“Where will our knowledge take you?”

Golden Beach and Bribie Island Breakthrough - Options, Design, Approvals and Investment Plan

Final Report

January 2015

Golden Beach and Bribie Island Breakthrough - Options, Design, Approvals and Investment Plan

Prepared for:	Sunshine Coast Council
Prepared by:	BMT WBM Pty Ltd (Member of the BMT group of companies)

Offices

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Document Control Sheet

BMT WBM Pty Ltd
Level 8, 200 Creek Street
Brisbane Qld 4000
Australia
PO Box 203, Spring Hill 4004

Tel: +61 7 3831 6744
Fax: + 61 7 3832 3627

ABN 54 010 830 421

www.bmtwbm.com.au

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Project Manager:	Matthew Barnes
Author:	Matthew Barnes
Client:	Sunshine Coast Council
Client Contact:	Michael Anderson
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Executive Summary

This report provides a review of the risk to Council-controlled assets and values associated with shoreline erosion and coastal inundation to mainland communities between Caloundra Bar and Bells Break, northern Pumicestone Passage. Particular attention is given to the increased coastal inundation risk associated with a breakthrough of the Bribie Island northern spit. Assessments undertaken in this and previous studies have identified:

- A breakthrough and new permanent entrance immediately south of Blue Hole would be just south of the entrance location observed in the early 1960s. This is presently the narrowest section of the Bribie Island northern spit and appears to be the most likely location where a new entrance would form. Tidal attenuation within the passage may slightly alter, however, would not be expected to cause undesirable water level impacts for the mainland communities. A new entrance would be expected to slowly migrate northward once formed, possibly over many decades as observed previously. During this period, the entrance may also widen in response to severe wave and flow events, as observed during the early 1970s. The character and amenity of northern Pumicestone passage and the mainland communities is likely to be maintained.
- A breakthrough and new permanent entrance opposite or to the south of the Lamerough Canal entrance is likely to cause a significant reworking of the existing mangrove landforms, increased tidal flows, development of new channels and an increase in tide height locally (due to reduced tidal attenuation). This would in turn increase the coastal inundation risk. There may also be significant landform changes to the most northern end of the passage as the existing entrance closes over and tidal flows are significantly reduced. The likelihood of a new entrance forming at this location is considered low; however, the consequences would be significantly greater than a new entrance immediately south of Blue Hole.

The key threat to the study area associated with a Bribie Island breakthrough is a change to the tidal regime within the northern Pumicestone Passage. Reduced tidal attenuation and therefore greater tidal amplitude will lead to an increased risk of coastal inundation associated with storm tide events. This threat is significantly greater for land assets on low-lying land in the southern half of the study area.

To address the perceived threat to assets and values, a strategy to implement the management options promoted in the Sunshine Coast Shoreline Erosion Management Plan (SCC, 2014) has been developed. This strategy is underpinned by the monitoring of shoreline erosion and water levels within Pumicestone Passage. The following triggers for enhanced management action have been developed:

(1) Material required for beach nourishment exceeds the existing permitted volume of 10,000m^3/year;

(2) An unstainable volume of sand is required for ongoing beach nourishment; and/or

(3) An observed increase to the mean high water springs level and/or mean sea level greater than 0.2m relative to 2014 levels.

Before any triggers are realised minor and existing permitted works, including the Golden Beach Nourishment program which allows the dredging and placement of up to 10,000m^3 of sand per year, are to continue under the strategy.

Realisation of the first trigger is intended to prompt an expansion of the dredging and nourishment program to provide material for the Nelson Street to Bells Creek Shoreline (up to 40,000m^3 of sand).

Realisation of the second and/or third trigger indicates that shoreline values and inundation risk are not being maintained via beach nourishment and that the detailed design and construction of a revetment seawall along the Nelson Street to Bells Creek Shoreline is to commence. This structure is primarily intended to mitigate coastal inundation risk associated with an undesirable change to the tidal regime with Pumicestone Passage.

The successful implementation of the promoted strategy requires proactive planning by Sunshine Coast Council and the Queensland State Government, including:

- Funding allocation;
- A commitment to the monitoring shoreline position and water levels within Pumicestone Passage;
- Conceptual and detailed design of management strategies; and
- Environmental approval and ongoing compliance.

Contents

List of Figures

List of Tables

1 Introduction

1.1 Project Overview

The Golden Beach and Bribie Island Breakthrough – Options, Design, Approvals and Investment Plan (The Plan) is intended to provide Council with a clear approach to implementing the management actions promoted by the Sunshine Coast Shoreline Erosion Management Plan (SCRC, 2014). Specifically, The Plan is intended to:

- Identify viable options for addressing prospective impacts from the permanent breakthrough(s) of Bribie Island;
- Provide Council with a clear, preferred approach to shoreline management option implementation between the northern entrance to Pumicestone Passage and Bells Creek, including existing permitted management approaches within an overall strategy for the study area;
- Provide a document that can be used to support further public consultation;
- Include sufficient detail and information for statutory bodies to consider and evaluate any proposed actions; and
- Form part of the information supporting a Development Application (DA) to implement a preferred shoreline management strategy or strategies.

The Plan builds on a number of previous studies, recent site inspections and liaison with relevant stakeholders and is organised as follows:

- Chapter 2 – A description of relevant coastal processes including a review of previous studies, presentation of recorded data and consideration of future scenarios.
- Chapter 3 – A summary of the shoreline current condition and permitted shoreline management activities.
- Chapter 4 – A description of the overall shoreline management strategy promoted by The Plan.
- Chapter 5 – A summary of the necessary environmental assessments.
- Chapter 6 – The proposed monitoring and implementation plan.

1.2 Study Area

The Bribie Island National Park is a sand barrier separating Pumicestone Passage from the Coral Sea. The northern extent of Bribie Island is adjacent to the mainland study area and can be characterised as a dynamic sand spit, constantly evolving in response to coastal and estuarine processes. Key locations within the study area are shown in Figure 1-1.

The narrowing, subsequent breakthrough and reforming of the northern spit is likely to be a relatively long term process occurring over hundreds of years. The Sunshine Coast Council, in conjunction with the former Pumicestone Passage Advisory Task Force, has produced a series of fact sheets describing the erosion and sedimentation processes occurring at Bribie Island and Pumicestone Passage. This useful background information is provided in Appendix A.

In late 2013 the northern spit had narrowed to 25m at some locations. During storms, wave runup has been observed to overtop the dunes and wash through vegetation at the narrowest sections of the spit. It appears a permanent breakthrough (at one or multiple locations) of the northern spit is imminent however the timing of such an event remains uncertain. There is some concern within the local community that a breakthrough of Bribie Island would cause undesirable impacts to the adjacent mainland shoreline.

Council has previously liaised with State agencies regarding possible shoreline erosion management works on Bribie Island to mitigate a potential breakthrough. The agencies have demonstrated a general reluctance to interfere with natural erosion processes on Bribie Island to ease the perceived impact to mainland shoreline assets and values. Consequently, the erosion management options promoted in The Plan focus on Council-controlled mainland shorelines.

Title:

Study Area Overview

Figure: 1-1

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1.3 Sunshine Coast Values and Assets

The Sunshine Coast Waterways and Coastal Management Strategy 2011-2021 (the Strategy) outlines the values, or desirable features, of the Sunshine Coast's coastal foreshores and waterways, as identified by Council and confirmed through an extensive community consultation program. This section summarises those ecological, social and economic values of the coastal foreshore within the study area.

1.3.1 Ecological Values

Coastal foreshores of the Sunshine Coast contain important coastal ecosystems including coastal dunes and beaches, wetlands, mangroves and seagrass and rocky headlands. These systems are all represented within or adjacent to the study area, noting that the northern spit of Bribie Island is State-controlled national park.

Coastal dune vegetation including spinifex, pandanus, sheoak and swamp paperbark occur at Bribie Island and the mainland shoreline. In addition to providing habitat for coastal fauna, this vegetation plays an important role in stabilising and protecting dunes from erosion by wind and waves. A large proportion of dune ecosystems on Bribie Island are vegetated by remnant vegetation and some areas are classed as essential habitat protected under the *Vegetation Management Act 1999.* Wetlands essentially occur along the length of the study area, with Pumicestone Passage listed in the Wetlands of National Importance Directory. The wetlands support a range of species, contribute to biodiversity and provide maintenance of ecological and hydrological functions, flood control and water purification. Marine plants occur throughout the study area, providing food and habitat for marine fauna. An extensive seagrass community exists within Pumicestone Passage, consisting of eelgrass (*Zostera capricorni*) and paddleweed (*Halophila ovalis*). Mangrove communities are also present with significant habitats on the west coast of Bribie Island and within the passage. A rocky headland is located at Caloundra Head (just north of the study area) and provides habitat for species tolerant of high energy environments.

Northern Pumicestone Passage is within the Moreton Bay Marine Park and zoned as a 'conservation park' under the Marine Parks (Moreton Bay) Zoning Plan 2008. Most of Pumicestone Passage is declared Fish Habitat Area with some excluded areas near urban populations and/or for navigation purposes. Significant species identified in the Strategy include turtles and migratory birds. The Loggerhead turtle (*Caretta caretta*) is listed as endangered under both State and Australian legislation, and a small but significant proportion of the Queensland mainland's southern breeding population of this species is supported within the study area with nesting known to occur sporadically at Bribie Island and Kings Beach (north of the study area). Protected migratory birds occur along the length of the Sunshine Coast and are commonly sighted feeding on intertidal banks between September and April.

1.3.2 Social Values

The major social values of the coastal foreshores within the study area are cultural heritage, recreation and open space and coastal protection.

The Strategy highlights the need to recognise, protect and conserve indigenous and European culture values associated with coastal foreshores and to factor these into all decisions affecting the planning and management of the coastline. The Strategy acknowledges the ancient and ongoing association of the local Aboriginal people with the environment along the foreshores of the Sunshine Coast. A modern attachment to the importance of coastal features has also developed, with strong links tying the community to certain coastal features and ecosystems. These ties are often portrayed through people’s choices in recreation and the involvement of community groups in environmental planning and management.

The open space of the coast, beaches and conservation areas are easily accessed and provide numerous recreational opportunities. Key activities that are undertaken within the study area include passive recreation (e.g. socialising, picnicking), walking, riding, swimming, snorkelling, sailing and kayaking. Combined with the coastal amenity and climate of the Sunshine Coast, these opportunities attract residents and visitors to the area.

Educational opportunities are also often provided by coastal ecosystems of the study area including the rocky headlands, wetlands, dunes and beaches. Management and enhancement of the coast has also become an ever-increasing focus of community and stakeholder groups, with many groups having an association to a particular ecosystem or part of the coast to which they identify.

The Strategy also identifies the protection value that coastal foreshores provide to the adjacent built environment.

1.3.3 Economic Values

In terms of profile and employment, tourism is a significant industry on the Sunshine Coast, attracting millions of visitors each year (for example, 3 million visitors in 2009). A high proportion of these are domestic visitors, the majority being visitors from within South East Queensland. With the major attractions for visitors being related to the coasts and waterways, the effective management of these areas is imperative to continued growth of the Sunshine Coast tourism industry.

2 Northern Pumicestone Passage and Coastal Processes

2.1 Geological Framework

The geological evolution of the study area fits within the broader evolution of Moreton Bay, Deception Bay, Pumicestone Passage and Bribe Island. Regional mapping of onshore geology and the depositional environment (indicating the age of sediment deposits) was presented by Stephens (1982) and is provided in Figure 2-1.

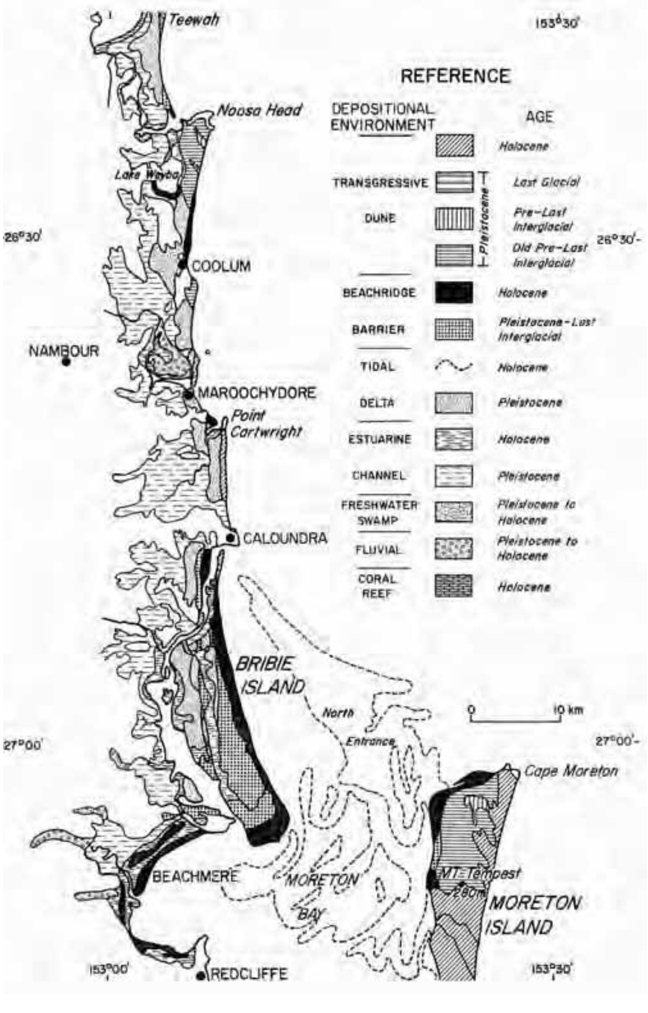

Figure 2-1 Regional Onshore Geology (from Stephens 1982)

On a geological timescale the low-lying coastal plains and waterways within the study area have experienced significant change. Over the last 120,000 years large variations in sea level have influenced the evolution of the shoreline.

The present northern Pumicestone Passage mainland shoreline is not static; however, it has been constrained in many locations using erosion control structures and vegetation. Most of the flat areas behind the present shoreline are formed by sediments deposited during the previous high sea level (about 120,000 years ago). The glacial period that followed caused a major drop in sea level (up to approximately 120m), 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 shoreline and, in part, transported onshore.

Riedel and Byrne (1979) suggest the northern end of Pumicestone Passage, as we know it today, formed during the early Holocene period (approximately 10,000 years ago). Before this time the rivers had scoured deeper, narrower channels and were depositing fluvial sediments east of the present shoreline. As the sea level rose, the rivers were drowned and sediments began depositing within what is now the Pumicestone Passage area. The rising seas reworked the old offshore delta deposits, pushing beach sands onto the eastern side of Bribie Island. Sediment samples indicate the northern end of Bribie Island developed to its present position approximately 4,000 years ago. Contemporary coastal geology mapping of the study area is presented in Figure 2-2.

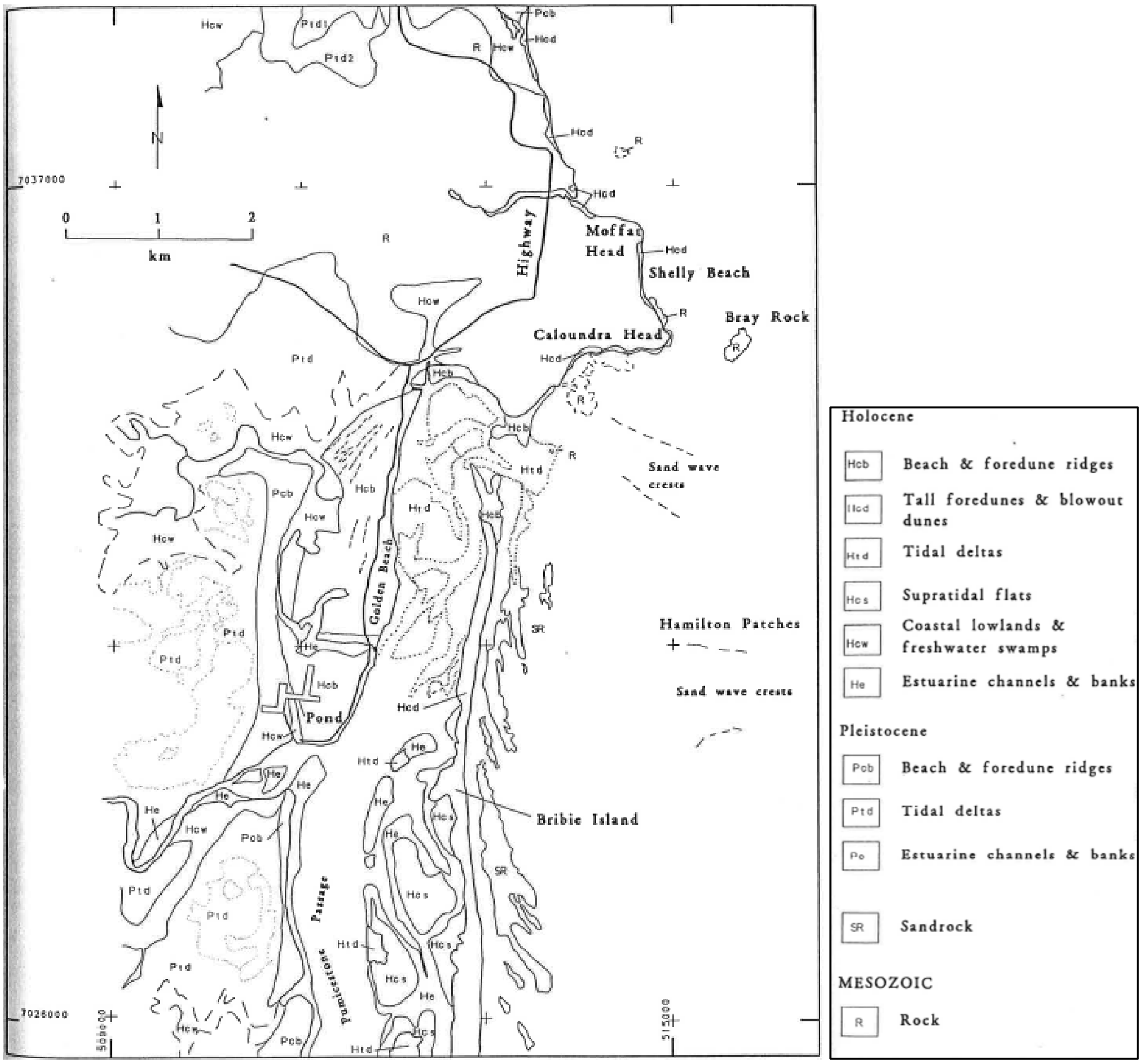

Figure 2-2 Coastal Geology of Northern Bribie Island and Pumicestone Passage (Jones, 1992)

2.2 Pumicestone Passage Northern Entrance

Dramatic changes have been observed at the northern end of Bribie Island and Caloundra Bar since the regular capture of aerial photography commenced in 1940. Examples of the Bribie Island northern spit and Caloundra Bar locations are shown in Figure 2-3, showing ‘extreme north’ and ‘extreme south’ entrance positions and the condition following a period of significant tropical cyclone activity.

The available historical aerial photos show the entrance position migrating north and south over a range of approximately 1km. It is expected that narrowing and eventual breakthrough of the Bribie Island northern spit was the catalyst for a permanent entrance to form in the more southern position observed in 1962. In the decades that followed, the entrance slowly migrated north and has been in its present ‘extreme north’ position since the late 1990’s. The entrance was observed to widen following a series of flood and severe wave events associated with tropical cyclone activity in the early 1970’s. Riedel and Byrne (1979) suggest the temporary widened condition did not destroy the underlying cyclic movement of the entrance, which is primarily controlled by the migration channels within the passage.

The former Beach Protection Authority (BPA) mapped shoreline change at northern Bribie Island and Pumicestone Passage between 1940 and 1992 using photogrammetry methods. These photos are presented in Appendix B and the key changes described by the BPA included:

- In 1940 the main entrance channel was within 50 metres of the small rocky headland on the mainland (Deepwater Point);
- By 1961 the sand had formed into a spit from the mainland progressing 850m southward, but by 1971 this spit had eroded back by 500m;
- Between 1971 and 1982 the mainland spit decreased a further 300m; and
- Between 1982 and 1992, fill was placed at the spit up to 160m from the mainland in an area used as a park. During this time the spit showed little change in length.

Due to ongoing erosion pressure, the commitment to maintain a park on the mainland spit was abandoned and the upper foreshore area is now protected by a rock revetment seawall.

Overall, the area of vegetated dune and the general dune heights at the northern spit reduced significantly between 1940 and 1992. The width of the island at the narrowest point (just south of Blue Hole) decreased progressively over the same period, from 155m in 1940 to 60m in 1992 (BPA, 1992). In a report to Council, the former Environmental Protection Authority (EPA) estimated that the annual loss of sand from the northern 5km of Bribie Island was between 30,000-144,000m^3/year (Queensland Government, 2008). Recent aerial imagery shows the vegetated dune at the narrowest point of the spit was approximately 25m in late 2013.

Shoreline processes throughout the study area are considered further in Section 2.8 and the current condition and present shoreline management activities are described Chapter 3.

Figure 2-3 Observed Bribie Island Northern Spit and Caloundra Bar Position: Extreme North (top); Extreme South (middle); Post Cyclone (bottom)

2.3 Tides and Water Level Variations

2.3.1 Pumicestone Passage Circulation

Pumicestone Passage effectively behaves as a ‘double-ended’ estuary, with tidal flows propagating into the passage from northern and southern ends. Relative to the swallow northern entrance at Caloundra Bar, the southern entrance near Bongaree (Deception Bay) is wide and unobstructed. A tidal ‘null point’ (where tidal flows meet and propagate in opposite directions) is thought to oscillate back and forth in the passage in the vicinity of the constricted section known as The Skids. The Inter-Departmental Committee (1982) and later Larsen (2007) presented observational data and hydrodynamic modelling results that support this assumption.

Several key characteristics of the passage circulation were described by the Inter-Departmental Committee (1982), including:

- Tidal flows in the northern passage, between The Skids and Caloundra Bar, are highly constrained by bathymetric features and a relatively small cross-sectional areas;
- Far greater tidal flows and tidal excursion occurs in the southern passage, between The Skids and Bongaree, due to the unobstructed entrance and larger cross-sectional areas; and
- In the absence of significant winds and/or freshwater inputs, a net northerly flow through the passage due to tidal phase differences and a gradient in mean water level between the northern and southern entrances.

2.3.2 Astronomical Tidal Water Levels

Circulation within Pumicestone Passage is primarily driven by differences in the phase and range of the tides between the northern and southern entrances. Pacific Ocean tides at Caloundra Head are considered representative of the water levels at the northern entrance and along the Bribie Island northern spit. The southern entrance experiences tides similar to Bongaree Jetty within Deception Bay. The astronomical tide water level time series at these locations are compared in Figure 2-4, indicating:

- A phase difference between the two locations, with high tide at Caloundra Head occurring approximately 90min earlier than Bongaree Jetty;
- A tidal range exceeding 2m at both locations;
- A slightly greater tidal range at Bongaree Jetty due to tidal amplification within Moreton Bay; and
- A +10cm difference in mean sea level at Bongaree Jetty.

Tidal planes published by Maritime Safety Queensland (2014) are provided in Table 2-1. The tidal planes for Caloundra Head are derived from the Mooloolaba Standard Port, while Bongaree Jetty and Golden Beach tidal planes are derived from the Brisbane Bar Standard Port.

Table 2-1 suggests that the tide is significantly attenuated at Golden Beach in comparison to the ranges observed at the entrances. This is also evident in water level recordings from the Golden Beach Alert flood warning rainfall station (BOM station number 540448) located at Military Jetty and shown in Figure 2-5. According to common tidal range classification, the entrances to

Pumicestone Passage are mesotidal (tidal range between 2m and 4m) and Golden Beach is a microtidal location (tidal range less than 2m).

