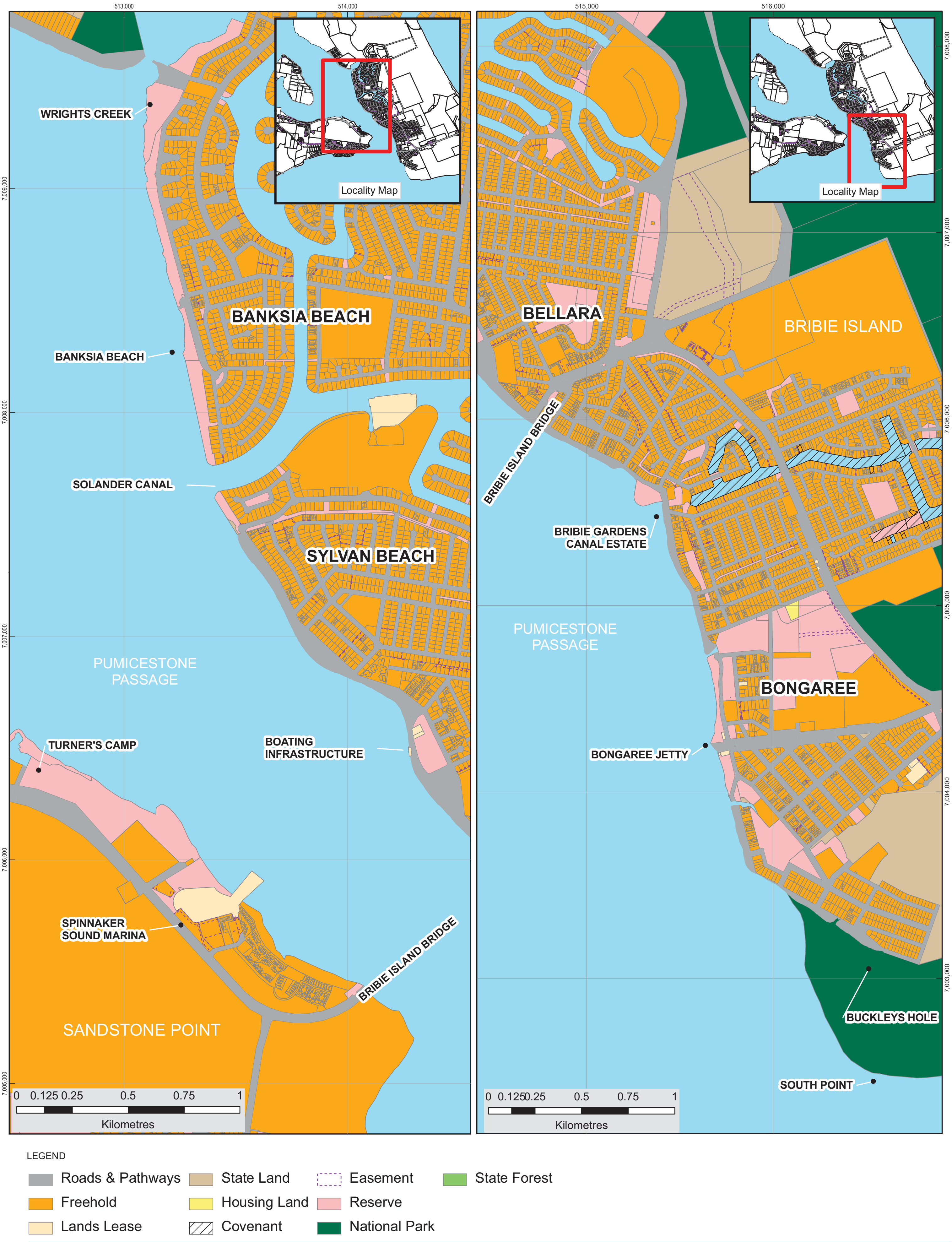
Data source: DERM/EPA, SEQ CMD 2007, Protected Areas of Qld Estates 2008, Ramsar Site of Qld 2004, DOI Wetlands, 2007, Marine Park Zoning, 2009; DPIF, Qld Fish Habitat Area 2008, Qld Coastal Wetland Vegetation 2001; Google Earth Professional, Image, 2009. Created by: S Potts



(Scales relative to A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

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Land Tenure

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Figure 18

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4-6 Innovation Parkway, Birtinya QLD 4575 **T** 61 7 5413 8100 **F** 61 7 5413 8199 **E** **W** www.ghd.com.au

Data source: MBRC Moreton Bay DCDB, 2009. Created by: S Potts