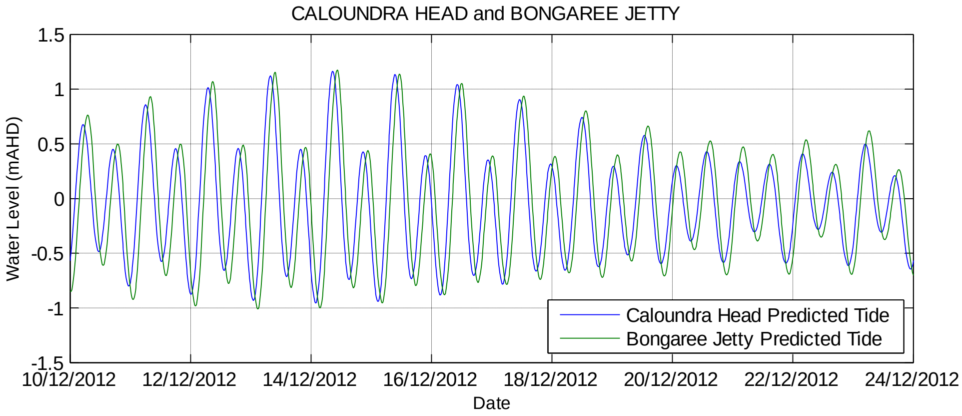

Figure 2-4 Astronomical Tides at Caloundra Head and Bongaree Jetty

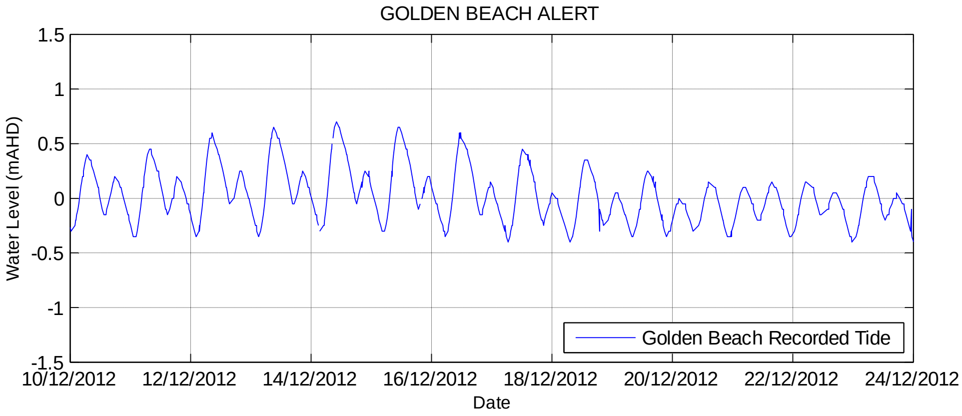

Figure 2-5 Tidal Water Level Recordings at Golden Beach Alert (Data Adjusted due to Uncertain Datum)

Table 2-1 Semidiurnal Tidal Planes - Height above Lowest Astronomical Tide (Maritime Safety Queensland 2014)

Location	Time Difference (H MM)		MHWS (m)	MHWN (m)	MLWN (m)	MLWS (m)	AHD (m)	MSL (m)	HAT (m)
	HW	LW							
Mooloolaba	**Standard Port**		**1.66**	**1.33**	**0.58**	**0.26**	**0.99**	**0.96**	**2.17**
Caloundra Head	+0 00	+0 00	1.63	1.34	0.57	0.28	0.99	0.95	2.05
Brisbane Bar	**Standard Port**		**2.17**	**1.78**	**0.76**	**0.37**	**1.24**	**1.27**	**2.73**
Bongaree Jetty	+0 00	-0 15	1.87	1.53	0.65	0.32	1.10	1.06	2.35
Golden Beach	-0 53	-0 11	1.12	0.82	0.43	0.32	0.66	0.77	1.52

The Inter-Departmental Committee (1982) analysed the variation in tidal range throughout Pumicestone Passage using an extensive data set and numerical modelling tools. The observed and modelled profiles of maximum high and low water (the water level envelope) are shown in Figure 2-6. This assessment shows the tidal attenuation occurring more rapidly from the northern entrance, with peak attenuation within a 5km distance of Caloundra Bar. In comparison, tidal attenuation from the southern entrance (Bongaree) occurs more gradually and over a 25-30km distance.

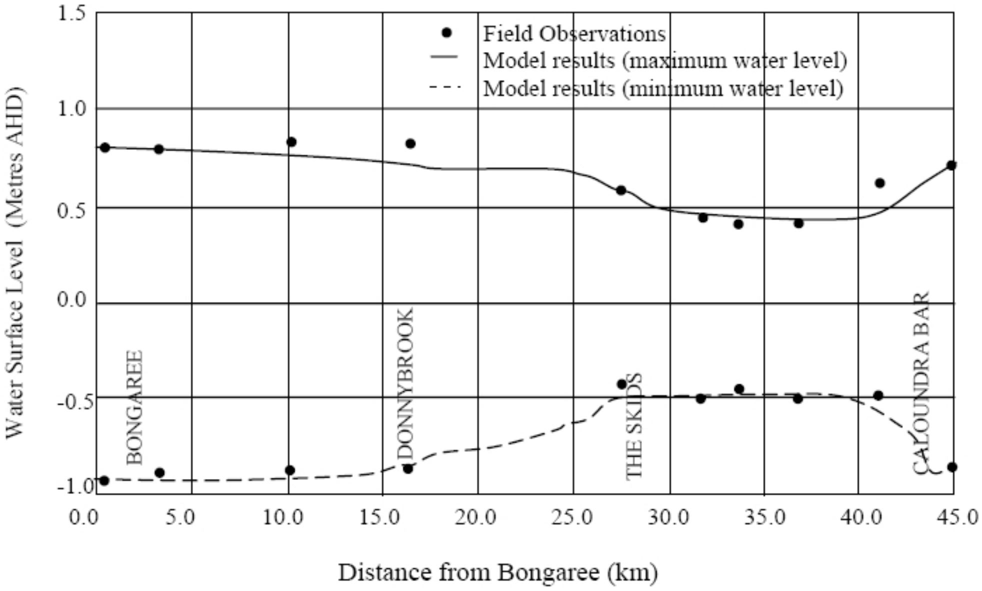

Figure 2-6 Profiles of High and Low Water within Pumicestone Passage in 1978 (Inter-Departmental Committee, 1982; reproduced in Larsen, 2007)

A key threat associated with a permanent breakthrough of the Bribie Island northern spit is a change to the tidal attenuation patterns within northern Pumicestone Passage (e.g. Aurecon, 2009). This could lead to a larger tidal range within the passage and an increased risk of coastal inundation to low lying areas. The coastal inundation threat and future planning levels are considered further in Sections 2.3.3 and 2.3.4.

2.3.3 Extreme Water Levels

Extreme water levels well in excess of HAT can be generated during severe weather events. The observed extreme water level, or ‘storm tide’, is the total water level caused by the combination of tide and surge. The surge, or ‘residual tide’, is generated by low atmospheric pressure, wind action over the water surface and wave processes. The surge corresponds to the height above the expected astronomical tide at a given time.

Major surge events within southeast Queensland are typically associated with east coast low or tropical cyclone weather systems. The three largest surge events recorded at the nearby Mooloolaba Storm Tide gauge were associated with tropical cyclone activity:

- TC Dinah (January 1967) ≈ 0.9m.

- TC Daisy (February 1972) ≈ 0.7m.
- TC David (January 1976) ≈ 0.6m.

Surges greater than 0.25m are relatively common at Mooloolaba, on average occurring approximately twice per year. Surges generated by east coast low weather systems are more common than those generated by tropical cyclones, and account for roughly two thirds of the largest surge events since 1965 (the year tide recording commenced at Mooloolaba).

Previous surge and storm tide risk assessments relevant to the study area are summarised in Table 2-2. These studies provide design water levels for Golden Beach and/or Caloundra Bar. The Ocean Hazards Assessment Stage 2 (Hardy et al., 2004) provided tropical cyclone-induced water levels and suggests attenuation of the extreme water level within northern Pumicestone Passage. More recently, Aurecon (2013) derived storm tide levels from recorded data and established a 100-year ARI water level of 1.65 metres above AHD at the northern entrance to Pumicestone Passage.

Table 2-2 Summary of Surge plus Tide Design Water Levels

Study	Location	Water Level 100-year ARI (mAHD)
Hardy et al. (2004)	Caloundra Bar	1.25
	Golden Beach	1.05
Aurecon (2013)	Pumicestone Passage Entrance	1.65

It is noted that the levels in Table 2-2 do not include the contribution of wave processes to the extreme water level, which can be significant on exposed beaches but are considered negligible within the passage. Wave processes during extreme events at the Bribie Island northern spit are discussed separately in Section 2.5.3.

2.3.3.1 Recently Observed Storm Tide

Water level recordings during ex-TC Oswald (January 2013) are presented in Figure 2-7. The water level data at Mooloolaba suggest a surge (residual tide) peak close to 0.5m and a recorded water level (storm tide) close to HAT was observed. It is assumed that these conditions were also experienced at the northern entrance to Pumicestone Passage. Similar conditions would be expected at the southern entrance to Pumicestone Passage, potentially slightly amplified as the surge wave propagated into Moreton Bay.

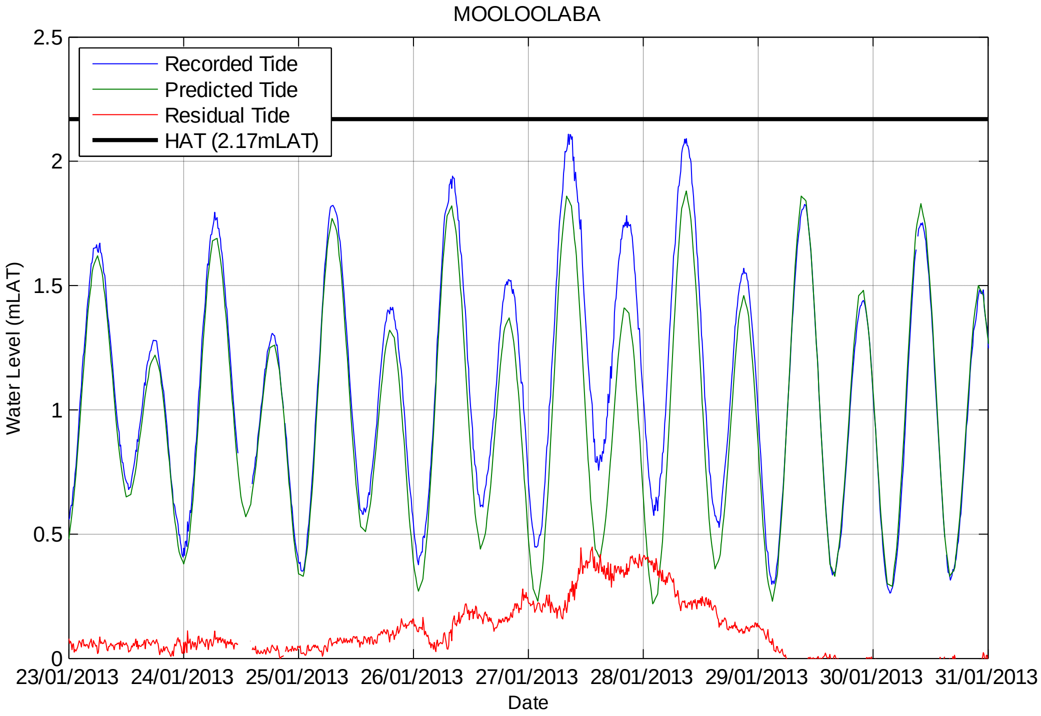

Figure 2-7 Recorded, Predicted and Residual Tide at Mooloolaba Storm Tide Gauge during ex-TC Oswald (data provided by DSITIA)

2.3.4 Future Planning Level Considerations

As discussed in Section 2.3.2, a permanent breakthrough at Bribie Island may cause changes to tidal attenuation within northern Pumicestone Passage and an increase in tidal range. An increase to the global mean sea level is also expected in future years, driven by a warming ocean and loss of ice glaciers and ice sheets (e.g. IPCC, 2014). Consequently, a likely future scenario is that the tidal regime within northern Pumicestone Passage will alter due to a combination of a Bribie Island breakthrough and sea level rise. Regardless of the cause, an increase in mean sea level will in turn increase the risk of coastal inundation to mainland communities.

The future coastal inundation threat is illustrated using mapping in Figure 2-8 to Figure 2-10. Each map considers the inundation associated with the 100-year ARI storm tide level (Aurecon 2013, refer Table 2-2) combined with a 0.2, 0.4 or 0.6m increase to the mean sea level within northern Pumicestone Passage. A land surface digital elevation model provided by Council and based on 2008 LiDAR survey data was used to map areas expected to inundate under each water level scenario. This assessment highlights the vulnerability of low-lying land throughout the southern half of the study area, particularly between Bells Creek and Lamerough Canal.

It is noted that the inundation mapping approach assumes that there is sufficient time and water available from the overtopping of coastal barriers to fill potential holding basins up to the given water level. In this respect, the mapped inundation areas are likely to be conservative, particularly where development is located some distance from significant waterways. This mapping approach is often referred to as “bathtub” mapping. More detailed “dynamic” storm tide mapping throughout the study area was recently completed for existing and future climate change scenarios as part of the Sunshine Coast Storm Tide Study (Aurecon, 2013).

Title:

100yr Storm Tide Inundation with 0.2m increase to Mean Sea Level (bathtup mapping)

Figure:

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Title:

100yr Storm Tide Inundation with 0.4m increase to Mean Sea Level (bathtub mapping)

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Title:

100yr Storm Tide Inundation with 0.6m increase to Mean Sea Level (bathtup mapping)

Figure:

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2.4 Offshore 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 2-11 and shows the directional spread of wind speed at the northern entrance to Moreton Bay, approximately 25km southeast of the study area. 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 2-12. 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;
- South-easterly trade winds during the autumn and winter months; and
- Lighter east to north-easterly winds occur seasonally, predominantly during summer and spring.

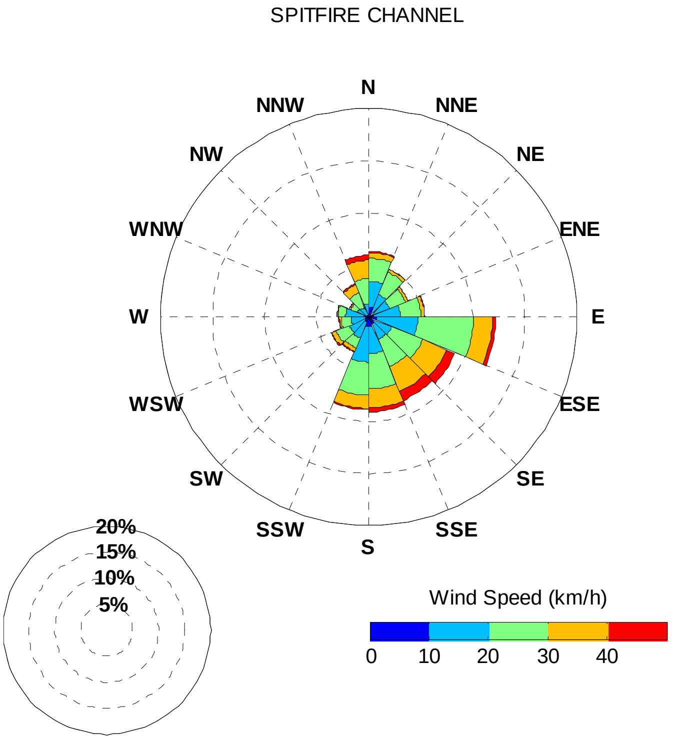
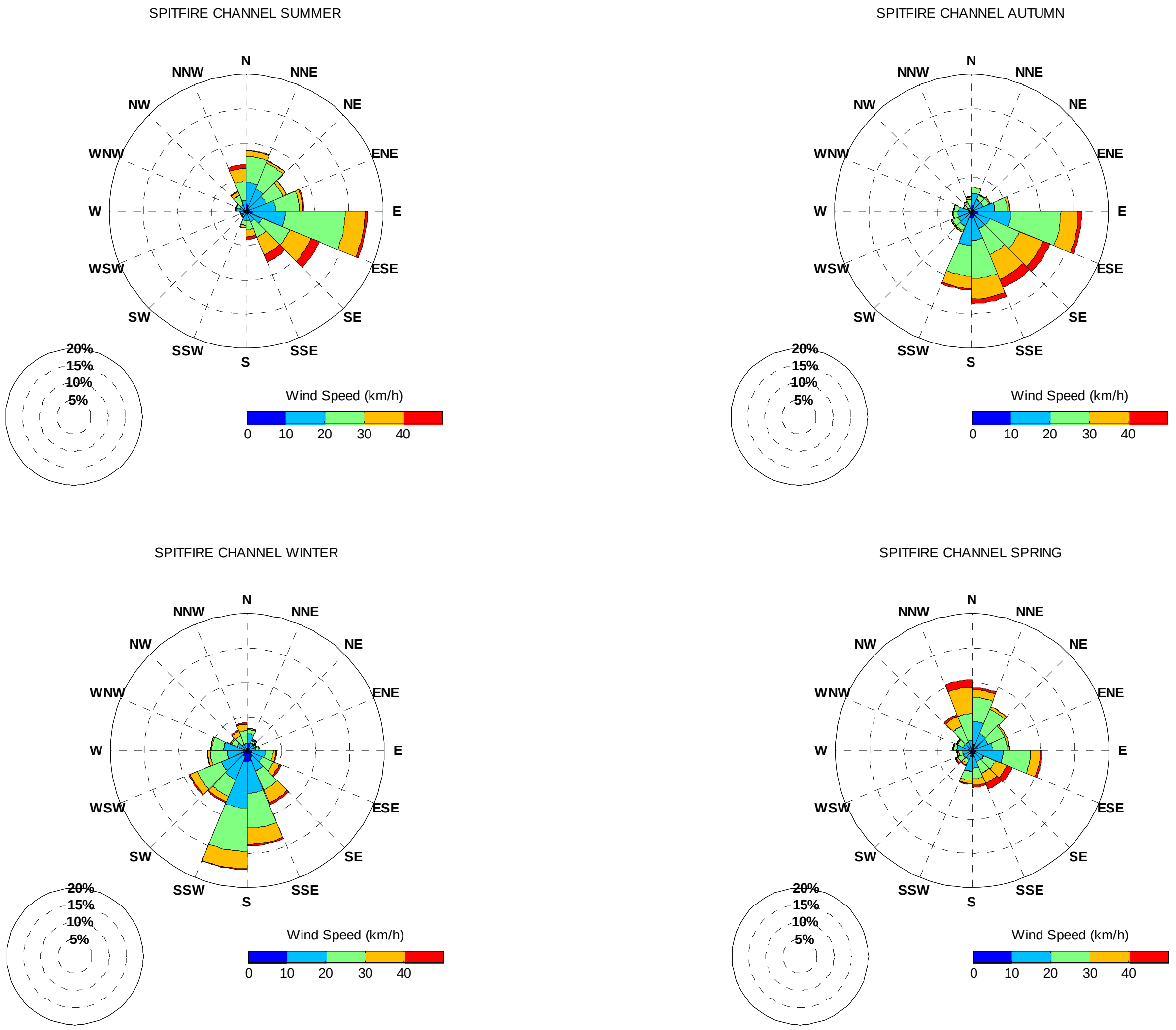


Figure 2-11 Long Term Average (2002 – 2011) Wind Rose – Spitfire Channel All Data


SPITFIRE CHANNEL SUMMER

SPITFIRE CHANNEL AUTUMN

SPITFIRE CHANNEL WINTER

SPITFIRE CHANNEL SPRING

Figure 2-12 Long Term Average (2002 – 2011) Seasonal Wind Roses – Spitfire Channel

2.5 Wave Climate

2.5.1 Offshore Wave Climate

The Bribie Island open coast shoreline is sheltered from the prevailing southerly “swell” waves by North Stradbroke and Moreton Islands. The ocean swell energy that reaches Bribie Island is substantially attenuated by the processes of refraction, bed friction and breaking across the shallow shoals at the Moreton Bay entrance.

Knowledge of the wave climate along the South East Queensland open coast 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 (offshore from Bribie Island) is of moderate to high energy, with median significant height about 1.3 metres and extreme wave heights occasionally exceeding 8 metres (typically generated by tropical cyclone conditions).
- 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. These waves are refracted by Moreton Island and arrive at the Bribie Island shoreline from a more easterly (shore normal) direction. This process is illustrated using numerical model output in the left hand panel of Figure 2-13.
- 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. These conditions are illustrated in the right hand panel of Figure 2-13.

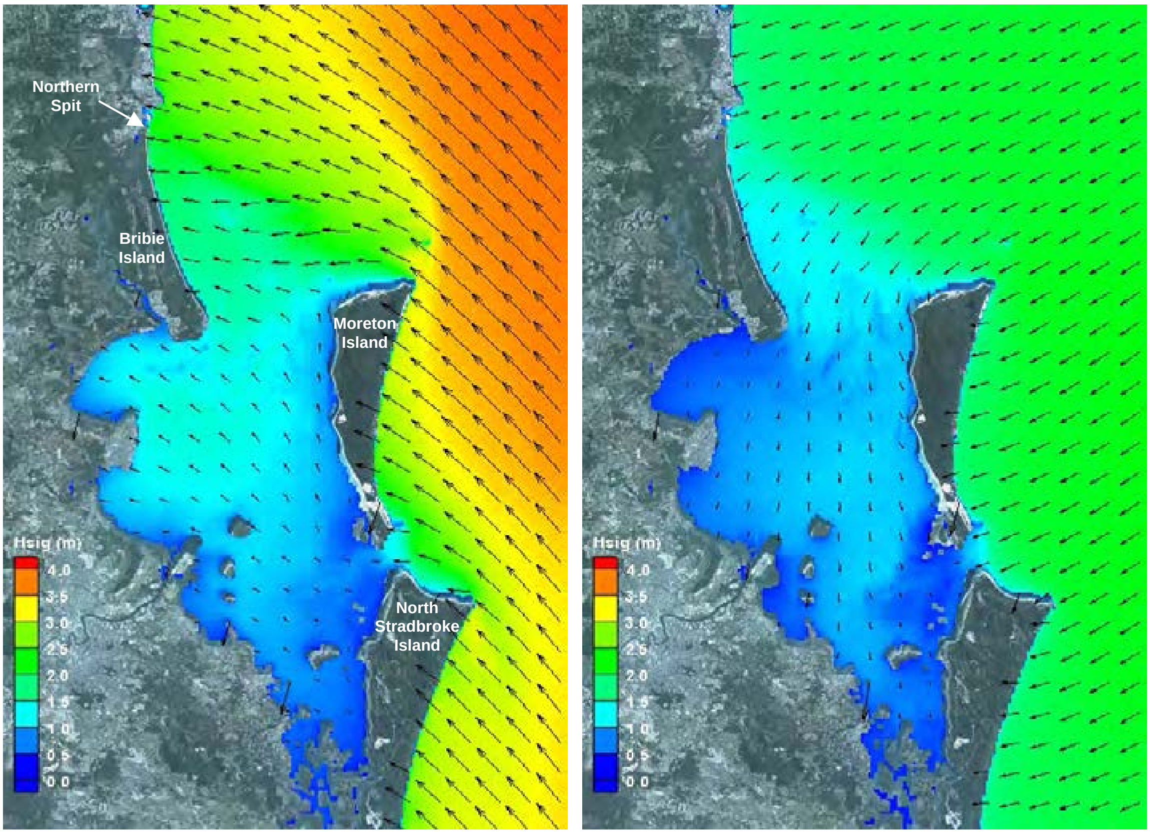


Figure 2-13 Example Regional Wave Climate: South-easterly Swell Conditions (left); North-easterly Wind Wave Conditions (right)

Existing, comprehensive spectral wave models covering the broader South East Queensland region have been used to develop a nearshore wave climate at a location approximately 1km offshore from the Bribie Island northern spit. The average wave climate (based on a hindcast period from June 2006 to April 2010) for this location is presented below as a wave rose and wave frequency recurrence table. The wave climate analysis indicates the following:

- Wave energy arriving at the Bribie Island coastline is typically from the east-north-easterly to east-south-easterly directional sector (approximately 80% of the time).
- Significant wave heights are less than 1m approximately 70% of the time.
- Significant wave heights greater than 1.5m are relatively rare, occurring less the 7% of the time.

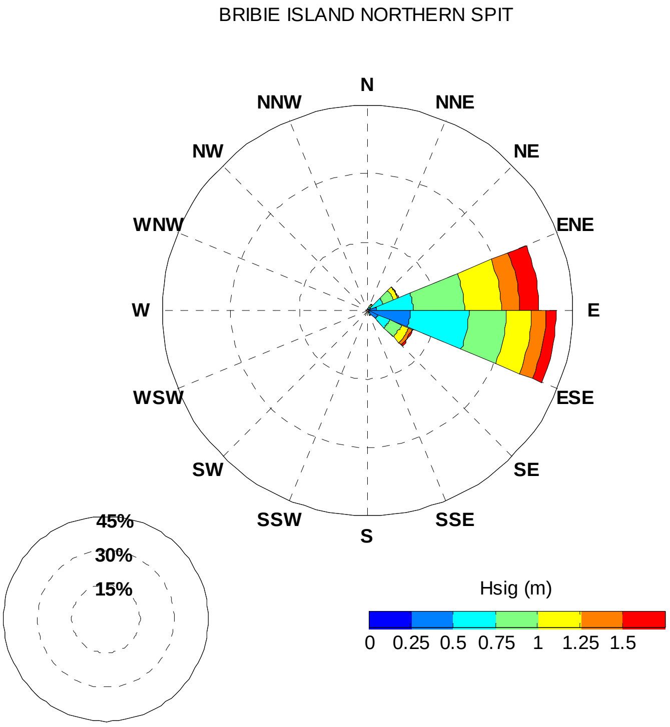


Figure 2-14 Bribie Island Northern Spit Wave Rose

Table 2-3 Bribie Island Northern Spit Wave Frequency Recurrence (% of time)

	Directional Bin (degN)									
Hsig (m)	**0**	**22.5**	**45**	**67.5**	**90**	**112.5**	**135**	**157.5**	**>157.5**	**Total**
0 - 0.5	0.1	0.3	0.8	1.9	9.4	2.4	0.6	0.2	0.1	15.7
0.5 – 1.0		1.1	5.3	19.3	21.0	5.6	0.4	0.1		52.9
1.0 – 1.5		0.0	1.2	12.1	8.7	2.5	0.0			24.6
>1.5			0.0	4.3	2.2	0.3				6.8
Total	0.1	1.4	7.4	37.6	41.3	10.8	1.0	0.2	0.1	100.0

2.5.2 Extreme Waves

Design wave conditions derived from the Brisbane Waverider buoy (located offshore from Point Lookout, North Stradbroke Island) reported by Allen and Callaghan (2001) were used by BMT WBM (2013) to estimate equivalent nearshore wave conditions throughout the Sunshine Coast. A system of nested SWAN wave models was used to transfer the design wave heights from the Brisbane buoy to the study area. This approach did not consider rapidly varying wind fields, such as those experienced during tropical cyclone events, and therefore provided wave estimates representative of non-cyclonic conditions. The design wave heights at a location offshore from Caloundra Headland at the 20m depth contour are summarised in Table 2-4.

Table 2-4 Non-Cyclonic Design Significant Wave Heights (BMT WBM, 2013)

Location	20-year ARI (m)	50-year ARI (m)	100-year ARI (m)
Caloundra Headland at 20m depth contour	5.3	5.7	6.0

The extreme wave analysis methodology adopted by BMT WBM (2013) was an efficient way to establish design wave heights throughout the Sunshine Coast, however, is somewhat limited by the relatively short historical wave record used as the basis for the assessment. As part of the Ocean Hazards Assessment Stage 2, Hardy et al. (2004) simulated wave conditions associated with a very large population of synthetic tropical cyclones that represented approximately 3000 years of storm activity. Cyclonic design wave heights at a location offshore from Caloundra at the 35m depth contour are summarised in Table 2-5.

Table 2-5 Cyclonic Design Significant Wave Heights (Hardy et al., 2004)

Location	100-year ARI (m)	500-year ARI (m)
Caloundra at 35m depth contour	8.9	12.0

2.5.2.1 *Recently Observed Extreme Waves*

In 2010 the State Government commenced directional wave recording approximately 17km southeast from the Bribie Island northern spit (referred to as the Northern Moreton Bay Waverider buoy). The maximum individual wave height recorded at this location is 10.3m (significant wave height approximately 5.5m) and occurred during ex-TC Oswald, 27 January 2013. A sample time series of recorded wave parameters during this event is shown in Figure 2-15. It is notable that the peak wave conditions occurred from the east to north-easterly directional sector. In comparison to the prevailing southerly swell conditions, these waves would experience less energy dissipation before reaching the Bribie Island coast. Under these conditions significant shoreline erosion and wave overtopping at the Bribie Island northern spit would be expected. Wave overtopping processes are considered further in Section 2.5.3.

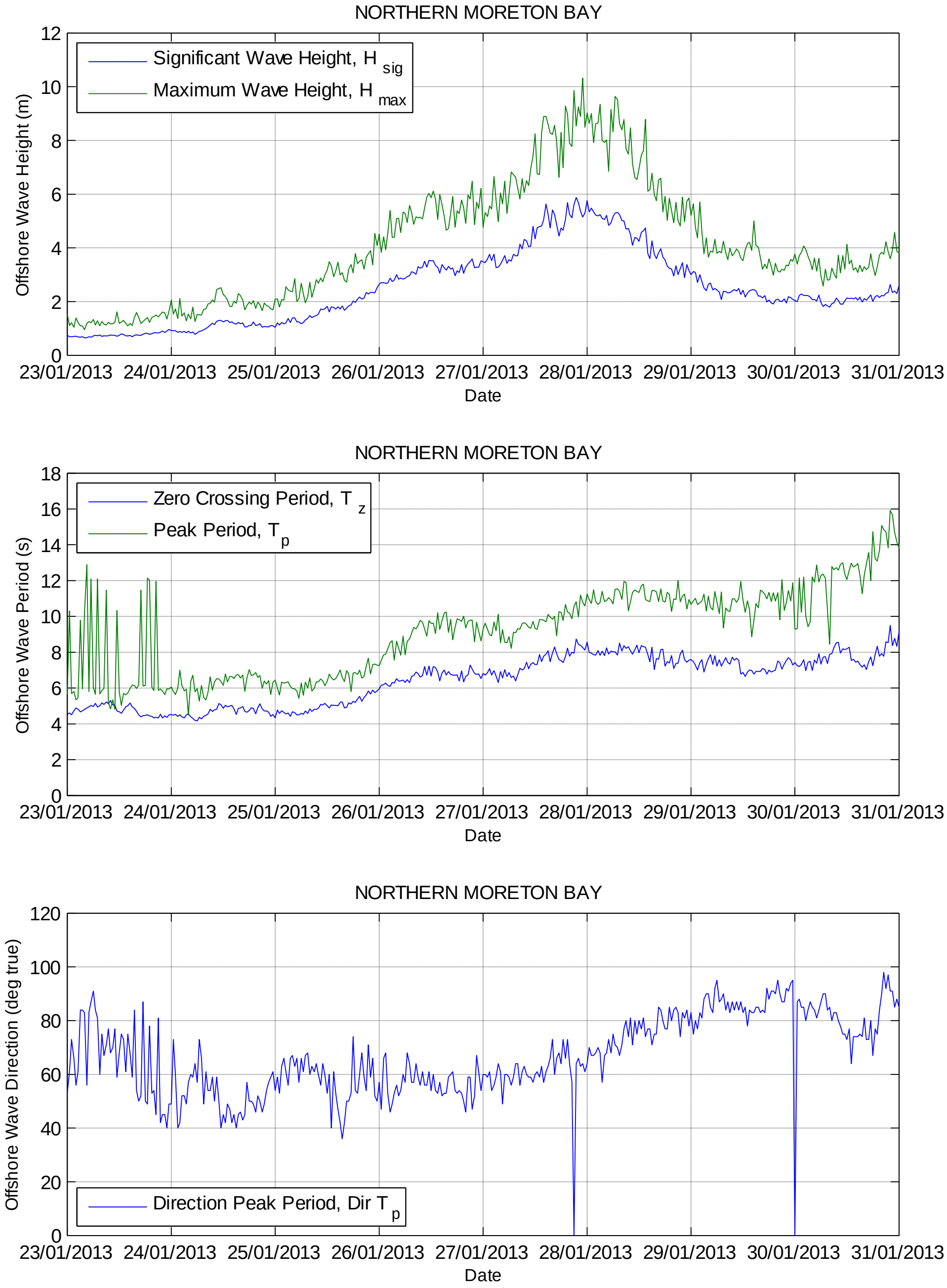


Figure 2-15 Recorded Wave Conditions Offshore from Bribie Island during ex-TC Oswald (data provided by DSITIA)

2.5.3 Wave Runup and Overtopping at the Bribie Island Northern Spit

Wave runup is the intermittent process of advancement and retreat of the instantaneous shoreline position on a timescale that is of the order of the incoming wave period. Along exposed coastlines the wave runup can be a significant contributor to the peak water levels observed during a storm. Furthermore, the large quantity of energy contained in individual wave runup events can lead to significant shoreline erosion.

Wave runup and the overtopping of sand dunes at the Bribie Island northern spit is often observed during severe weather events. These wave driven processes can lead to:

- Erosion of the dune system and loss of vegetation during the storm, with the eroded sand typically deposited offshore; and
- Degradation of mangrove habitat due to the deposition of sand transported by sediment laden overwash (discussed further in Section 2.8.1).

Overwash only occurs at locations where the runup height exceeds (overtops) the dune crest elevation. Figure 2-16 provides examples of erosion along high dunes and evidence of wave overtopping at a low crested dune location.

Figure 2-16 Erosion along High Dunes (left) and Mangrove Degradation due to Wave Overwash (Queensland Government, 2008)

The wave runup contribution to shoreline water levels has been estimated using an empirical formulation based on 10 dynamically diverse field experiments described in Stockdon et al (2006). The runup height predicted with this formula is the level above the offshore mean water level that is exceeded by 2% of runup events (*R_2*). The general expression for runup on beaches provided in Stockdon et al. (2006) is:

$$R_2 = 1.1\left(0.35\beta_f\left(H_0L_0\right)^{1/2} + \frac{H_0L_0\left(0.563\beta_f^2 + 0.004\right)^{1/2}}{2}\right) \qquad \textbf{Equation 2-1}$$

where β_f is the foreshore slope, H_0 is the deep water significant wave height and L_0 is the deep water wave length.

Using existing information to estimate design wave parameters and foreshore slope, wave runup levels along the Bribie Island northern spit have been determined following Equation 2-1 and are presented in Table 2-6.

Table 2-6 Wave Parameters and Runup Level Estimates

Wave Parameter Reference	H_0 (m)	T_p (s)	L_0 (m)[1]	β_f	R_2 (m)
Hardy et al. (2004)[2]	8.9	13.5	284.5	1 in 20	3.0
ex-TC Oswald (January 2013)[3]	5.9	10.8	182.1	1 in 20	2.0

When combined with the 100yr water level of 1.65mAHD presented by Aurecon (2013), extreme wave runup at Bribie Island could be expected to reach elevations well above 3.65mAHD. Sections of dune along the Bribie Island northern spit where the elevation is below 3.65mAHD and above 4.65mAHD are presented in Figure 2-17. This mapping demonstrates the vast region on Bribie Island considered vulnerable to wave overtopping.

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[1] Estimated from H_0 and T_p using linear wave theory
[2] 100-year design wave conditions at Caloundra, Table 7 in Hardy et al. (2004)
[3] Estimated from Northern Moreton Bay recorded wave conditions, refer Figure 2-15

Title:

Elevation at Bribie Island Northern Spit

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2-17

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0 375 750m
Approx. Scale

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2.5.4 Northern Pumicestone Passage Wave Climate

Wave energy within the northern Pumicestone Passage is low due to limited depths and fetches. The direction of small waves generated within the passage will generally follow the wind conditions (most frequently from the south-easterly sector) and rarely exceed 0.5m. Despite these very mild conditions, waves are still expected to contribute to sediment transport in the upper beach areas along the mainland shoreline. In the deeper channels of Pumicestone Passage, and along the western side of the northern spit sheltered from the prevailing local wave climate, sediment transport is expected to be dominated by tidal flows. Sediment supply and sediment transport mechanisms are considered further in Section 2.6 and Section 2.7.

2.6 Sediment Supply

There has been a continual supply of marine sand to Bribie Island 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 the prevailing ocean swells and associated sediment transport within Moreton Bay and Pumicestone Passage.

Caloundra Head represents a littoral drift divide, with sediment being transported to the north and south of the rocky headland. The dominant longshore transport is to the south which supplies sediment to the northern Pumicestone Passage entrance. Current and wave processes at the entrance control the position of the Caloundra Bar. The northern section of Pumicestone Passage is characteristic of a bar-built estuary with relatively shallow depths inside the mouth. Figure 2-18 provides a conceptual diagram of the dominant sediment transport mechanisms and bed types throughout the study area.

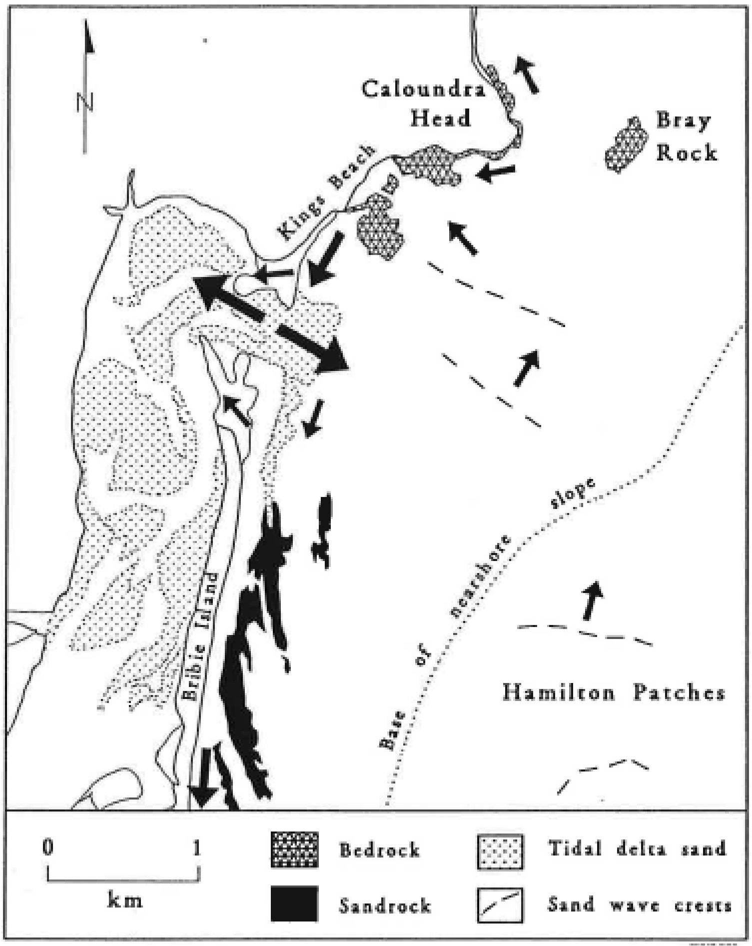

Figure 2-18 Sediment Transport and Bed Types at the Northern Entrance to Pumicestone Passage (Jones, 1992)

2.7 Sediment Transport Mechanisms

2.7.1 Coastal Sediment Transport

The eastern side of the Bribie Island northern spit is exposed to wave-driven longshore and cross shore sediment transport processes.

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. estuaries, rivers and 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.

These processes are all likely contributors to the observed narrowing of the Bribie Island northern spit.

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.

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.

2.7.2 Northern Pumicestone Passage Sediment Transport

Sand that enters the northern entrance is re-worked by tidal and wave processes within the passage to form intertidal banks. Aerial photograph shows these banks extending south beyond the entrance to Lamerough Canal. Under normal conditions, the position of the Caloundra Bar and the intertidal bank morphology remain relatively stable. During storm conditions rapid changes at the entrance may be observed as the position and morphology of the Caloundra Bar rapidly changes. This causes a subsequent change to the tidal efficiency at the entrance and sediment transport patterns and intertidal bank morphology will also adjust toward a new equilibrium.

Prior to urbanisation, the width of the northern Pumicestone Passage beaches was strongly dependant on the position of the ebb and flood channels (Riedel and Byrne, 1979). Today, the beaches are managed using a combination of shoreline erosion management options which are summarised in Chapter 3.

2.7.3 Shorelines with Terminal Protection

Natural sediment transport processes are interrupted on shorelines where erosion control strategies have been implemented. Rock revetments and seawalls, which are present at many locations throughout the study area, are typically implemented to limit landward shoreline movements and therefore the sediment transport 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 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.

2.8 Assessment of Historical Shoreline Erosion and Future Scenarios

2.8.1 Bribie Island Northern Spit

The former Queensland BPA commenced formal monitoring of shoreline change at the Bribie Island northern spit via hydrographic surveys in 1970. On the open coast shoreline, the average rate of shoreline recession between 1970 and 1984 was estimated to be 2m/year; however, erosion and accretion rates were as high as 50m in single years (Queensland Government, 1992). The BPA also mapped shoreline change using photogrammetry methods which is presented in Appendix B. This mapping highlights the dynamic nature of the spit and the northern migration of the entrance between the 1971 and 1992.

In 1997, the former Queensland Environmental Protection Agency (EPA) identified an emerging erosion issue on Bribie Island eastern shoreline. Four narrow locations along the northern spit were subsequently monitored by the EPA are indicated in Figure 2-19. The changes in shoreline position at the four narrow locations between 1958 and 2004 are shown in Figure 2-20.

A series of severe weather events during the 2007/08 summer caused significant dune erosion, widespread wave over wash and subsequent death of vegetation at the Site 2 and Site 3 locations. In a report to Council, the EPA estimated that the annual loss of sand from the northern 5km of Bribie Island was between 30,000-144,000m^3/year (Queensland Government, 2008).

The Queensland Government completed dune reconstruction works at Site 2 in 2008 in an effort to mitigate overwash and delay a permanent breakthrough. These works involved excavating sand from the high dune to the immediate south and reconstructing the lowered dune at Site 2 and were only intended to provide temporary relief (up to 2 years) while a Bribie Island Breakthrough Assessment (Aurecon, 2009) was completed. No evidence of these works was observed during a site visit in 2014 and widespread overwash had caused vegetation dieback between Site 2 and Site 3, highlighting the challenges associated with erosion management on the northern spit of Bribie Island. Despite the ongoing lowering of the dune at this location a permanent breakthrough has not occurred. The consolidated mud flat of the landward side of the spit between Site 2 and Site 3 (refer Figure 2-21) is expected to resist the formation of a permanent entrance at this location for many years.

Analysis of recent aerial photography and information gathered during a site visit in early 2014 suggest the pattern of shoreline recession and vegetation loss is ongoing. A vast area of mangrove die back between Site 2 and Site 3 can be seen in Figure 2-21. Sediment laden wave overwash and sedimentation appears to be the primarily cause of mangrove habitat loss. Sand deposition acts to smother the mangrove pneumatophores causing suffocation and eventual death of the plant. Evidence of wave overtopping and mangrove die back are shown in Figure 2-22 and Figure 2-23. The width of the vegetated dune at the narrowest point (Site 4) was approximately 25m in late 2013.

Title:

Bribie Island Northern Spit Narrow Locations

Figure:
2-19

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0 0.5 1km
Approx. Scale

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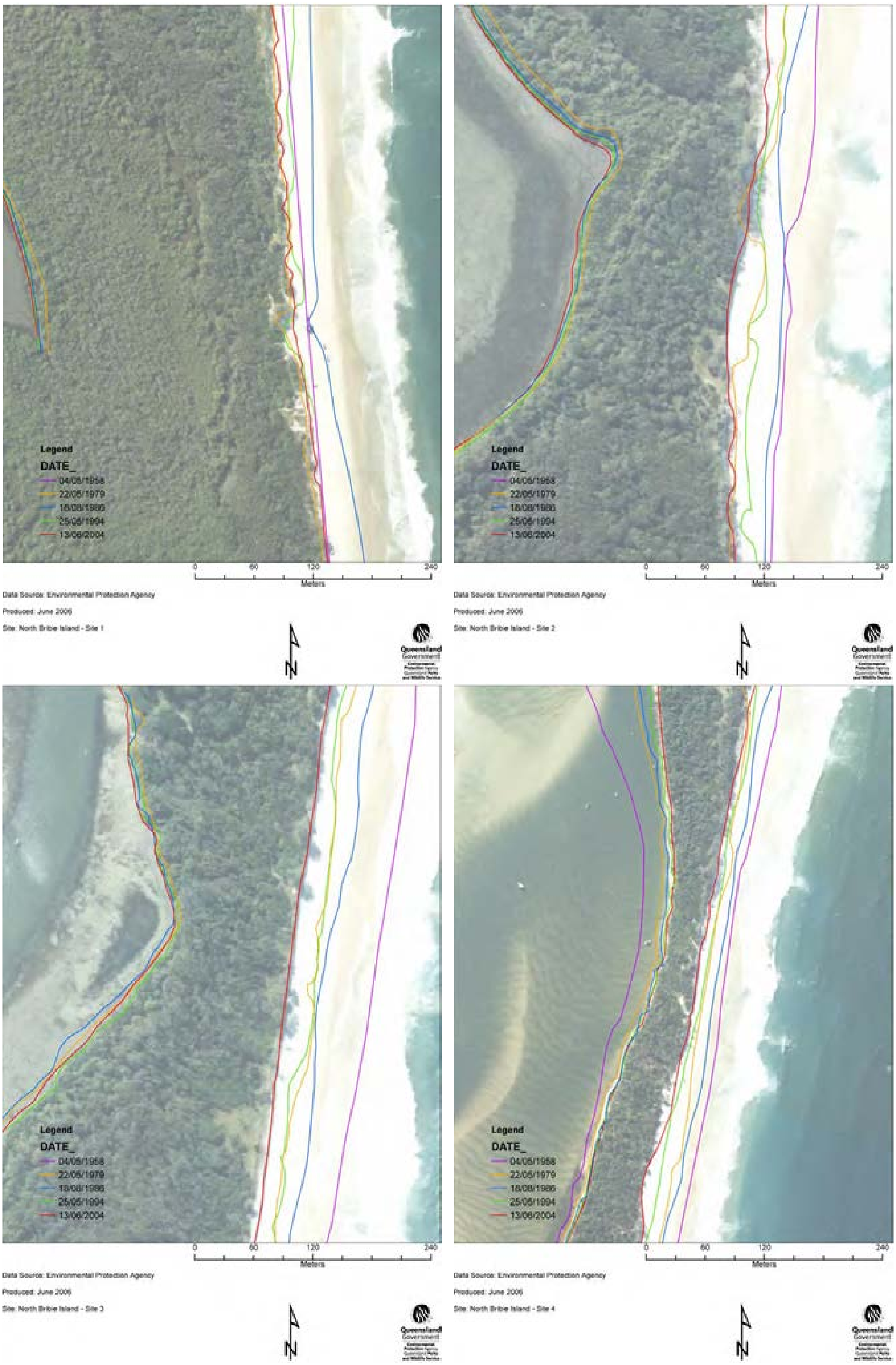
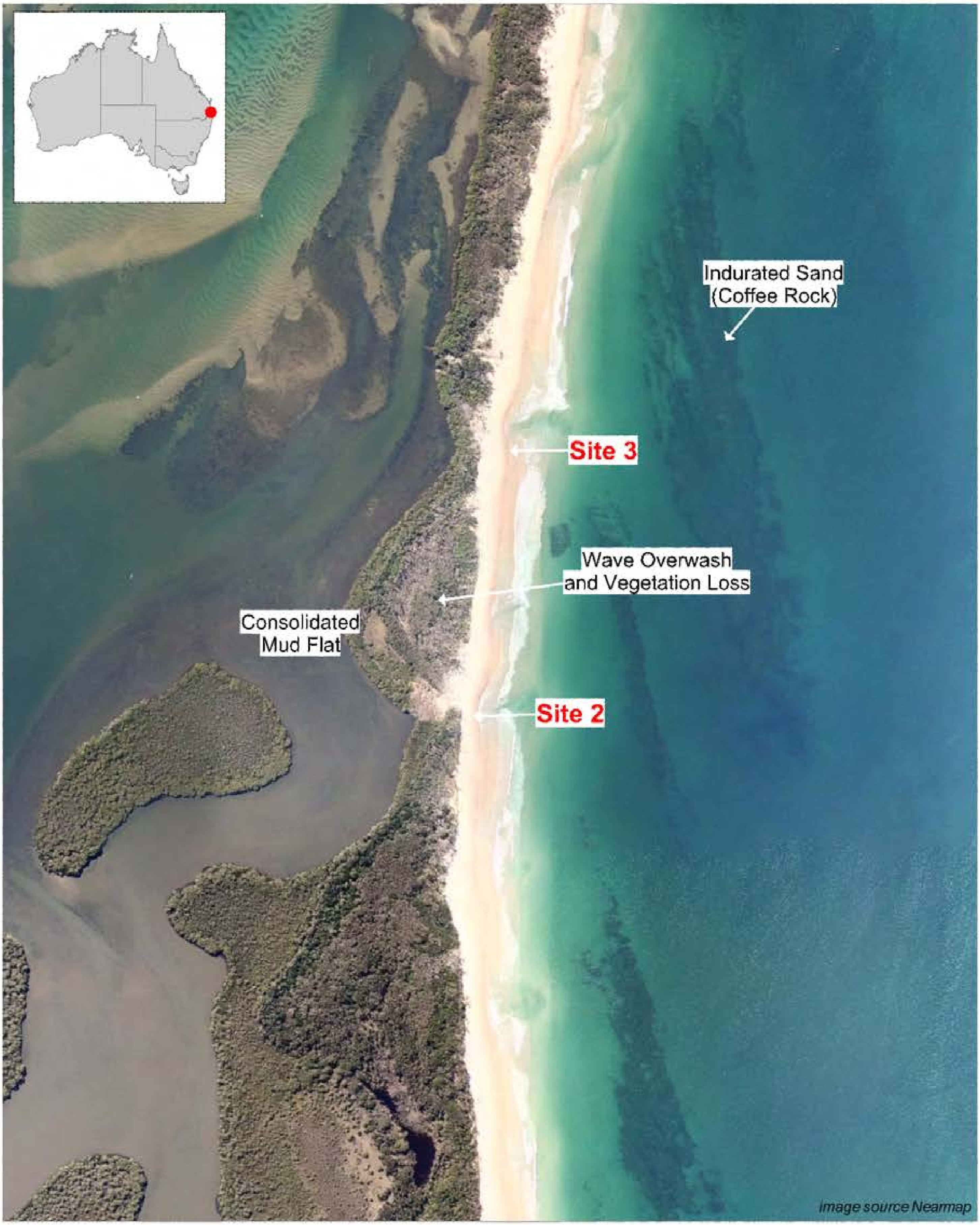


Figure 2-20 Shoreline Position at Four Bribie Island Northern Spit Locations between 1958 and 2004 (Queensland Government, 2008)



Title:

Vegetation Loss at Site 2 and Site 3 (November 2013)

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2-21

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A

N

0 250 500m

Approx. Scale

BMT WBM

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Figure 2-22 Evidence of Wave Overwash at Site 2 (Queensland Government, 2008)

Figure 2-23 Sand Deposition and Mangrove Die Back at Site 2 (April 2014)

2.8.2 Pumicestone Passage

The historical aerial photos provided in Appendix B show that on a regional scale the changes to the mainland shoreline within Pumicestone Passage have been relatively small, with the exception of the shoreline between Nelson Street and Earnshaw Street that has been subject to erosion/accretion associated with the migration of the main flood and ebb channels (refer below to extracts from Riedel and Byrne, 1979). Other notable localised changes and/or responses to structures include:

- Mangrove clearing and land reclamation works between Bells Creek and Lamerough Canal appears to have commenced in the late 1950s. This relatively low lying land is now dominated by residential development and is part of the Pelican Waters community.
- Dredging of the Bells Creek entrance has occurred since 1970 and provides deep water shelter for small boats. During the 1970s some of the material was used for land reclamation. Surplus dredge material was pumped to the north of the entrance and created a large shoal which has remained relatively stable.
- Dredging in 1973 and 1974 created the anchorage at the Caloundra Power Boat Club (north of Lamerough Canal). The dredge spoil was used as reclamation material to extend Woorim Park. Mangrove habitat was removed to the south of the Club and replaced with narrow sandy beaches (Riedel and Byrne, 1979).
- Rapid construction of the Pelican Waters canals took place in the early 1990s however aerial photos show the initial canal construction actually commenced in the early 1980s.
- Mangrove clearing and land reclamation works occurred in the early 1980s to create the land where the TS Onslow Naval Reserve is now located. Today this area suffers shoreline erosion problems.
- During 2007 and 2008, concrete blocks were used to defend the shoreline at the Naval Reserve. This material type is inappropriate and likely to accelerate local shoreline erosion problems.
- The area north of Oxley Street including Leach Park has been protected by a rock wall since the mid-1960s. Geofabric groynes have been unsuccessful in stabilising a beach in this area. These groynes have recently been formalised by rock however it remains unlikely that a beach will form in this area until the main channel migrates offshore (possibly driven by morphological change at the entrance).
- Bulcock Beach has remained relatively stable due to the control provided by the rocky outcrop around Deepwater Point. Bulcock Beach is observed to widen and extend to the east when the channel entrance migrates toward the south.

Significant change along Nelson Street to Earnshaw Street shoreline has occurred, generally in response to the changes to the Pumicestone Passage northern entrance and flood/ebb channel morphology. Since 1999/2000 this section has been stabilised by a geofabric sand container groyne field. Prior to stabilisation, Riedel and Byrne (1979) described some of the changes along this section associated with the migration of the flood and ebb channels (accompanying illustrations in Figure 2-24):

a) *In 1940 the coastline consisted of three crenulated bays. Each bay was aligned parallel to an historic channel path. It did not appear in 1940 that any of the channels was actively moving or was carrying a significant part of the tidal current.*

b) *By 1958 the middle channel was an active ebb channel and another ebb channel had formed to the south. All traces of the northern channel had been obliterated by the slow movement south of a large sandbank under the influence of the flood current. This caused the southern most point (south of Jellicoe Street) to erode, and the beaches opposite Earnshaw Street to advance.*

c) *Between 1958 and 1961 the flood channel had migrated to the left and was still scouring the southern point. The flood tide was moving the sand bar south and straightening the beach between Earnshaw Street and Beattie Street. The large sand bar is being moved south by the flood tide. As the sand spills over into the ebb channel it is swept back out towards the passage entrance.*

d) *By 1972 the main ebb channel had moved north and had rotated further to the left. The secondary flood channel still existed but was less well defined because of the southerly movement of a large sandbank under the influence of the flood tide.*

e) *In 1974 the ebb channel was continuing to move to the left and was causing a general straightening of the beach. It had eaten into most of what was left on the northern sand bar. The secondary channel still existed, but the sand bars were making it less well defined. Natural movements of the beach are now restricted because of rock placed at the eroding parts of the beach.*

f) *By 1977 the main channel had started to veer to the right and sand was building up opposite McLean Street. The apparent reason for this is that as the main entrance bar has moved north, Bulcock Channel has taken more of the flood tide, and there has been a resurgence of the sand bar opposite McLean Street, fed by the flood tide from Bulcock Channel. The increased sand had deflected the ebb channel to the right. This has allowed the beaches to grow between Beattie Street and Earnshaw Street.*

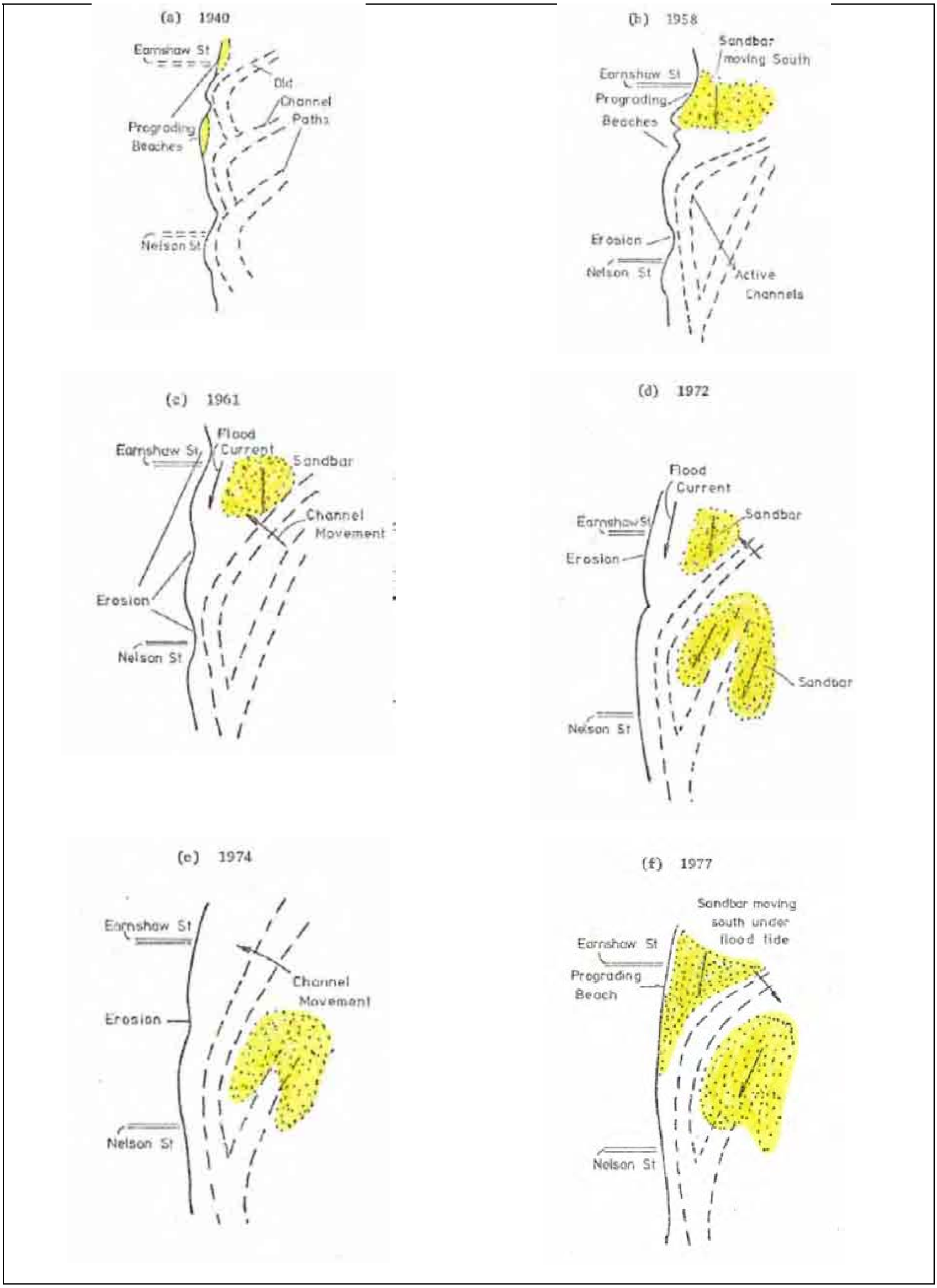


Figure 2-24 Illustrations Describing Golden Beach Shoreline Change Associated with Tidal Channel Migration between 1940 and 1977 (Riedel and Byrne, 1979)

2.8.3 Northern Pumicestone Passage Future Scenarios

The likely hydrodynamic and morphological changes within northern Pumicestone Passage due to a Bribie Island breakthrough were discussed by the former EPA (Queensland Government, 2008) and subsequently assessed by Aurecon (2009). These possible changes can be broadly grouped into two scenarios:

Scenario 1 – Breakthrough and permanent entrance forms to the south of Blue Hole

A breakthrough and new permanent entrance immediately south of Blue Hole (Site 4 in Figure 2-19) would be just south of the entrance location observed in the early 1960s (refer Section 2.2). This is presently the narrowest section of the Bribie Island northern spit and appears to be the most likely location where a new entrance would form. In this area the passage morphology is dominated by sand banks which are regularly reworked by tidal channel migration and strong tidal flows. The mainland foreshore is approximately 1.2km to the west, has clean sandy beaches (stabilised with groynes at some locations) and is separated from the possible new entrance by 800m of shallow sand banks exposed at low tide. The sand banks would be expected to provide a high level of protection to the mainland shoreline from offshore coastal processes and wave penetration. Tidal attenuation within the passage may slightly alter, however, would not be expected to cause undesirable water level impacts for the mainland communities. A new entrance would be expected to slowly migrate northward once formed, possibly over many decades as observed during the 1960s-1990s. With an entrance at this location the character and amenity of northern Pumicestone passage will be maintained. Economic, social and recreational impact associated with Scenario 1 is rated as low to moderate (Queensland Government, 2008).

Scenario 2 – Breakthrough and permanent entrance forms south of Lamerough Canal

This scenario considers a new permanent entrance forming opposite or to the south of the Lamerough Canal entrance (Site 1, Site 2 or Site 3 in Figure 2-19). The passage in this region is a low energy environment comprising muddy to sandy sediments with mangrove dominating the foreshore and intertidal islands. The mainland foreshore between Lamerough Canal and Bells Creek is generally very low, typically 0.5m to 1.0m above HAT. This foreshore is characterised by narrow sandy beaches with muddy intertidal areas, and with mangrove frequency increasing to the south. Formation of a new entrance opposite these low lying mainland areas is likely to cause a significant reworking of the existing mangrove landforms, increased tidal flows, development of new channels and an increase in tide height locally (due to reduced tidal attenuation). This would in turn increase the coastal inundation risk. There may also be significant landform changes to the most northern end of the passage as the existing entrance closes over and tidal flows are significantly reduced. The economic, social and recreation impact associated with Scenario 2 would be significant.

As briefly discussed in Section 2.3.2, a key threat to mainland assets and values associated with a permanent breakthrough of the Bribie Island northern spit is a change to the tidal attenuation patterns within northern Pumicestone Passage. The threat is considered greater for Scenario 2; however, the likelihood of a permanent entrance forming is this region is considered low due to the presence consolidated bed material on the landward side of the spit (refer Figure 2-21).

The future planning levels and mapping presented in Section 2.3.4 illustrate the coastal inundation threat associated with the 100yr ARI storm tide and an increase to the mean sea level within northern Pumicestone Passage. Gradual increases to mean sea level are expected in the coming decades due to sea level rise, while a more rapid change to the tidal regime within Pumicestone Passage maybe driven by a breakthrough and the formation of a new entrance. The Bribie Island eastern shoreline would be expected to recede with sea level rise, placing increased pressure on low and narrow sections of the northern spit. Given the uncertainty in timing and the processes that may cause changes to hydrodynamics (and morphology) throughout the study area, the shoreline management strategy presented in Chapter 4 is underpinned by an improved capacity to monitor and react to emerging shoreline erosion issues and/or tidal regime changes within Pumicestone Passage.

3 Current Condition and Shoreline Management Programs

3.1 Current Condition

The mainland shoreline types and the adjacent assets and values are described in the following sections and indicated in Figure 3-1 to Figure 3-6. The descriptions are based on recent site inspections completed for both this study and as part of the Sunshine Coast Council SEMP (SCC, 2014).

3.1.1 Bulcock Beach

This beach unit receives heavy usage from the local community and visitors and includes a patrolled beach, boardwalk, picnic areas, toilet facilities and private resort waterfront. The area is located at the northern entrance to Pumicestone Passage which provides boating access to the open sea via Caloundra Bar.

The foreshore area within this beach unit has undergone considerable redevelopment since 2009 as part of the Bulcock Beach Redevelopment Project. Some new seawall and/or seawall realignment works have occurred south of the Ithaca Caloundra City Surf Life Saving Club - a Council-owned building on Council controlled land. The shoreline extending around Deepwater Point is armoured by a rock revetment that protects car parking, toilet facilities and a section of the Sunshine Coast Coastal Path.

3.1.2 Leach Park

Leach Park includes a public boat ramp and Sailing Club and is therefore an important area for recreational boaters. The park also provides open space for the local community and visitors to the adjacent holiday apartments and Tripcony Holiday Park. This park also includes a section of the Sunshine Coast coastal pathway.

Leach Park has recently undergone improvement works and forms part of the wider Golden Beach Foreshore Master Plan. Stage one works were completed in December 2010 and included an upgrade of the existing revetment seawall and formalisation of a sandbag groyne, with degraded sandbags replaced by rock.

As needed beach nourishment complements the rock groynes. Nourishment between the structures immediately adds value to the redevelopment; however, it may be a challenge to maintain a sandy shoreline at this location due to the proximity of the present main channel flow.

3.1.3 Oxley St to Beattie St

This area offers high recreational and scenic amenity value to the Golden Beach community and includes a bathing reserve and patrolled beach. The section is characterised by a sandy shoreline that is stabilised by a geofabric sand container groyne field that was established during 1999 and 2000 in response to erosion pressure (seven groynes over approximately 1200m of shoreline). At many locations, the geofabric containers also provide scour protection to stormwater outfalls that form part of the local drainage infrastructure. The upper beach and foreshore area has been further stabilised by coastal vegetation, which is providing a suitable buffer to storm erosion at most locations.

3.1.4 Beattie St to Nelson St

A very narrow buffer exists within this section and a low sandstone seawall protects most of the shoreline. Some sections of this wall are degraded. The area provides popular and scenic pedestrian thoroughfare.

Foreshore works are close to completion (new groyne scheduled for construction in 2015/16) between Jellicoe Street and Nelson Street, including: new hard protection (rock seawall) and widening of the shoreline to accommodate a 3m wide pedestrian/cycle path that will form part of the Sunshine Coast Coastal Path. There are two geofabric groynes at the northern extent of this section. The expected lifespan of these groynes is uncertain and individual sand containers are replaced as required, in accordance with a regular maintenance program.

3.1.5 Nelson St to Lamerough Canal

South of Nelson Street to Lamerough Canal carries high human use values owing to the extensive district recreation parks (including a section of shoreline protected by mangrove habitat), boat ramp and car park, Caloundra Power Boat Club and TS Onslow Naval Cadet Base. The recreational values of the area comprise both social and economic value groups, and are mainly based on the opportunities and access provided for boating, recreational fishing, bathing, walking, picnicking and the social interaction at the Club and Navel Cadet Base (which is used by the Caloundra Sea Scouts). The waters of this area carry significant natural value, being designated High Ecological Significance Marine Waters, Fish Habitat Area and part of the Moreton Bay Marine Park (Habitat Protection Zone and Conservation Park Zone).

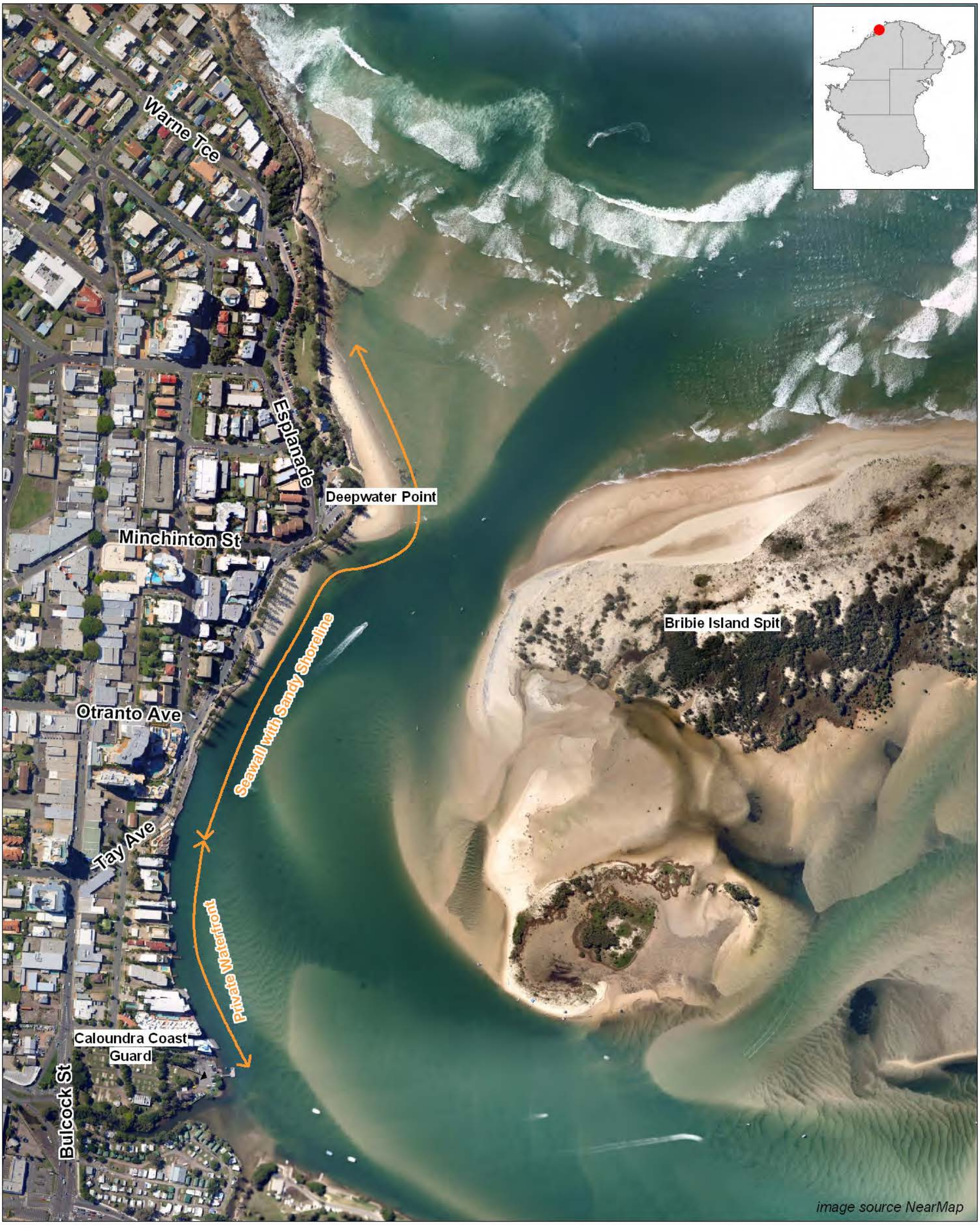
The Caloundra Power Boat Club is located north of the Lamerough Canal entrance. Together with the public boat ramp, jetty and car/trailer parking space the Club is a valuable asset to the local community and visiting recreational boaters. The Club has been built on low-lying land bordered to the north by mangrove habitat that extends approximately 400m north of the Club. This area includes a pedestrian boardwalk and lookout areas. No erosion protection structures exist along this section with the wide buffer and mangrove vegetation providing suitable protection against shoreline erosion. The TS Onslow Naval Cadet Base is located to the north of the mangrove habitat. The club leases this land from the State Government.

As demonstrated in Section 2.3.4, this section of shoreline is vulnerable to coastal inundation. The need for emergency works at the shoreline adjacent to Nelson Street was previously noted in 2010 (Aurecon, 2010). Subsequently, seawall and foreshore widening works have been completed at this location as part of the Sunshine Coast Coastal Pathway project.

3.1.6 Lamerough Canal to Bells Creek

This beach unit extends from Lamerough Canal to Bells Creek. The residential and open space areas between Lamerough Canal and Bells Creek is built on low lying reclaimed land that was once wetland. This section of shoreline is particularly vulnerable to coastal inundation and a change to the tidal regime within Pumicestone Passage is expected to increase this theat.

This beach management unit carries high human use values owing to the extensive district recreation parks, the Sunshine Coast Coastal Pathway (including section of shoreline protected by native vegetation), boat ramps and car park. The recreational value of the area comprises both social and economic (tourism and commercialised recreation) value groups, and are mainly based on the opportunities and access provided for boating, recreational fishing, bathing, walking, and picnicking. Caloundra Military Jetty Memorial is identified as a heritage item. The waters of this area comprise very significant natural values being a designated High Ecological Significance Marine Waters area, Fish Habitat Area and part of the Moreton Bay Marine Park (Habitat Protection Zone and Conservation Park Zone).



Title:

Bulcock Beach Shoreline Types

Figure:
3-1

Rev:
A

N

0 125 250m
Approx. Scale

BMT WBM
www.bmtwbm.com.au

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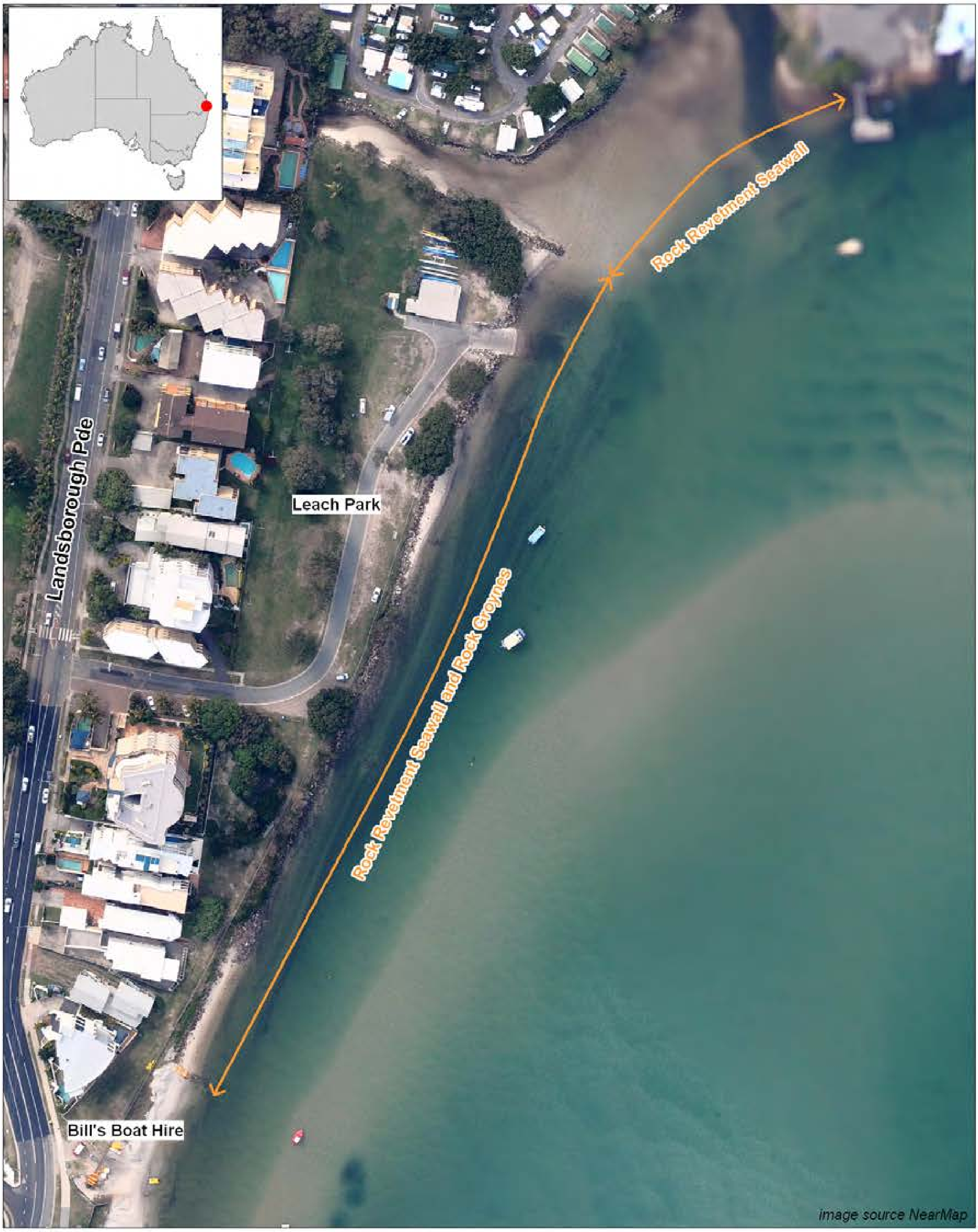

Title:

Leach Park Shoreline Types

Figure:

3-2

Rev:

A

N

0 37.5 75m

Approx. Scale

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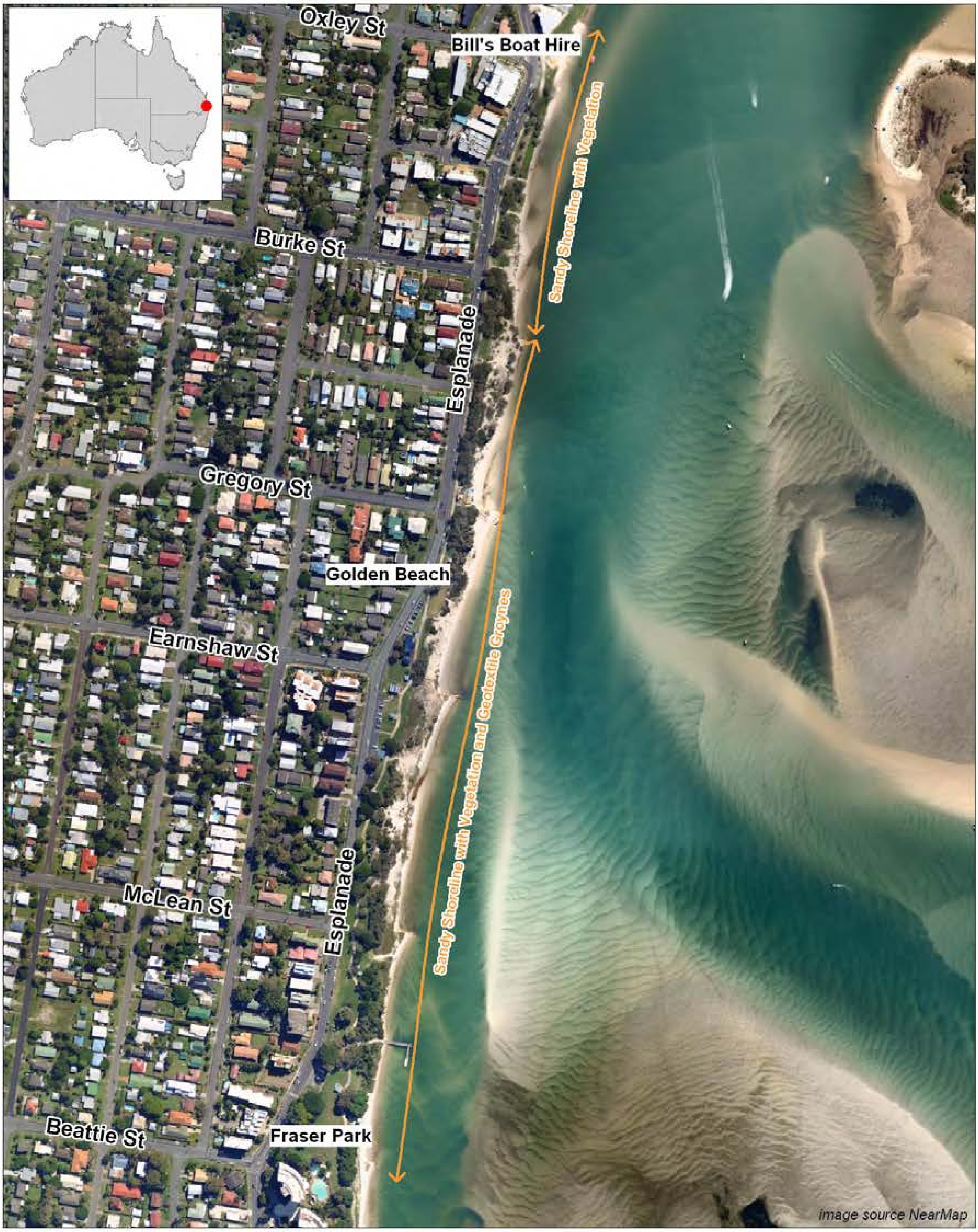
Filepath : I:\B20780_I_BRH Golden Beach Bribie Island MB\DRG\COA_003_140514_ShorelineTypes_LeachPark.wor



Title:

Beattie Street to Oxley Street Shoreline Types

Figure: 3-3

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Title:

Nelson Street to Beattie Street Shoreline Types

Figure: 3-4

Rev: A

N

0 50 100m

Approx. Scale

BMT WBM

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Title:

Lamerough Canal to Nelson Street Shoreline Types

Figure:

3-5

Rev:

A

N

0m 100 200

Approx. Scale

BMT WBM

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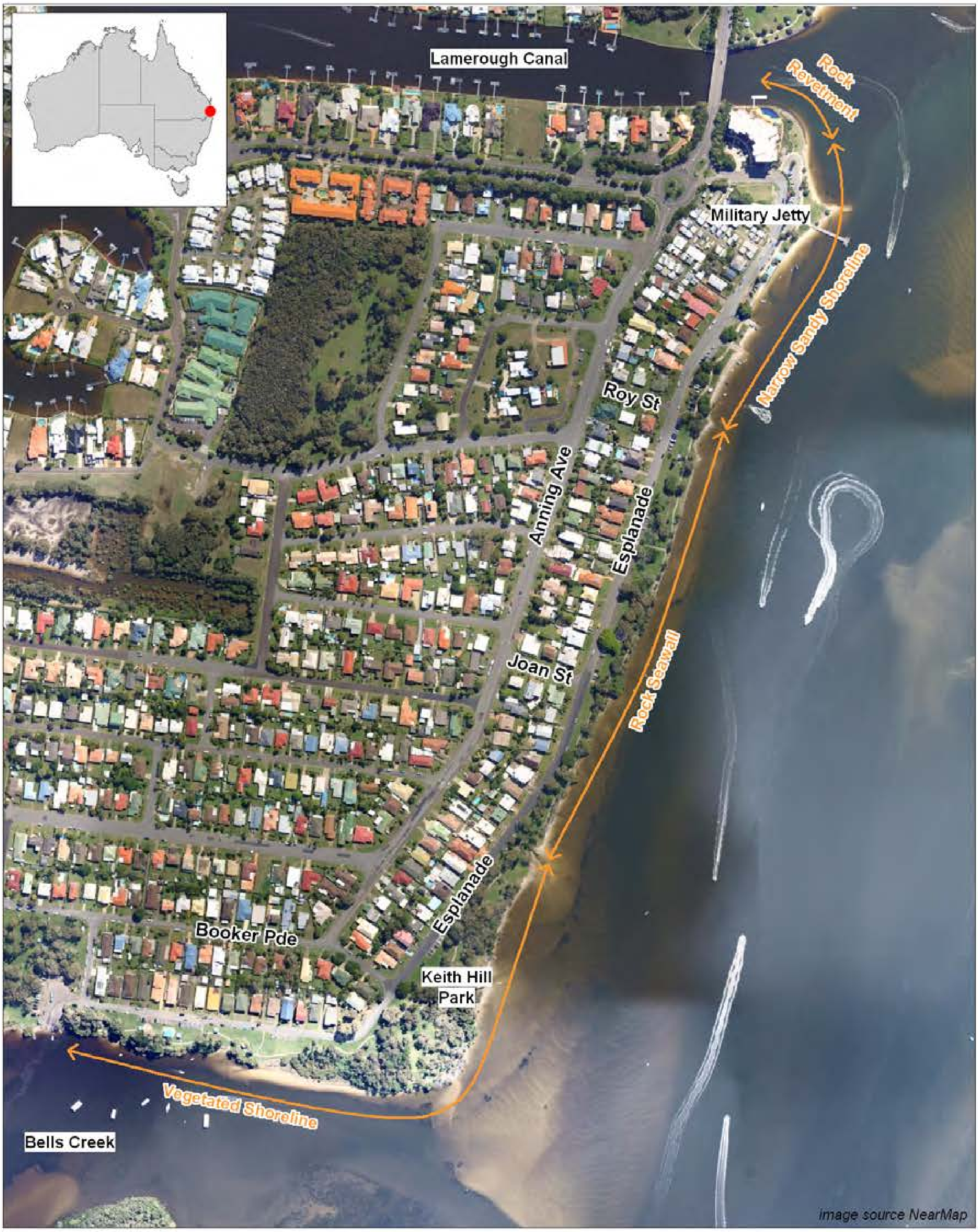

Title:

Bells Creek to Lamerough Canal Shoreline Types

Figure: 3-6

Rev: A

N

0 125 250m

Approx. Scale

BMT WBM

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3.2 Existing Permitted Shoreline Management Activities

SCC holds the following approvals for shoreline management activities in the study area:

- **MPW2013/MBMP0041*** (2013) – Marine Park Permit to dredge up to 5,000t per year and place and profile dredged sand for beach nourishment within Bribie Island (north) Habitat Protection Zone (HPZ01) of the Moreton Bay Marine Park.
- **ENRE04732113** (2013) – Registration Certificate for ERA 16 (dredging of 1,000 to 10,000t in a year) under SPDE04284412.
- **EPPR00188713** (2013) Registration Certificate for ERA 16a (dredging of 1,000 to 10,000t in a year) under SPDE04284412.
- **SPDE04284412** (2012) – Material Change of Use Development Permit for ERA 16 (dredging of 1,000 to 10,000t in a year) for the Pumicestone Passage adjacent to Lots 573 and 576 on CG5004.
- **EPBC 2012/6397** (2012) – Approval under the EPBC Act for beach nourishment and dredging works at Golden Beach.
- **QS2012/MCY2635** (2012) – Marine Park Permit to conduct dredging and beach nourishment works within the Pumicestone Passage Habitat Protection Zone of the Moreton Bay Marine Park.
- **2012NA0464** (2012) – Concurrence approval for Operational Works involving the removal, damage or destruction of marine plants on Unallocated State Land (USL) adjacent to the road reserve along the foreshore of Golden Beach from Jellicoe Street to Bells Creek.
- WICL0892210 (2010) – Clearing Permit under *Nature Conservation (Administration) Regulation 2006* to clear up to 1800m^2 of least concern plants from Nelson Street and the Golden Beach Esplanade.
- **SPCC00199010** (2010) – Concurrence approval for Operational Works consisting of prescribed tidal works being minor works across the Sunshine Coast Regional Council.
- IPDE0038106A11 (2006) – Material Change of Use Development Permit for ERA 19(a) (dredging of not more than 5,000t in a year) within the Pumicestone Passage navigation and access channels.
- *Harbours Act 1955* s86 sanction (1991) – dredging and beach replenishment works in Pumicestone Passage at the northern end of Golden Beach.

***Permits in BOLD are still in force**

Details of the permits still in force are provided below.

3.2.1 ERA 16 Development Permit (SPDE04284412) and Registration Certificate (ENRE04732113)

The Development Permit SPDE0428112 covers ERA 16 Extractive and Screening Activities (1) dredging in a year, the following quantity of material (a) 1000t to 10,000t. Specifically this permit covers dredging in Pumicestone Passage adjacent to Golden Beach (Lots 573 and 576 on CG5004) for erosion protect works to undertake beach nourishment of Golden Beach. This permit was issued by the Department of Environment and Heritage Protection (DEHP) on the 15th August 2012 and has no expiry date.

This permit sets the following water quality monitoring conditions:

Monitoring location[4]	**Quality characteristics**	**Release limit**	**Minimum monitoring frequency**
S1, S2	pH	8 – 8.3 during dry weather 6.5 – 8.3 during wet weather	Daily when dredging
S1, S2	Turbidity	No visible plume in receiving waters is to extend beyond 50m from any deposition point and/or the dredge operation	Daily when dredging
S1, S2	Petroleum products (oil, grease, fuel etc.) scum and litter	Not visible or otherwise noticeable	Daily visual inspections when dredging

Registration Certificate ENRE04732113 authorises the registered operator (Sunshine Coast Regional Council) to undertake the activities of SPDE0428112, in accordance with the *Environmental Protection Act 1994*.

3.2.2 Marine Park Permits (MPW2013/MBMP0041 and QS2012/MCY2635)

Marine Park Permit QS2012/MCY2635 was issued by DEHP in 2012 to permit the conduct of maintenance dredging and beach nourishment works within the Pumicestone Passage Habitat Protection Zone of the Moreton Bay Marine Park. The dredging volumes and activities authorised under this permit are to occur 'in accordance with the conditions of a current Environmental License issues under the *Environmental Protection Act 1994*' (condition 3(c)), that is, Development Permit SPDE048112 and the associated Registration Certificate ENRE04732113. The permit is valid until August 2018.

Marine Park Permit MPW2013/MBMP0041 was also issued by the Queensland Parks and Wildlife Service (QPWS) of the Department of National Parks, Recreation, Sport and Racing (DNPRSR) to permit dredging of sand from the Pumicestone Passage within the Bribie Island (north) Habitat Protection Zone (HPZ01) and the placement and profiling of dredged sand for beach nourishment purposes on tidal lands and tidal waters of Golden Beach and Bulcock Beach. The permit allows dredging of up to 5,000t of sand per year up to the expiry of the permit in August 2018.

3.2.3 Concurrence Approval for Operational Works involving Marine Plants (2012NA0464)

The Concurrence Approval 2012NA0464 was provided by DAFF in regards to a Development Permit application for operational works involving the removal, damage of destruction of marine

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[4] Monitoring Location S1 – within three metres offshore from the location of beach nourishment
Monitoring Location S2 – a down-current sampling point in the receiving water situated not more than 100m from the dredge in the down-current direction at times when tidal flows or other flows are occurring and not more than 50m distance from the dredge during slack water conditions

plants. The approval permits the disturbance of approximately 820m^2 of marine plants in association with the annual placement of approximately 10,000m^3 of sand from Pumicestone Passage on USL adjacent to the Esplanade from Jellicoe Street to Bells Creek. Condition 8 of the concurrence approval provides that 'dredging and beach nourishment activities must cease ten years from the date of the commencement of dredging and beach nourishment operations approved' under in conjunction with the concurrence approval.

Condition 5 requires buffer zones free of development to be incorporated between the development and fisheries resources as follows:

- Minimum of 100m buffer zone between the dredge operation works and the boundary of the Pumicestone Channel FHA; and
- Minimum of 50m buffer zone between the dredge operation works and any mapped seagrass locations.

To achieve buffers between dredging and seagrass, the conditions require surveying and mapping of seagrass locations immediately prior to the commencement of works each year.

3.2.4 Commonwealth Approval (EPBC 2012/6397)

A referral to the (former) Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) was made for the dredging of Pumicestone Passage and beach nourishment at Golden Beach. The referral related to wetlands of international importance and listed migratory species. Based on the referral, a decision was made to assess the works on preliminary documentation. The Commonwealth Approval EPBC 2012/6397 was granted on 14th December 2012.

The approval limits dredging to a maximum of 10,000m^3 a year until the end of 2022, with dredging not to exceed a maximum of 30 days of dredging in any calendar year. Prior to any dredging in any calendar year, seagrass surveys are to be conducted to confirm the presence and extent of seagrass patches. Dredging is to maintain a 50m buffer from any seagrass identified as part of these surveys.

The approval also requires the submission of a seagrass monitoring plan prior to the commencement of dredging each year. The most recent Seagrass Monitoring Plan was approved January 2014. Commitments under this plan (prepared by GHD) include the following:

- Submission of sampling program to DNPRSR for approval under GHD Marine Parks permit (January 2014);
- 2014 seagrass survey and reporting (February to March 2016);
- 2015 seagrass survey and reporting (February to March 2016);
- 2016 seagrass survey and reporting (February to March 2016); and
- New three year program to be contracted by Council 2017-2019.

3.2.5 Prescribed Tidal Works Concurrence Approval (SPCC00199010)

Concurrence approval SPCC00199010 was issued by the (former) Department of Environment and Resource Management (DERM) for prescribed tidal works across the entire Sunshine Coast foreshore. Specifically, the approval provides for prescribed tidal works, being minor works across the Sunshine Coast Regional Council including:

- Back-passing sand for erosion management purposes: 20m^3 per linear metre on high energy (open) coast, and 10m^3 per linear metre on low energy shorelines;
- Back-passing at Noosa Main Beach up to the preferred beach profile;
- Open intermittently closed and open lakes and lagoons (ICOLs) and drainage lines around creeks in the low energy areas;
- Maintenance and minor extensions of no more than 3m in length to boat ramps that are managed by local government;
- Maintenance and minor extension of no more than 7.2m to stormwater pipes; and
- Burial of marine carcasses.

There is no expiry date attached to this concurrence approval.

4 Description of Promoted Shoreline Management Strategy

4.1 Strategy Overview

For developed coastlines, it is convenient to consider appropriate adaptation measures in response to changing natural processes using the simple tool developed by BMT WBM (described in Fisk and Kay, 2010). The tool was originally developed for climate change risk assessment and works by establishing a time continuum for each parameter or impact being assessed and identifies three key stages:

- The baseline (current condition) of the parameter being examined at the time of plan preparation;
- The identification of one or more trigger points along the time continuum that flags to planners and/or responsible management agencies that more aggressive or decisive adaptation actions need to occur prior to the undesirable impact occurring; and
- The undesirable impact or end-state of the parameter being examined (e.g. what are the impacts that are trying to be avoided?).

The tool can help decision-makers align perceived risk to assets and values with the selection of the most appropriate adaptation measures and actions. In this regard, the tool is equally valuable when assessing long-term climate variability impacts or more immediate shoreline planning and management decisions. The tool is illustrated in Figure 4-1.

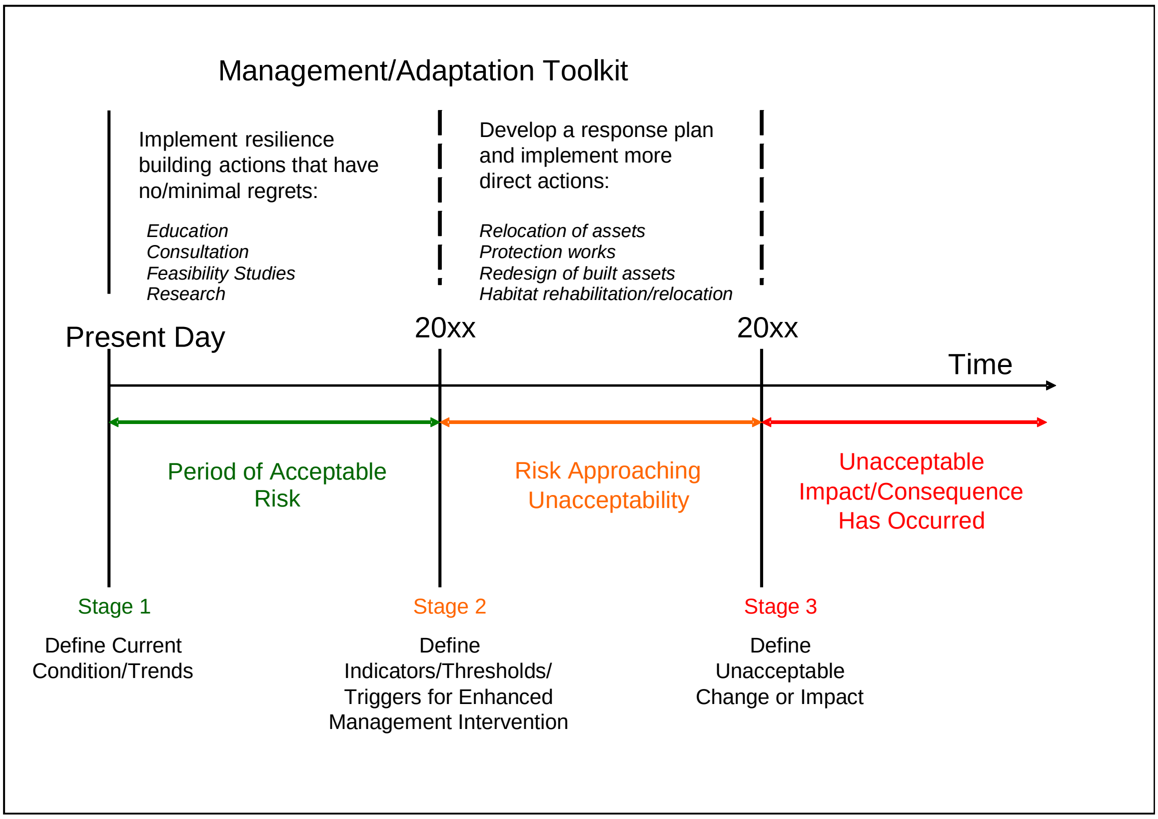

Figure 4-1 Application of Adaptation Actions along the Climate Change Risk Continuum

As discussed by Fisk and Kay (2010), using the tool to characterise risks and the associated impacts has a number of advantages, including:

- It provides a starting point in terms of establishing the context or the current condition of the risk parameter at the present day (on the left hand side of the continuum – Stage 1).
- It can be used to define and obtain agreement about the undesirable future impact that is trying to be avoided (on the right hand side of the continuum – Stage 3). An undesirable impact may be defined any number of ways but could include, for example, defining what is unacceptable in terms of regular inundation of critical infrastructure by tidal incursion and flooding or the loss of a particular coastal habitat type.
- It starts to try and define the risk over time and introduces the idea of one or more trigger points (between the two end points) that serve as flags for enhanced management action or consideration.

For the present study, triggers for enhanced management action have been based shoreline erosion and/or observed changes to the tidal regime within northern Pumicestone Passage. These changes may be accelerated by a permanent breakthough of the Bribie Island northern spit, or occur more gradually in response to climate change induced sea level rise. The proposed monitoring and shoreline management strategy is described in the following sections.

4.2 Identifying Triggers for Enhanced Management Action

4.2.1 Shoreline Erosion

Historically, the shoreline position at mainland beaches within Pumicestone Passage has been dependant on the main ebb and flood channel positions. Prior to the installation of a geofabric groyne field, the shoreline between Nelson Street and Earnshaw Street was subject to erosion associated with the landward migration of the main flood and ebb channels. When the channels are positioned close to the shoreline tidal flows and, to a lesser extent, wave processes increase the erosion pressure on the foreshore and other land-based assets.

Unlike many of the open coast beaches throughout southeast Queensland, historical beach profile survey data is generally lacking throughout northern Pumicestone Passage. There are a number of likely reasons why these beaches have not been included in previous state-wide shoreline monitoring programs (e.g. the former BPA COPE and ETA programs), including:

- Previous programs have typically focused on open coast sites where relatively rapid shoreline erosion (dominated by cross-shore sediment transport processes) may occur during severe weather events (or sequence of events);
- Emerging shoreline trends within Pumicestone Passage are typically driven by channel migration and have occurred gradually with “reactive” management strategies able to mitigate the risk; and
- Most mainland shoreline sections are already protected by seawalls and groynes, thereby limiting gradual landward erosion associated with channel migration.

The development of a formalised shoreline and channel location monitoring program is promoted in this strategy. Ideally, this program would be informed through the collection of the following information:

(1) Airborne bathymetric survey of northern Pumicestone Passage;

(2) Shoreline assessment based on the visual inspection of sites with emerging erosion problems, supplemented by available aerial imagery (e.g. NearMap); and

(3) Local beach profile surveys before and after beach nourishment works, with a follow-up survey within 12 months to assess the “benefit” of the works.

Airborne bathymetric surveys would provide detailed foreshore and seabed elevation throughout the study area. The analysis and comparison of sequential surveys would allow morphological changes relative to the previous survey to be quantified, including:

- Channel migration patterns;
- Local areas of erosion or accretion; and
- Shoreline position (based on a pre-defined elevation).

While comprehensive in coverage, airborne bathymetric survey techniques are typically expensive and would be expected to require a commitment of approximately $200,000 per year for data acquisition and analysis. A long-term commitment to regular surveys may be cost prohibitive for Council, particularly in consideration of the relatively gradual morphological changes typically observed at Pumicestone Passage mainland shorelines. Even in the event of a breakthrough of the Bribie Island spit, morphological change at the mainland shoreline is not expected to occur rapidly and therefore the risk to land based assets associated with shoreline erosion is likely to be manageable even in extreme cases.

As discussed above, emerging erosion problems throughout the study area have been typically mitigated through reactive management strategies (i.e. the implementation of groynes, beach nourishment or seawall construction). The trigger for implementation of previous works has been based on informal visual inspection, with the relatively slowly emerging erosion issues providing sufficient time for planning and implementation. If the cost for regular bathymetric surveys cannot be sustained, then a formalised visual inspection of shorelines with emerging erosion problems and beach profile surveys are expected to provide Council with sufficient information to guide management activities. Further details regarding the promoted shoreline monitoring activities are provided in Section 6.

4.2.2 Tides and Water Levels (Coastal Inundation Risk)

Regardless of the cause for a change in water level within northern Pumicestone Passage (i.e. sea level rise and/or a permanent breakthough), the installation and maintenance of a permanent tide gauge and the ongoing analysis of recorded water levels forms an integral part of the promoted shoreline management strategy.

The Queensland Government, various port authorities and the Australian Maritime Safety Authority (AMSA) jointly operate a tide gauge network around the Queensland coast. The closest permanent tide gauge to the study area is at Caloundra Head. This instrument is located to the north of the study area and records open coast tidal conditions which would not be affected by a breakthrough at Bribie Island.

Ideally, the proposed instrument to monitor water levels within northern Pumicestone Passage would be located near the entrance to Lamerough Canal and be an addition to the existing Queensland tide gauge network. This location has been selected considering the potential risk of inundation to assets and communities located on nearby low lying land. It’s likely that a radar sensor would be a suitable instrument type which could be situated on the Lamerough Canal Bridge (or other nearby location). Radar sea level measurement devices are located above the water and measure the distance from the instrument to the water surface. A typical instrument is shown in Figure 4-2. The instrument sensors provide a signal, which a data logger converts to a water level referenced to a datum (typically lowest astronomical tide). This information can then be sent via cellar modem to the end users. Housing for the data logger, cellular modem and other components (including backup battery power) would also need to be established nearby.

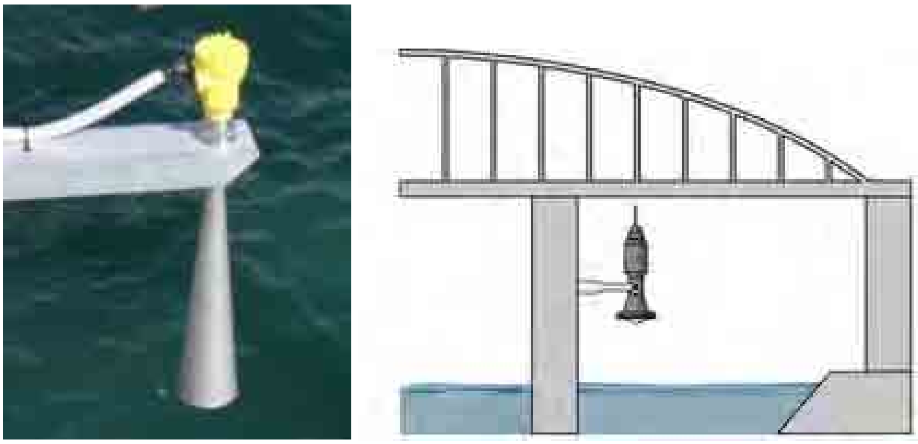

Figure 4-2 Radar Sea Level Measurement Instrument and Storm (Queensland Government, 2014) and Schematic of Typical Bridge Installation (Vega, 2014)

The proposed permanent tide gauge location is indicated in Figure 4-9 (Section 4.6). When combined with tide recordings from Caloundra Head and/or Mooloolaba, data from the proposed gauge would allow any rapid changes to the tidal regime (i.e. due to a permanent breakthough) to be identified, together with any long term gradual changes associated with sea level rise. Ideally, data would be managed and analysed by the Queensland Government who would inform SCC of any observed, undesirable changes to the tidal regime within Pumicestone Passage.

Radar sea level instrumentation is relatively inexpensive, with sensor costs not expected to exceed $10,000 (with housing for the instrument components and installation at an addition cost). The annual costs associated with data management and analysis is estimated at $40,000 per year.

It is noted that an existing flood warning water level monitoring instrument is presently located near Military Jetty which is owned by SCC and operated by the BOM (station number 540448). The accuracy of this instrument (± 5cm) is not considered sufficient for monitoring gradual changes to the tidal regime or mean sea level within Pumicestone Passage.

4.3 Discussion of Options

The following generic shoreline management options have been previously described in the Sunshine Coast SEMP (SCC, 2014) and promoted throughout the Bells Creek to Caloundra Bar study area:

- Beach nourishment;
- Dune construction and revegetation; and
- Structural (seawalls and groynes).

These options are considered further in the following sections.

4.3.1 Beach Nourishment

The primary intent of beach nourishment is to provide protection to the adjacent land assets by rebuilding the beach with sand imported from outside the active beach system. These works also typically restore beach amenity and recreational values. Beach nourishment aims to replace the loss of sand from the system and/or the deficit in the supply of sand that is causing the erosion. In this way a natural beach and its associated values will be returned and maintained while providing a buffer of sand to accommodate natural beach fluctuations and protect the assets and facilities behind.

The quantity of sand required will depend on the level of initial and ongoing protection, the grain size of the material and the use of structures, such as groynes, to enhance the longevity of the works. Ideally, sufficient sand is provided to accommodate short term storm erosion and a period of long term recession associated longshore sediment transport differentials and sea level rise.

Provision should be made for the placed sand to extend across the full beach profile to nourish depleted nearshore areas as well as the upper beach, the total quantity of sand being determined accordingly. If the sand is placed only on the upper visible portion of the beach, redistribution will quickly occur to establish an equilibrium profile giving the impression that the sand is ‘lost’ and the project is a failure. In such a case, the sand is, in fact, not lost but remains in the active system providing an overall net gain commensurate with the quantity placed after cross-shore distribution. Sunshine Coast Council completed a significant nourishment program (approximately 100,000m^3 of sand) at Maroochydore Beach during 2013. This project involved dredging sand from the Maroochy River entrance using a small cutter suction dredge and delivering the nourishment material to Maroochydore Beach via a pipeline (refer Figure 4-3).

Figure 4-3 Cutter Suction Dredge and Pipeline Sand Delivery to Maroochydore Beach

Short term ecological impacts are typically associated with beach nourishment programs. Generally it is recognised that the location where sand is placed is one of substantial fluctuations and disturbances to which the ecological communities adapt naturally. Furthermore, the nourishment would effectively rebuild the beach and nearshore profile to where they once were. As such, while there may be some short term ecological impacts, in the longer term the environment will adapt and recolonise to behave as a natural beach system.

One of the inherent advantages of beach nourishment is that it maintains the natural character and recreational amenity of the beach while also providing protection to coastal assets. As such, where the beach is severely depleted, it provides many benefits to the general community, as well as a direct economic benefit to those businesses that rely on tourism and the presence of a usable beach.

Identification and access to sources of suitable nourishment sand is usually a key issue, as is the ongoing cost to maintain this protection and amenity. Transport of the sand to the beach is usually most cost-effectively achieved by dredging procedures.

4.3.2 Dune construction and re-vegetation

Dune construction and stabilisation works to prevent sand loss due to wind erosion usually needs to form part of any substantial beach nourishment scheme aimed at restoring the beach and dune system. To protect northern Pumicestone Passage assets and communities, it would incorporate design provisions to prevent dune overtopping and oceanic inundation as well as to accommodate the effects of changes to the tidal regime associated with a Bribie Island breakthrough and/or sea level rise.

Native vegetation plays an important role in stabilising constructed dunes, with dunes naturally building in height and width as pioneer plant species establish. The Queensland Government (2013) provide guidelines for dune rebuilding and restoration of vegetation, with the key steps including:

- Design and construction of a dune of appropriate size, shape and location (a typical constructed dune profile is illustrated in Figure 4-4);

- Immediate temporary stabilisation of the constructed dune to prevent deformation by wind action using brush matting or a cover crop until a stable cover of native vegetation can be established;
- Establishment of native vegetation to prevent long-term wind erosion of the dune, encourage further sand deposition and to allow the dune to regenerate naturally after storm damage; and
- Protection of the vegetation cover by restricting access (refer Figure 4-5).

Sunshine Coast Council and various local environmental and land care groups are actively involved in dune management activities. Following the Maroochydore Beach nourishment program in 2013, the constructed dune was re-vegetated with more than 17,000 individual native plants (Sunshine Coast Council, 2013). Such efforts help to stabilise the dune system, providing resilience to future erosion events and maximising the benefit of the nourishment works.

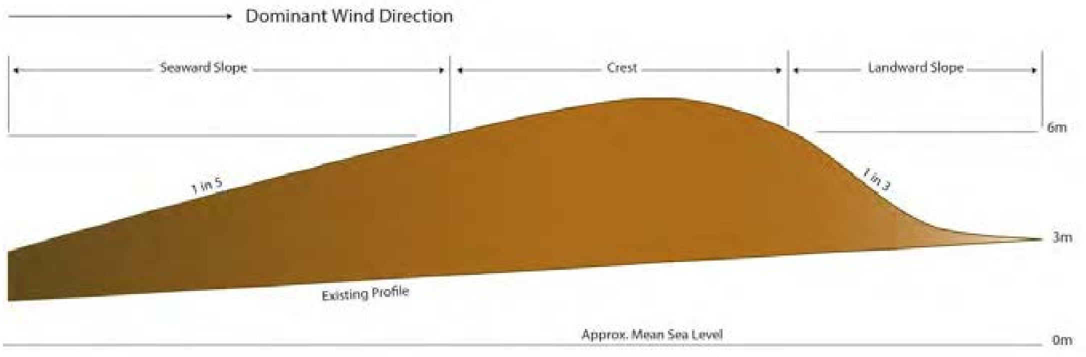

Figure 4-4 Typical Profile for a Re-established Frontal Dune (Queensland Government, 2013)

Figure 4-5 Dune Stabilisation using Vegetation and Temporary Access Restriction

As discussed in Section 2.8.1, dune reconstruction works were undertaken on Bribie Island at Site 2 (refer Figure 2-19) during 2008 in an effort to mitigate dune overwash and delay a breakthrough (Queensland Government, 2008). While these works successfully provided temporary relief to shoreline erosion and overtopping, there has been virtually no long term benefit with the area now characterised by widespread dune lowering and vegetation die-back. Notably, these works highlighted the challenges associated with erosion management on the northern spit of Bribie Island due to the extent of the narrow dune system and high-degree of exposure to coastal processes.

4.3.3 Structural Protection

Structural options provide protection of assets against ongoing erosion either directly through the construction of a seawall or by rebuilding of the beach through the construction of groynes. They are options that could be considered in the event that sufficient beach nourishment sand is not available and/or retreat options are not viable. However, there are always some adverse impacts of such an approach where no additional sand is provided, as outlined below.

Terminal structures are typically of flexible rubble mound design with rock being sourced and trucked to the site from quarries in the region. While they may be effective in protecting assets or providing a localised wider beach (in the case of groynes), they are generally accompanied by associated costs related to adverse impacts on the adjacent beaches. This cost is typically made up of direct costs associated with lost income from the tourist industry and other intangible costs associated with the natural coastal amenity, beach access and loss of recreational beach area and degradation of ecological values.

The design life of coastal erosion structures varies and is typically a function of the risk to people and/or value of the land based assets being protected. It is noted that the intent of the Sunshine Coast Council Planning Scheme (2014) is that long term infrastructure, such as terminal structures at the coastline, be designed to 2100 conditions (or be designed to be upgradable to 2100 conditions).

4.3.3.1 Seawalls

Seawalls or rock revetments are commonly built with the intent of providing terminal protection against shoreline retreat. Seawalls are robust structures constructed along the shoreline which provide a physical barrier separating the erodible material immediately behind the structure from wave and current forces acting on the beach itself. They are typically constructed of loosely placed rock to allow for some flexible movement and, on exposed coastlines, need to be designed to withstand severe wave attack. Figure 4-6 provides an example cross-section of a rock revetment on a sandy shoreline with the toe of the structure down to the bedrock (impermeable layer).

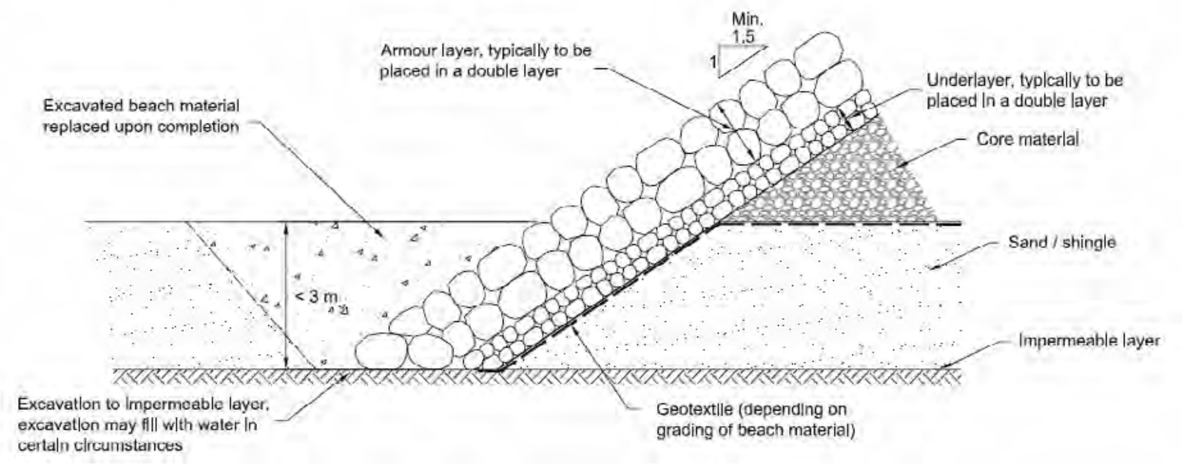

Figure 4-6 Cross-section of a Typical Rock Revetment Seawall (CIRIA, 2007)

Where possible, seawalls should be continuous to prevent end effects and/or discontinuities that could threaten the overall integrity of the wall. They also have to be suitably founded for stability against scour at the toe of the structure, particularly on a receding shoreline. Haphazardly placed rock and/or the use of inappropriate materials intended to provide shoreline erosion protection can have the opposite affect by accelerating the erosion problem.

While a properly designed and constructed seawall can protect the landward assets from erosion, it effectively isolates the sand located behind the wall from the active beach system and may lead to other adverse consequences.

On a receding shoreline, the seawall becomes progressively further seaward on the beach profile over time. This leads to a gradual increase in the quantity of sand effectively lost from the beach system, with:

- Lowering and eventual loss of the beach in front of the wall; and
- Exacerbation of the erosion on the downdrift end of the wall where the losses are transferred and concentrated.

Scour and lowering of the beach in front of the wall ultimately exposes it to higher wave attack and can lead to slumping and the need for ongoing maintenance. Such maintenance is typically in the form of topping up of the wall with additional rock. However, where the seawall is not adequately designed or constructed, complete reconstruction may be needed.

Seawalls in isolation can therefore be effective in protecting the land behind, but will potentially cause a loss of beach during severe erosion events. Beach profile change on an eroding shoreline without terminal protection and an eroding shoreline with terminal protection is illustrated in Figure 4-7. The loss of beach in front of seawall can be mitigated with beach nourishment when a viable source of sand exists.

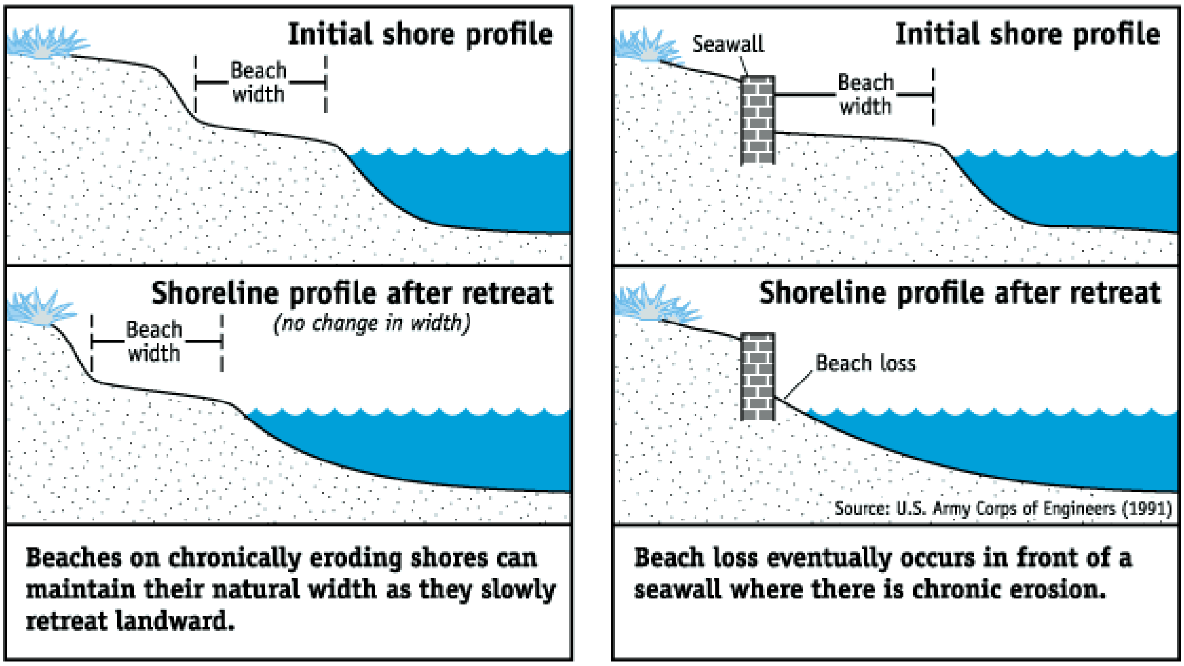

Figure 4-7 Beach Profile Change on Eroding Shorelines

A number of seawalls of varying design exist throughout the study area and are discussed in Section 3.1. Generally, these structures are performing as intended and are supplemented with beach nourishment sand as required. The Sunshine Coast Council SEMP (SCC, 2014) identifies the existing seawall between Bells Creek and Lamerough Canal as potentially requiring upgrade and extension to accommodate changes in water level associated with a Bribie Island breakthrough. Long term, if a significant change in water level was observed, fill material may also be required at this location to elevate the foreshore ground level.

4.3.3.2 Groynes

Groynes are impermeable structures generally constructed at right angles to the shoreline and extend across the beach and the nearshore surf zone. Their function is to trap sand moving along the shoreline under longshore transport processes to build up and stabilise the alignment of the beach on the updrift side. By necessity they starve the beach of sand supply on the downdrift side causing erosion. This negative effect is often mitigated with beach nourishment.

The sand trapped on the updrift side of a groyne provides a buffer of sand to accommodate short term storm erosion. The shoreline alignment will also change providing greater stability and reduce long term erosion immediately updrift of the structure. The extent of accretion and length of shoreline affected is dependent on the length of the structure as well as the characteristics of the longshore transport processes. Generally, the longer the groyne, the more sand it will trap over a longer distance with decreasing influence away from the structure.

There is a physical limit to the length of shoreline affected by a single groyne and therefore a number of structures may be needed if substantial benefit or protection is required over a long stretch of shoreline. In such a case, there is a balance between the length and spacing of groynes that needs to be optimised as part of a detailed design process. A series of groynes constructed from geotextile containers have been successfully used at Golden Beach to maintain a section of beach as Figure 4-8. In this instance, the groynes are mitigating shoreline recession associated with landward channel migration and providing scour protection to stormwater infrastructure as some locations. Beach nourishment, dune management and re-vegetation also assist in stabilising this section of shoreline.

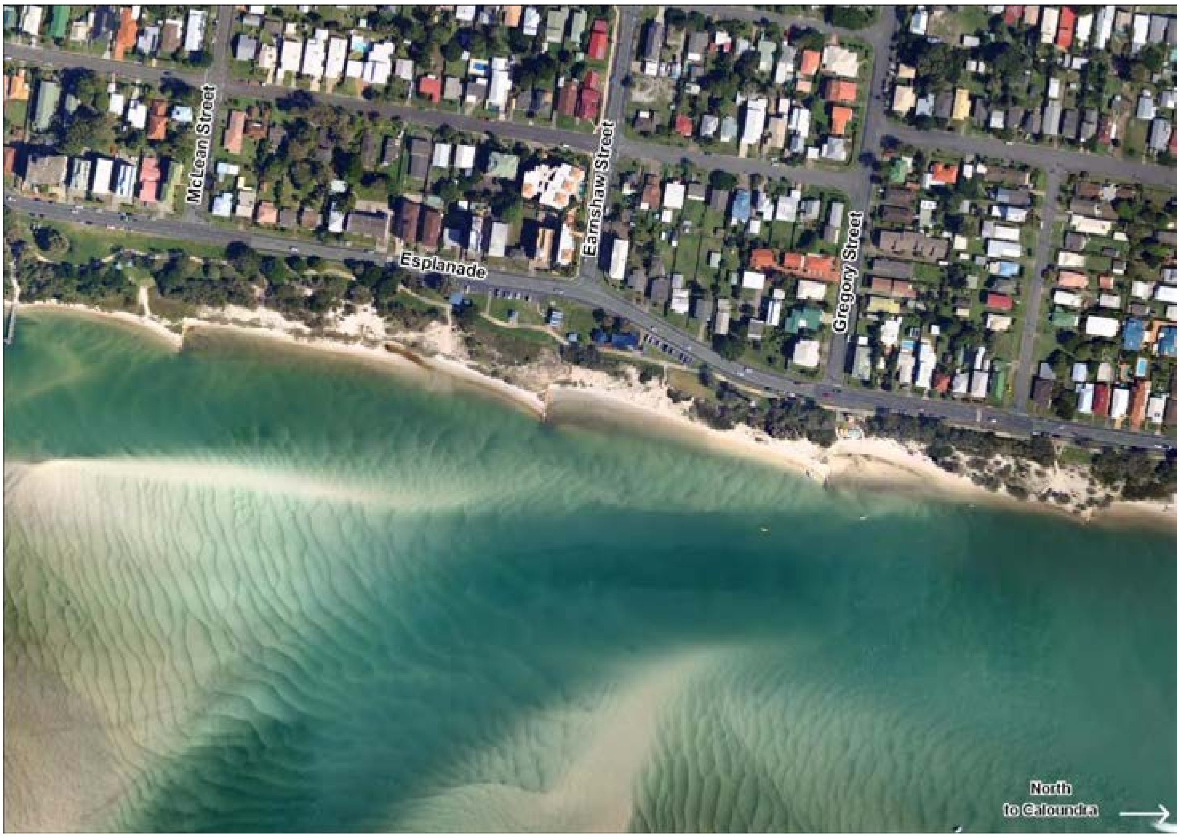

Figure 4-8 A Series of Groynes at Golden Beach (NearMap Pty Ltd, 2013)

4.4 Justification and Need

As outlined in the Sunshine Coast SEMP (SCC, 2014), the priority areas identified for enhanced shoreline erosion and/or coastal inundation risk management throughout the study area are:

- Nelson Street to Lamerough Canal; and
- Lamerough Canal to Bells Creek.

Assets and values within these southern sections of the study area include:

- Significant recreational value comprising both social and economic value groups with access provided for boating, recreational fishing, bathing, walking, and picnicking;
- TS Onslow Naval Cadet Base (State Government leased land);
- Caloundra Power Boat Club (State Government leased land);

- Dual boat ramp and car park;
- Caloundra Military Jetty Memorial (identified as a heritage item); and
- Sunshine Coast Coastal Pathway.

The benefits to be gained by enhanced shoreline management of these areas include:

- Improved protection of infrastructure and land based assets that cannot be reasonably relocated or abandoned;
- Increased shoreline amenity; and
- Increased recreational value associated with amenity values.

The proposed strategy is outlined in the following section.

4.5 Proposed Works

The shoreline management works described below were identified as the preferred actions between Caloundra Bar and the SCC southern boundary as part of the Sunshine Coast SEMP (SCC, 2014). In general, significant investment in shoreline management (including groynes, beach nourishment, dune management and seawall upgrades) north of Nelson St to Caloundra Bar is successfully maintaining economic, social and recreational values. Although the threats associated with shoreline erosion and coastal inundation are relatively lower for the northern section of the study area, ongoing management is still required and the existing permitted activities described in Chapter 3 are expected to continue.

It is noted that long term risk considerations for the study area would be more appropriately dealt with by a Coastal Land Management Plan or a Coastal Hazard Adaption Strategy that looks to planning horizons beyond 50 years. Such studies typically integrate all natural hazards and other long term planning issues, rather than only focusing on short to medium term shoreline erosion and coastal inundation issues.

4.5.1 Bulcock Beach

Maintain existing permitted management activities as required (refer Section 3.1.1).

4.5.2 Leach Park

Maintain existing permitted management activities (refer Section 3.1.2).

4.5.3 Oxley St to Beattie St

Maintain existing permitted management activities (refer Section 3.1.3).

4.5.4 Beattie St to Nelson St

Maintain existing permitted management activities (refer Section 3.1.4).

4.5.5 Nelson St to Lamerough Canal (priority actions required)

The Sunshine Coast SEMP (SCC, 2014) identifies the following preferred priority actions between Nelson St and the entrance to Lamerough Canal:

- Mangrove habitat protection between the Caloundra Power Boat Club and TS Onslow Naval Cadets Reserve;
- Beach nourishment; and
- Upgrade/construction of a revetment seawall at the Council-controlled boat car park to existing rock revetment the Lamerough Canal entrance.

It is proposed that the mangrove habitat protection and beach nourishment are undertaken as part of the existing permitted management activities. Council responsibility only extends to Council-controlled land. The State Government leases land to the Caloundra Power Boat Club and Naval Cadets and therefore Council does not have management control of these areas. Nevertheless, the Sunshine Coast SEMP (SCC, 2014) promotes beach nourishment and shoreline revegetation as the preferred management options at these locations.

It is proposed that beach nourishment is undertaken to stabilise the shoreline and mitigate coastal inundation risk of Council-controlled land. Minor nourishment works have been previously completed under existing permits. An expanded beach nourishment program (described in Section 4.6) is recommended if the required volume exceeds the annual permitted amount. The trigger to implement the expanded beach nourishment program is therefore:

(1) The volume of sand required for beach nourishment exceeds the existing permitted volume of 10,000m^3/year (to be informed by shoreline monitoring).

Planning to extend the length of rock revetment to provide an increased level of protection for the Council-controlled boat ramp car park and associated facilities should commence before the second trigger is reached (i.e. concept design and preliminary approval). The primary purpose of a seawall is to mitigate coastal inundation risk; however the structure would also resist shoreline recession. The trigger to develop the detailed design and construct a revetment seawall upgrade is:

(2) An unsustainable volume of sand required for ongoing beach nourishment to maintain shoreline position and mitigate coastal erosion and inundation risk (to be informed by shoreline monitoring); and/or

(3) An observed increase to the mean high water spring level and/or the mean sea level greater than 0.2m relative to 2014 levels.

The perceived benefit of any beach nourishment works is to be quantified via beach profile surveys before, after and within six months following sand placement. This monitoring and analysis of repeated surveys will allow Council to determine whether the placed sand is helping to maintain shoreline values and protect land based assets or is simply being lost from the beach system.

The tide monitoring described in Section 4.5.7 is designed to identify the above water level trigger for enhanced management.

4.5.6 Lamerough Canal to Bells Creek (priority actions required)

The Sunshine Coast SEMP (SCC, 2014) identifies the following preferred priority actions between the entrance to Lamerough Canal and Bells Creek:

- Beach nourishment;
- Groynes or similar flow deflection structures near the northern boat ramps and Military Jetty; and
- Upgrade and extend the existing rock revetment between Keith Hill Park and Roy Street.

It is proposed that beach nourishment followed by dune restoration and revegetation is undertaken to stabilise the shoreline and mitigate coastal inundation risk. The conceptual design of the expanded nourishment program is provided in Section 4.6. Groynes and other flow deflection structures may also be incorporated if sufficient stabilisation of the placed material cannot be achieved through revegetation only. The trigger to implement the expanded beach nourishment program is:

(1) The volume of sand required for beach nourishment exceeds the existing permitted volume of 10,000m^3/year (to be informed by shoreline monitoring).

The need for an upgrade of the rock revetment seawall will be dependent upon the success of the expanded beach nourishment program and shoreline stabilisation works (to be informed by shoreline monitoring) and/or the realisation of a significant change to the tidal regime or mean water level within Pumicestone Passage which increases the coastal inundation risk.

The trigger to develop the detailed design and construct a revetment seawall upgrade is:

(2) An unsustainable volume of sand required for ongoing beach nourishment to maintain shoreline position and mitigate coastal erosion and inundation risk (to be informed by shoreline monitoring); and/or

(3) An observed increase to the mean high water spring level and/or the mean sea level greater than 0.2m relative to 2014 levels.

The perceived benefit of any beach nourishment works is to be quantified via beach profile surveys before, after and within six months following sand placement. This monitoring and analysis of repeated surveys will allow Council to determine whether the placed sand is helping to maintain shoreline values and protect land based assets or is simply being lost from the beach system.

The water level monitoring described in Section 4.5.7 is designed to identify the above trigger for enhanced management. It is noted that planning for the seawall upgrade (i.e. concept design and preliminary approval) should commence prior to realisation of the water level trigger in order to minimise the time required for implementation.

4.5.7 Permanent Tide Gauge Installation

A permanent tide gauge to allow continuous water level monitoring within Pumicestone Passage is recommended to assess the risk to land assets and values located on relatively low lying land and identify the trigger to construct revetment seawalls. The primary purpose of the upgraded seawalls is to mitigate coastal inundation risk associated with an undesirable change to the tidal regime within Pumicestone Passage. As described in Section 4.2, ideally this gauge would be located near the entrance to Lamerough Canal (indicated in Figure 4-9) and be an addition to the existing Queensland tide gauge network with the recorded data managed and processed by the Queensland Government.

4.6 Proposed Expanded Beach Nourishment Operations

Dredging within Pumicestone Passage is limited to areas outside the declared Fish Habitat Area (FHA) and within marked navigation channels, where there is a proven benefit to the community. It is assumed these areas could provide the proposed volume of nourishment material, estimated to be 40,000m^3. This volume would be primarily used to construct an elevated dune along the foreshore between Bells Creek to Lamerough Canal and may combine additional structural measures such as geofabric sand container groynes to hold the placed sand, deflect tidal current further offshore and protect existing drainage infrastructure (refer Section 4.8). Dune stabilisation works would be undertaken immediately after the completion of the dredge program. A smaller volume of material may also be used to nourish the Council-controlled shoreline between Nelson St and Lamerough Canal.

Indicative target beach nourishment sand and placement areas are shown in Figure 4-9. The maintenance dredge area has been previously reported by Cardno Bowler (2011). Numerous sediment bores were extracted from within the maintenance dredge area and analysed to determine sediment quality and suitability for beach nourishment purposes. This report is provided in Appendix C for indicative purposes. There may be a regulatory requirement to undertake additional sediment characterisation prior to operations, particularly if navigational channel and/or FHA boundaries are modified in response to a permanent breakthrough at Bribie Island.

The target sand area in Figure 4-9 is approximately 30,000m^2. Sediment bores to depths of 2-3m within this area (bores 7, 8 and 10) suggest the material type and particle size (fine to medium grained sand) is suitable for shoreline nourishment. These results indicate a sand reserve of at least 60,000m^3 within the proposed dredge area. It is noted that material from this location may be of variable colour and silt content (Cardno Bowler, 2011).

It is assumed that a small cutter suction dredge (CSD) similar to that shown in Figure 4-3 could access the target dredge areas. A CSD works most effectively in loose unconsolidated material which is pumped directly by pipeline to a disposal area. Such operations are an efficient means of delivering sand to a target dredge area; this type of dredging and nourishment operation has been recently undertaken at Maroochydore Beach (refer Section 4.3.1). The maximum distance of pumping depends on the dredge capacity. For the type of dredger that would have sufficient manoeuvrability to operate effectively in Pumicestone Passage a maximum pumping distance of approximately 1 km may apply. If required, delivery of sand beyond this distance would be achieved using booster pumps along the pipeline route. A pipeline would need to be permanently in place over the dredging period, as it cannot be easily dismantled and installed each day.

It is noted that the placement of 40,000m^3 of material between Bells Creek and Lamerough Canal is intended to be an expansion of the existing permitted dredging activities for a single year only. In subsequent years, the permitted allocation of up to 10,000m^3/year is expected to provide sufficient material for nourishment throughout the wider Golden Beach study area.

4.6.1 Sand Delivery Pipeline

It is assumed that a sand delivery pipeline would provide the most efficient means of sand placement at the target nourishment areas (to be confirmed during detailed design). The proposed tidal works infrastructure consists of a temporary 400mm OD PN8 poly pipeline running from dredge location to the placement area. At the beginning of the works, the pipeline is expected to be sunken and extend to the closest location within the placement area. During operations, the pipeline would be progressively extended along the shoreline as the constructed beach develops between Bells Creek and Lamerough Canal (from north to south).

If the pipeline crosses shoreline access points or other obstructions it can be buried or fed through a purpose design conduit. Positioning of the pipeline may require minor excavation and/or vegetation clearing. Such works would seek to avoid mangroves, major trees or shrubs but would include the clearing of smaller plants. Any vegetation clearing will be guided by an expert to assist in identifying the most appropriate pipeline route, avoiding vegetation loss wherever possible. Following the laying of the pipeline, cleared areas will be rehabilitated and replanted with native vegetation as part of the wider revegetation and dune stabilisation works.

4.6.2 Dune Construction and Stabilisation

Conventional earth moving machinery (excavator) may also be used to distribute the sand delivered to the beach and construct the dune profile. A constructed dune crest elevation of at least 2mAHD is required to mitigate coastal inundation risk. This constructed coastal barrier is intended to reduce the inundation associated with the future planning scenario water levels assessed in Section 2.3.4. Once established, dune vegetation is expected to sufficiently maintain dune stability. If stabilisation using vegetation cannot be achieved, additional structural measures such as geofabric sand container groynes may be necessary.

During operating hours (7am to 5pm, Monday to Saturday) shoreline access would be restricted in the immediate area where sand is being placed and the excavator is working. It is anticipated that dune revegetation and stabilisation works would commence following completion of the material placement and profiling operations.

Title:

Proposed Target Sand and Placement Areas

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4-9

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4.6.3 Proposed Schedule

The selected dredge contractor will develop a conceptual cut plan/program for the dredging of the sand from within Pumicestone Passage navigational areas. This plan will incorporate input from the study team and where relevant, Council and stakeholders in terms of preferential dredging of areas to provide navigable channels for recreational use, minimising environmental and social impacts (including to those waterway users) and maximising/optimising the delivery of the sand to the Bells Creek to Lamerough Canal shoreline.

The timing of works has been considered and is based on various seasonal and operational factors, including:

- A preference to undertake works during the winter months outside of the shorebird season. This period is also likely to provide the most favourable operating conditions, thereby maximising project efficiency and the longevity of nourishment works.
- Extraction and delivery of approximately 10,000m^3 of sand per week. This estimate assumes a dredge rate of 200m^3/h and operating six days per week between 7am and 5pm.
- Completion of works within four weeks (between June and September).

Updated bathymetric surveys, sediment sampling and seagrass mapping before and after the works may be necessary to enable:

- Confirmation of the target dredge area and volume of material available within navigational areas and outside the FHA;
- Confirmation of the suitability of the material for beach nourishment purposes; and
- Feasibility of potential future sand extraction and re-nourishment works.

4.7 Bribie Island Works

Significant works at Bribie Island are not supported by the Plan due to the existing legislative constraints and low likelihood of successfully delaying a breakthrough. Nevertheless, minor works including dune revegetation may provide some benefit and are generally supported. Such works are unlikely to require a Development Approval or Park Permit.

4.8 Stormwater Drainage Network

A number of stormwater outlets are located within the study area. The works proposed in the Strategy are not expected to significantly influence drainage; however any infrastructure at the shoreline will need to be considered as part of the detailed design of an enhanced management option (i.e. the placement of beach nourishment material and/or seawall design). As discussed in Section 3.1.3 and 4.3.3.2, groynes constructed from geotextile sand containers have been used between Oxley St and Beattie St for the dual purpose of stabilising the shoreline and providing scour protection to stormwater infrastructure (see Figure 4-10). Where necessary, a similar installation is likely to be successful between Bells Creek to Lamerough Canal shoreline (in conjunction with the proposed expanded beach nourishment program).

Figure 4-10 Stormwater Outlet Concealed and Protected using Geotextile Sand Containers

It is noted that stormwater drainage performance may be influenced by changes to the tidal regime and/or an increase to mean sea level within Pumicestone Passage. Council is planning to assess stormwater drainage performance as part of the Northern Pumicestone Passage Flood and Coastal Processes Investigation (scheduled for 2014/15). These assessments will consider the enhanced shoreline management options promoted by the Plan.

5 Approvals and Stakeholder Consultation Plan

This Section outlines the recommended process for the obtaining approvals and engaging with relevant Government stakeholders as part of proposed strategy.

5.1 Stage Approach to Works

The proposed Strategy relies upon trigger values which identify distinct phases of development. These phases are:

- *Before any trigger levels are reached* – Minor and Existing Permitted Works;
- *First trigger level reached* – Expanded Dredging and Nourishment Program for Council-controlled shorelines between Nelson Street and Bells Creek and Commence Planning for Revetment Seawall; and
- *Second trigger level reached* – Revetment Seawall Detailed Design and Construction for Council-controlled shorelines between Nelson Street and Bells Creek.

These are shown in Figure 5-1. The environmental values relative to these activities and related approvals are discussed below.

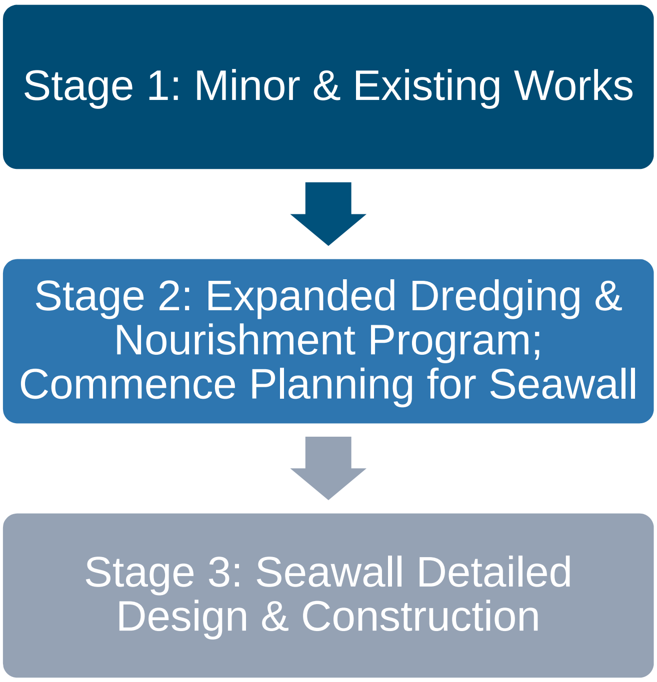


Figure 5-1 Stages of the Approvals and Stakeholder Consultation Plan

5.2 Environmental Values

This Section describes the existing environmental values of the Study Area as it relates to the works that would be undertaken in accordance with the proposed strategy. Consideration has also been had to the relevant management documents that apply to each of the environmental values, and their relationship to the proposed works. In considering these environmental values and management instruments, this Section has been broken up based on the values listed in Table 5-1. This table also lists the management instruments relevant to each environmental value.

Table 5-1 Environmental values and management instruments of the Study Area

Environmental value	Governing instrument(s)
State land	*Land Act 1994* *Coastal Protection and Management Act 1995* *Fisheries Act 1994* *Nature Conservation Act 1992* *Recreation Areas Management Act 2006*
Coastal processes and hydrodynamics	*Coastal Protection and Management Act 1995* Coastal Protection State Protection Regulatory Provision (SPRP) 2013 State Development Assessment Provisions (SDAP) Module 10 – Coastal Protection Coastal Management Plan 2014 State Planning Policy (SPP) interim development assessment requirements – Coastal Environment
Water quality	*Environmental Protection and Biodiversity Conservation Act 1999* *Environmental Protection Act 1994* *Environmental Protection (Water) Policy 2009* SDAP Module 4 – Environmentally Relevant Activities SPP interim development assessment requirements – Water Quality
Sediment quality	*Environmental Protection Act 1994* *Coastal Protection and Management Act 1995* Coastal Protection SPRP 2013 SDAP Module 4 – Environmentally Relevant Activities *Sunshine Coast Planning Scheme 2014*
Aquatic and terrestrial ecology	*Vegetation Management Act 1999* *Nature Conservation Act 1992* *Fisheries Act 1994* Coastal Protection SPRP 2013 SDAP Module 5 – Fisheries Resources SDAP Module 8 – Native Vegetation Coastal Management Plan 2014 SPP interim development assessment provisions – Biodiversity SPP interim development assessment provisions – Coastal Environment Fish Habitat Management Operational Policies
Threatened and migratory	*Environmental Protection and Biodiversity Conservation Act 1999*

Environmental value	Governing instrument(s)
species	*Nature Conservation Act 1992* and relevant conservation plans Coastal Protection SPRP 2013 SDAP Module 8 – Native Vegetation Coastal Management Plan 2014 SPP interim development assessment provisions – Biodiversity
Protected areas	*Environmental Protection and Biodiversity Conservation Act 1999* *Nature Conservation Act 1992* and relevant management plans *Marine Parks Act 2004* and *Marine Parks (Moreton Bay) Zoning Plan 2008* *Land Act 1994* *Fisheries Act 1994* SDAP Module 5 – Fisheries Resources Fish Habitat Management Operational Policies
Heritage	*Queensland Heritage Act 1992* *Aboriginal Cultural Heritage Act 2003* *Sunshine Coast Planning Scheme 2014*
Visual and recreational amenity	Coastal Protection SPRP 2013 Coastal Management Plan 2014 *Sunshine Coast Planning Scheme 2014*
Native Title	*Native Title Act 1993*

A summary of each of these environmental values, including the aspects requiring protection and management under legislation and policy, is provided below.

5.2.1 State Land

State Land identified for the Study Area includes (Figure 5-2):

- Unallocated State Land (USL) – all land below mean high water springs;
- Reserve – Lot 707 on CG3863, Lot 694 on SP255683, Lot 714 on SP233188, Lot 67 on CP847966, Lot 497 on CG3091, and Lots 573, 574, 575 and 576 on CG5004;
- State Land – Lot 900 on SP239524, Lot 764 on SP239731 and Lot 765 on SP223350;
- Bribie Island National Park and Recreation Area – Lot 105 on NPW806;
- Quarry material, i.e. sand and other material on State coastal land; and
- Pumicestone Channel Fish Habitat Area (FHA).

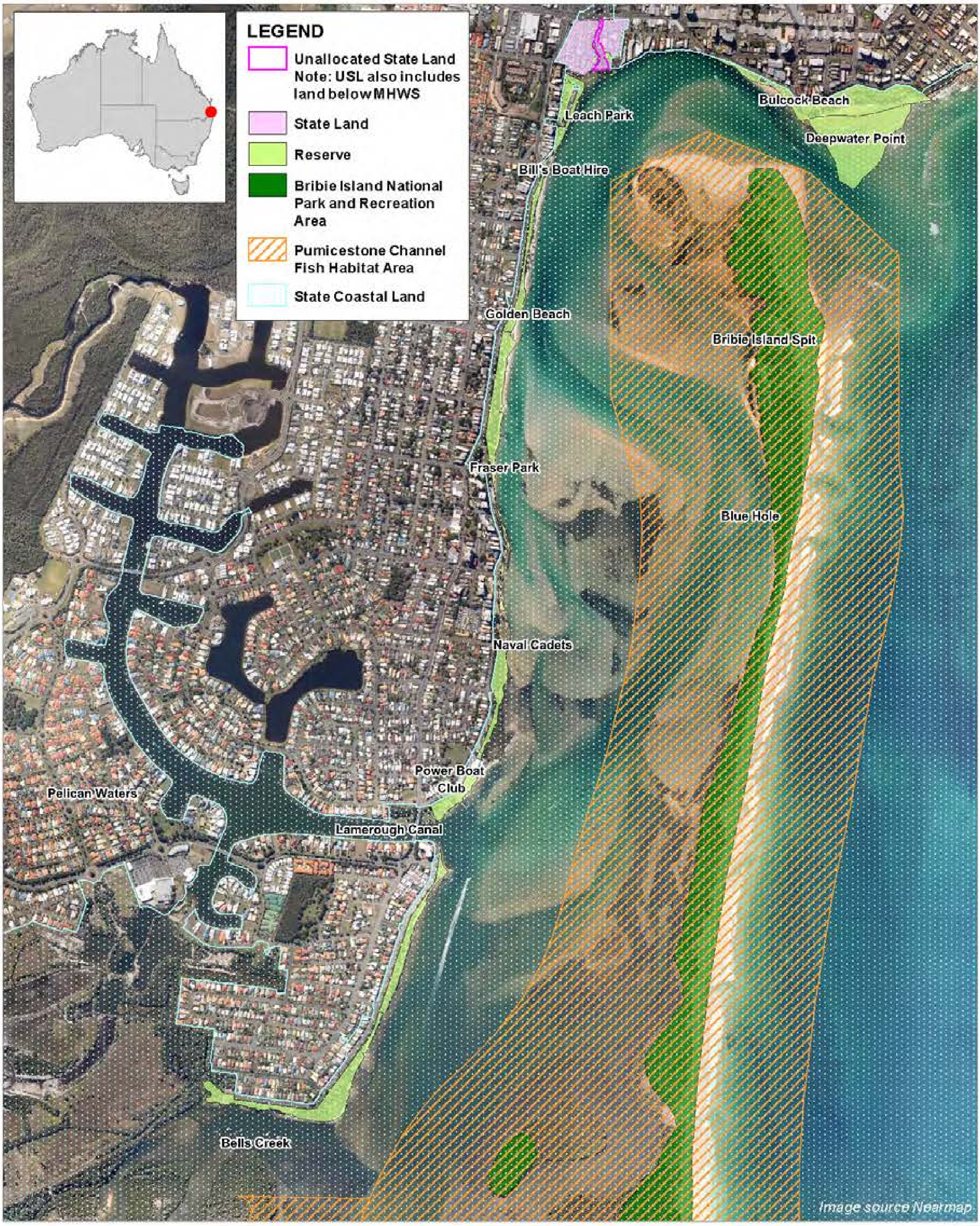
State Land is to be managed in accordance with the conditions of an owner's consent obtained from the Department of Natural Resources and Mines (DNRM). In addition, land reserved under the *Land Act 1994* is to be managed in accordance with the community purpose for which it was reserved (e.g. park, beach protection, and heritage).

National Park and Recreation Reserve land on Bribie Island is to be managed in accordance with the *Bribie Island National Park and Bribie Island Recreation Area Management Statement 2013*.

This Management Statement was prepared by the Queensland Parks and Wildlife Service (QPWS) under a series of legislative instruments. It is considered further in Section 5.2.7.

The extraction and use of quarry material (i.e. in dredging and nourishment campaigns) and the use of land within a FHA require resource allocation. Applications for quarry material allocation are assessed under the *Coastal Protection and Management Act 1995* (CPM Act) while a resource allocation authority for fisheries development is assessed under the *Fisheries Act 1994* and in accordance with relevant Fish Habitat Management Operational Policies (FHMOPs).

All land below the high water mark within the Study Area is also included in the Moreton Bay Marine Park. Use of this land is governed by the *Marine Parks (Moreton Bay) Zoning Plan 2008* discussed further in Section 5.2.7.



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State Land in the Study Area

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Relationship to Proposed Strategy

Owners' consent will be required for all works involving State Land, including works on land below mean high water springs (i.e. on USL). This can be obtained from DNRM. In the process of applying for consent, it is important to inform the relevant trustee/lessee of reserve land (usually the local government), the Department of Environment and Heritage Protection (DEHP) and the Department of National Parks, Recreation, Sport and Racing (DNPRSR, including QPWS).

Resource allocation for quarry material and land in a FHA will be required prior to development commencing. Quarry material allocation is sought from DEHP while a resource allocation authority for fisheries development is granted by the Department of Agriculture, Fisheries and Forestry (DAFF).

5.2.2 Coastal Processes and Hydrodynamics

The coastal processes and hydrodynamics of the Study Area are described in Chapter 2. The dominant features of the coastal environment within the Study Area include the significant sandbank formations within the Pumicestone Passage (known as the Caloundra Sandbanks). These provide habitat for local and migratory species and are considered further in Section 5.2.6.

In the event of a breakthrough, there will be a modification to the prevailing coastal processes within the Study Area, though it is unlikely that this will cause a significant loss or shift in the Caloundra Sandbanks. Proposed works, particularly the extraction of sand from Pumicestone Passage, may have an impact upon the coastal processes prevalent in the Study Area where sand is removed from the active system. A comprehensive study on the filling rates of dredged sand in the Pumicestone Passage has not yet been undertaken.

The need to protect coastal processes is recognised under the *Coastal Protection and Management Act 1994* and upheld in a number of statutory instruments. These include Module 10 of the State Development Assessment Provisions (SDAP), the Coastal Management Plan 2014, the Coastal Protection State Planning Regulatory Provision (SPRP) 2013, and the interim development assessment provisions of the State Planning Policy (SPP) in relation to the Coastal Environment state interest.

Relationship to Proposed Strategy

The removal of sand from the northern Pumicestone Passage active system and its placement along the foreshore at between Nelson Street and Bells Creek may have a localised and minor impact on coastal processes in the vicinity of the dredge footprint. In applying for a permit to undertake works, it will be necessary to consider the impacts these works will have on coastal processes. Works will need to be designed to meet the objectives of the SDAP Module 10, the Coastal Management Plan, the Coastal Protection SPRP and the SPP interim development assessment provisions.

5.2.3 Water Quality

Under the *Pumicestone Passage Environmental Values and Water Quality Objectives* Plan WQ1413, the waters of the entire Study Area, except in Bells Creek and Lamerough Canal, are classed as high ecological value (HEV) waters under the *Environmental Protection (Water) Policy 2009* (EPP Water). The management intent of HEV waters is to maintain the natural values and conditions of these waters. These waters support both aquatic ecosystem and human use environmental values (EVs), including:

- Aquatic ecosystems and seagrass;
- Aquaculture and oystering;
- Human consumption;
- Primary, secondary and visual recreation; and
- Cultural and spiritual values.

Bells Creek and Lamerough Canal also support EVs for aquatic ecosystems and human use, including irrigation, farm supply/use and stock water. The water quality of the Study Area is a contributor to the ecological values, especially the provision of seagrass beds used by marine megafauna and fish, as well as to the values of protected areas. See further Section 5.2.5 and 5.2.7

Despite this identification of EVs and HEV waters in the Study Area, however, it should be noted that the marine waters of the Pumicestone Passage catchment and estuary received a D+ in 2013 under the Health Waterways Report Card system (Healthy Waterways 2014). This was due to increased turbidity in central and northern areas, and increased sewage nitrogen signal and decrease in seagrass depth. This indicates that, despite the ability of the Passage to support EVs, it is located within a highly modified catchment with significant nutrient and sediment loads.

The achievement of water quality objectives (WQOs) associated with these EVs is governed by the EPP Water, including the *Pumicestone Passage Environmental Values and Water Quality Objectives* scheduled to the EPP. In addition, development is to achieve the objectives listed in the SPP interim development assessment provisions for the Water Quality state interest. Where dredging is undertaken, SDAP Module 4 Environmentally Relevant Activities and parts of s3.2.6 of the Coastal Protection SPRP will apply.

The Pumicestone Passage is also part of the Moreton Bay Aggregation Ramsar Site, protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Any changes to the ecological character of the Ramsar site, including water quality impacts, may be classed as a significant impact and are therefore regulated under the EPBC Act.

Relationship to Proposed Strategy

Dredging activities may cause a localise impact to water quality within the Pumicestone Passage and will be required to meet the requirements of the EPP Water, SPP, SDAP Module 4 and Coastal Protection SPRP. In particular, according to the EPP Water, works will need to maintain the status of the HEV waters within which dredging and placement activities will be undertaken.

5.2.4 Sediment Quality

The dominant sediment type in the Study Area is unconsolidated sand, though the Sunshine Coast is also known to contain large areas of consolidated indurated sands (i.e. coffee rock) (Brooke et al. 2008). Previous testing within the Passage (Cardno Bowler, 2011) has indicated low levels of silts in subsurface strata with a small portion of local sediment consisting of potential acid sulfate soils (PASS). Based on mapping under the *Sunshine Coast Planning Scheme 2014* (Overlay Map OVM46A) there may also be PASS in the soil of Diamond Beach, within the zone required to be excavated for the seawall construction.

Dredging and the placement of dredge material are managed under SDAP Module 4: Environmentally Relevant Activities, and under the Coastal Protection SPRP s3.2.6, in relation to the exposure of PASS and other contaminants (e.g. silts) while water quality impacts are dealt with in accordance to the instruments identified in Section 5.2.3.

Relationship to Proposed Strategy

Due to the potential for ASS and other contaminants within the Study Area, studies may need to be undertaken prior to dredging and foreshore works to identify potential contaminants. The objectives of the *Sunshine Coast Planning Scheme 2014*, the Coastal Protection SPRP s3.2.6, and the SPP interim development assessment provisions for Water Quality will need to be met as part of the works. In addition, dredging and placement of dredge material will need to be managed in accordance with SDAP Module 4 and the Coastal Protection SPRP.

5.2.5 Aquatic and Terrestrial Ecology

Aquatic and terrestrial ecology of the Study Area is described in the context of regional ecosystems (REs) and marine plants, wetland communities, intertidal habitats and known flora and fauna. A number of threatened and migratory species that may occur in the Study Area; these are discussed in Section 5.2.6.

Regional Ecosystems and Native Vegetation

The REs of the Study Area are:

- RE 12.1.2 Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains;
- RE 12.1.3 Mangrove shrubland to low closed forest on marine clay plains and estuaries; and
- RE 12.2.5 *Corymbia intermedia* +/- *Lophostemon confertus* +/- *Banksia* spp. +/- *Calitris columellaris* open forest on beach ridges usually in the southern half of the bioregion.

These REs occur on Bribie Island (with RE 12.2.5 dominating Bribie Island to the south of the Study Area) as well as in riparian areas of Bells Creek. This vegetation is mapped as Category B on the Regulatory Vegetation Management Map and the least concern on the Vegetation Management Supporting Map (DNRM 2014). Notably, RE 12.1.2 is also a Vulnerable Threatened Ecological Community (TEC) under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) (see Section 5.2.6). The management of development involving clearing of REs is provided for under both the *Sustainable Planning Act 2009* (SP Act) and the *Vegetation*

Management Act 1999 (VM Act), while individual species are protected under the *Nature Conservation Act 1992*.

Outside of the Study Area, the upper reaches of Bells Creek are also Category B and least concern REs (RE 12.2.7 *Melaleuca quinquenervia* or rarely *M. dealbata* open forest on sand plains and RE 12.3.6 *Melaleuca quinquenervia +/- Eucalyptus tereticornis, Lophostemon suaveolens* open forest on coastal alluvial plains).

Vegetation communities scattered along the foreshore of Diamond Head, Golden Beach and parts of Bulcock Beach consist of mangrove and saltpan species. While these communities are not mapped as REs, they are protected as marine plants under the *Fisheries Act* due to their habitat value for fisheries. Marine plants also include casuarinas which may grow in the intertidal zone of the Study Area, and seagrass species (see below).

Wetland Communities

The Directory of Important Wetlands in Australia (DIWA) lists the following nationally important wetlands in the Study Area (Figure 5-4):

- *Pumicestone Passage*. This is an estuarine wetland but with significant freshwater inflows from Bells Creek and other nearby waterways (Amos 1995). The wetland supports shallow estuarine water systems, including seagrass beds, lower intertidal mudflats, mangrove communities and supratidal flats, and is habitat for a number of significant fauna and flora species, including a number of migratory shorebirds (see Section 5.2.6).
- *Upper Pumicestone Coastal Plain*. This wetland is composed primarily of swamps, freshwater creeks and the floodplains of Bells Creek (Knight et al. 2002b). The wetland is dominated by freshwater wetland communities, including melaleuca and she-oak communities, and supports a variety of fish, bird, amphibian, reptile and mammal species.
- *Bribie Island*. Wetlands in the Study Area consist predominantly of intertidal and estuarine shrubland and forests, including mangrove communities (Knight et al. 2002a). The wetland also includes some of the tidal waters west of Bribie Island, which have both seagrass and fisheries values.

In addition, parts of Bells Creek, including most of the banks, are mapped as estuarine wetland under the SPP and therefore are a Matter of State Environmental Significance (MSES). MSES are managed under the SPP Biodiversity state interest, including the interim development assessment provisions. Wetlands are also recognised and managed under the Coastal Protection SPRP and the Coastal Management Plan.

Seagrass

Extensive seagrass meadows are known to occur within the Pumicestone Passage (Figure 5-4). These provide habitat values to fish species and marine megafauna that may occur within the Study Area. See further Section 5.2.5.

Seagrass is managed as a marine plant under the *Fisheries Act 1994* and relevant FHMOPs. Where seagrass is contained within the Pumicestone Channel FHA or the Moreton Bay Marine Park, it will also be subject to additional protection (see Section 5.2.6 and 5.2.7). Due to the importance of seagrass to a number of migratory and/or threatened species under the EPBC Act, permits for activities affecting these species will typically require the protection of seagrass habitat (e.g. current dredging permit for Pumicestone Passage requires seagrass protection). See further Section 5.2.6.

Intertidal Habitats

Pumicestone Passage has extensive areas of interidal sandbanks, known as the Caloundra Sandbanks. These areas provide habitat values to migratory shorebirds (see Section 5.2.6) as well as other local fauna, such as resident waders and infauna (e.g. crabs). While these sandbanks are likely to migrate in the event of a breakthrough, evidence of historical changes in the mouth of Pumicestone Passage suggest that minimal to no impact will result to habitat values following a future breakthrough.

Intertidal habitat in the Study Area also consists of mudflats along the Bribie Island and Golden Beach/Diamond Head foreshores. These areas also provide habitat for shorebirds and waders, infauna and some mammal species (e.g. mice, rats and similar species).

These habitat values will be managed and protected in accordance with associated species (e.g. migratory shorebirds – Section 5.2.6).

Flora and Fauna

A large variety of flora and fauna species are known to occur within the Study Area. This includes fish species, acid frogs, small terrestrial mammals and reptiles, marine megafauna (e.g. turtles and dugongs), migratory and resident shorebirds and waders, other avifauna, and seagrass, mangrove, saltmarsh and dune vegetation species. More details of threatened and migratory flora and fauna are provided in Section 5.2.6.

Native species that are not currently listed as threatened and/or migratory are protected under the *Nature Conservation Act 1992* (NC Act) as 'least concern' species. Activities involving the taking of these species (e.g. clearing native vegetation) will require a permit under this Act. In addition, works involving an impact on flora and fauna within a national park (i.e. Bribie Island National Park) or marine park (i.e. Moreton Bay Marine Park) will also require a permit under the NC Act and *Marine Parks Act 2000* (MP Act), respectively. See Sections 5.2.6 and 5.2.7.

Relationship to Proposed Strategy

Due to the variety of ecological receptors in the Study Area, especially wetlands and seagrass, dredging and placement works may involve the disturbance of some environmental values. The preparation of project methodologies needs to consider the location of these receptors and the requirements under the EPBC Act, the NC Act, the *Fisheries Act* (and related FHMOPs), the SDAP Module 4, the Coastal Protection SPRP, the Coastal Management Plan, and the SPP interim development assessment provisions for Biodiversirty and the Coastal Environment.

Title:

Regional Ecosystems

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5-3

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Title:

Wetlands and Indicative Seagrass Beds in the Study Area

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5.2.6 Threatened and Migratory Species

Threatened species are protected under the EPBC Act as Matters of National Environmental Significance (MNES), and under the NC Act and SPP as MSES. The EPBC Act also protects migratory species as MNES.

Previous studies of threatened and migratory species have been conducted of the Study Area in relation to dredging campaigns (GHD 2012; cf. QWSG 2010). The species identified during the GHD 2012 study, along with a preliminary assessment of species identified for the area by the Commonwealth protected matters search tool (PMST) and the Queensland Wildnet database, are provided in Table 5-2.

Table 5-2 Threatened and migratory species likely or known to occur in the Study Area (GHD 2012)[5]

Common name	Scientific name	*EPBC Act*	*NC Act*
Regent honeyeater	*Anthochaera phyrgia*	Endangered & Migratory	Endangered
Australasian bittern	*Botaurus poiciloptilus*	Endangered	Least concern
Australian painted snipe	*Rostratula australis*	Endangered & Migratory	Vulnerable
Swift parrot	*Lathamus dicolor*	Endangered	Endangered
Fork-tailed swift	*Apus pacificus*	Migratory	Least concern
White-bellied sea-eagle	*Haliaeetus leucogaster*	Migratory	Least concern
White-throated needletail	*Hirundapus caudacutus*	Migratory	Least concern
Rainbow bee-eater	*Merops ornatus*	Migrator	Least concern
Black-faced monarch	*Monarcha melanopsis*	Migratory	Least concern
Spectacled monarch	*Monarcha trivirgatus*	Migratory	Least concern
Satin flycatcher	*Myiagra cyanoleuca*	Migratory	Least concern
Rufous fantail	*Rhipidura rufifrons*	Migratory	Least concern
Sooty oystercatcher	*Haematopus fuliginosus*	-	Near threatened
Migratory shorebirds (see below)		Migratory	-
Dugong	*Dugong dugon*	Migratory	Vulnerable
Dusky dolphin	*Lagernorhynchus obscurus*	Migratory	Least concern
Australian snubfin dolphin	*Orcaella heinsihni*	Migratory	Near threatened
Indo-Pacific humpback dolphin	*Sousa chinensis*	Migratory	Near threatened
Loggerhead turtle	*Caretta caretta*	Endangered	Endangered

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[5] Species highlighted in blue have previously been identified by GHD as having a moderate to high potentially of occurring in identified dredging and nourishment areas of Pumicestone Passage and Golden Beach/Diamond Head

Common name	Scientific name	*EPBC Act*	*NC Act*
Green turtle	*Chelonia mydas*	Vulnerable	Vulnerable
Leatherback turtle	*Dermochelys coriacea*	Endangered	Endangered
Hawksbill turtle	*Eretmochelys imbricata*	Vulnerable	Vulnerable
Olive Ridley turtle	*Lepidochelys olivacea*	Endangered	Endangered
Flatback turtle	*Natator depressus*	Vulnerable	Vulnerable
Wallum sedge frog	*Litoria olongburensis*	Vulnerable	Vulnerable
Wallum rocketfrog	*Litoria freycineti*	-	Vulnerable
Wallum froglet	*Crinia tinnula*	-	Vulnerable
Koala	*Phascolarctos cinereus*	Vulnerable[6]	Vulnerable[7]
Grey-headed flying-fox	*Pteropus poliocephalus*	Vulnerable	Least concern
Water mouse	*Xeromys myoides*	Vulnerable	Vulnerable

In addition, RE 12.1.2 is a Vulnerable TEC (*Subtropical and temperate coastal saltmarsh*). This is not MNES under the EPBC Act but is required to be considered and protected when the Commonwealth Minister is assessing environmental impacts of a proposed activity.

The key areas providing habitat for threatened and migratory species are:

- Bribie Island.
- Caloundra Sandbanks.
- Pumicestone Passage seagrass meadows.

Bribie Island

The Essential Habitat Map under the VM Act identifies much of Bribie Island as supporting *essential habitat* for three species of wallum frog (sedge frog, rocket frog and froglet), the water mouse, and the koala. Essential habitat consists of vegetation in which a species that is Endangered, Vulnerable, Near Threatened or (formerly) Rare under the NC Act has been known to occur. The mapping of an area as essential habitat does not confirm the current presence of the species in the area but does increase the likelihood of the species occurring. It also indicates that the local environment of Bribie Island can support the above listed species.

Clearing of essential habitat is managed under the SDAP Module 8: Native Vegetation and is also likely to be considered by the interim development assessment provisions of the SPP Biodiversity state interest where the habitat relates to MSES species.

Caloundra Sandbanks

In accordance with the methodology provided in the draft EPBC Act Policy Statement 3.21 *Significant impact guidelines for 36 shorebird species* (2009), the Caloundra Sandbanks provide *important habitat* for migratory shorebird species protected under the EPBC Act. This is due to the fact that the site supports over 15 species of migratory shorebirds. The shorebird species

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[6] Combined populations of Queensland, New South Wales and the Australian Capital Territory
[7] Southeast Queensland bioregion

supported at the site include (Amos 1995; Chan & Dening 2007; GHD 2012; QPWS 2005P; QWSG 2010):

- Eastern curlew (*Numenius madagascariensis*)
- Common sandpiper (*Actitis hypoleucos*)
- Great egret (*Ardea alba*)
- Cattle egret (*Ardea ibis*)
- Ruddy turnstone (*Arenaria interpres*)
- Sharp-tailed sandpiper (*Calidris acuminata*)
- Sanderling (*Calidris alba*)
- Red knot (*Calidris canutus*)
- Curlew sandpiper (*Calidris ferruginea*)
- Red-necked stint (*Calidris ruficollis*)
- Great knot (*Calidris tenuirostris*)
- Double-banded plover (*Charadrius bicinctus*)
- Greater sand plover (*Charadrius leschenaultii*)
- Lesser sand plover (*Charadrius mongolus*)
- Oriental plover (*Charadrius veredus*)
- White-winged black tern (*Childonias leucopterus*)
- Latham’s snipe (*Gallinago hardwickii*)
- Grey-tailed tattler (*Heteroscelus brevipes*)
- Caspian tern (*Hydroprogne caspia*)
- Broad-billed sandpiper (*Limosa falcinellus*)
- Bar-tailed godwit (*Limosa lapponica*)
- Black-tailed godwit (*Limosa limosa*)
- Little curlew (*Numenius minutus*)
- Whimbrel (*Numenius phaeopus*)
- Pacific golden plover (*Pluvialis fulva*)
- Grey plover (*Pluvialis squatarola*)
- Little tern (*Sternula albifrons*)
- Lesser crested tern (*Thalasseus benhalensis*);
- Wood sandpiper (*Tringa glareola*)
- Common greenshank (*Tringa nebularia*)
- Marsh sandpiper (*Tringa stagnatilis*)
- Terek sandpiper (*Xenus cinereus*)

The site is *not* important habitat for Latham’s snipe, as there is no naturally occurring open freshwater wetland with vegetation cover nearby.

Under both the EPBC Act *Significant Impact Guidelines 1.1* and the EPBC Act Policy Statement 3.21, the significance of the designation of the site as important habitat is that this becomes a proxy for determining if an action will have a significant impact. Where an activity will cause a loss of important habitat, degradation of important habitat leading to a substantial reduction in migratory shorebird use of the site, increased disturbance leading to a substantial reduction in migratory shorebirds using the site, or direct mortality of birds leading to a substantial reduction in migratory shorebirds using the site, it will be considered a significant impact. Further details of significant impacts and the management of activities to prevent significant impact are provided in draft EPBC Act Policy Statement 3.21. Where a significant impact is likely to occur, approval from the Commonwealth Department of Environment (DoE) is required.

Pumicestone Passage Seagrass Meadows

The seagrass meadows of Pumicestone Passage support feeding activities by threatened and migratory marine megafauna. In particular, dugongs and green turtles are known to use these seagrass beds, and other species (e.g. loggerhead turtles, hawksbill turtles and flatback turtles) can be supported by these areas. Seagrass is often treated as a proxy for impacts upon these species, especially where there is evidence of significant grazing occurring.

Management Instruments

Management priorities for all the species listed in Table 5-2 are set by DoE (at a Commonwealth level) and DEHP (at a Queensland level). The instruments used for protecting threatened and migratory species include:

- SPP interim development assessment provisions for Biodiversity state interest;
- Coastal Management Plan section 2 (nature conservation);
- Coastal Protection SPRP s3.2.3;
- SDAP Module 8 Native Vegetation;
- EPBC Act Policy Statement 1.1 *Significant impact guidelines* (2013) and other policy statements; and
- National Recovery Plans for threatened species (e.g. wallum frogs, marine turtles).

Relationship to Proposed Strategy

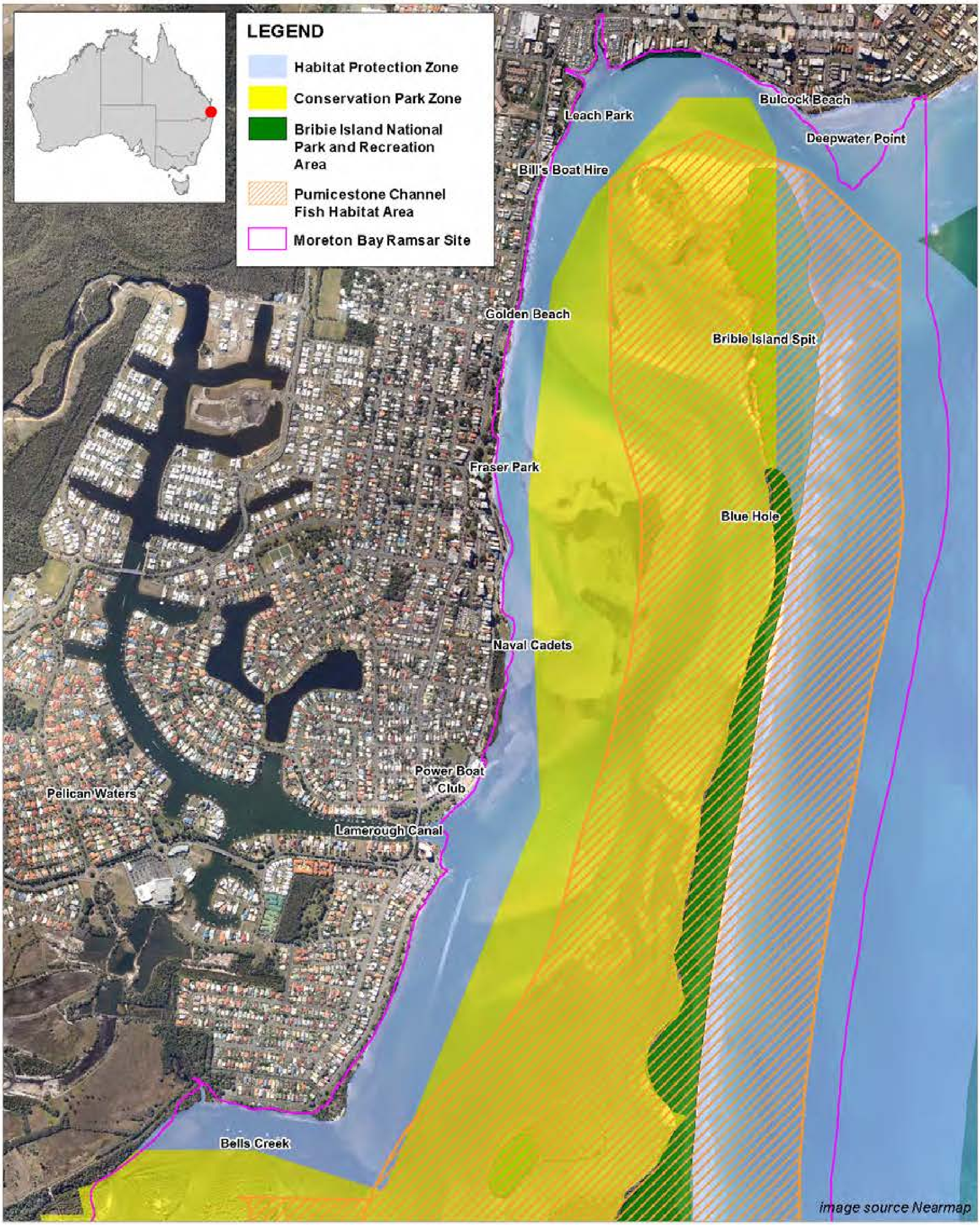
The most important sensitive receptors to the proposed works in terms of threatened and migratory species are shorebird roosting/feeding in Pumicestone Passage, and seagrass beds. All activities will need to be managed in accordance with the EPBC Act and relevant Policy Statements (especially 3.21) as well as National Recovery Plans for threatened species, the SDAP Module 8 in regards to essential habitat, and the instruments identified in regards to aquatic and terrestrial ecology (Section 5.2.5).

5.2.7 Protected Areas

Figure 5-5 and Table 5-3 summarises the protected areas of the Study Area, including the management plans for these areas.

Table 5-3 Protected areas in the Study Area

Name	Management plan	Administering authority
Bribie Island National Park	*Bribie Island National Park and Bribie Island Recreation Area Management Statement 2013*	DNPRSR (NC Act)
Bribie Island Recreation Area		DNPRSR (*Recreation Areas Management Act 2006*)
Moreton Bay Marine Park: • Habitat protection zone (dark blue) • Conservation park (yellow)	*Marine Parks (Moreton Bay) Zoning Plan 2008*	DNPRSR (MP Act)
Pumicestone Channel FHA: • Management 'A'	FHMOPs	DAFF *(Fisheries Act)*
Moreton Bay Ramsar site	n/a – refer to Ecological Character Description (ECD) for Ramsar site	DoE (EPBC Act)



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Protected areas in the Study Area

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Relationship to Proposed Strategy

Bribie Island National Park and Bribie Island Recreation Area: Works conducted in the Bribie Island National Park requires a National Parks Permit under the NC Act. The decision on a permit application will take into account the management principles of national parks provided for in s17 of the Act as well as any relevant management statement that has been prepared for the area. This includes the *Bribie Island National Park and Bribie Island Recreation Area Management Statement 2013*.

Moreton Bay Marine Park: Works below the high water mark in any part of the Study Area will require a permit under the MP Act, establishing consistency with the objectives of the zone in which the works are being undertaken. These objectives are set by the *Marine Parks (Moreton Bay) Zoning Plan 2008*.

Pumicestone Channel FHA: Dredging and placement activities need to be designed to comply with DAFF policies. Specifically, the DAFF policies applicable to the proposed strategy are:

- FHMOP 004 *Dredging, Extraction and Spoil Disposal Activities* – limits dredging to areas outside a FHA or within marked navigation channels, where there is a proven benefit to the community.
- FHMOP 001 *Management and Protection of Marine Plants and Other Tidal Fish Habitats* – requires disposal of dredge material in tidal areas to be compliant with FHMOP 010.
- FHMOP 010 *Tidal Fish Habitats, Erosion Control and Beach Replenishment* – establishes the need for 'significant erosion' and a proven community benefit before tidal works and erosion control can be undertaken.

Moreton Bay Ramsar Site: The Study Area is included within the Moreton Bay Ramsar site. The EPBC Act Policy Statement *Significant Impact Guidelines 1.1* requires referral and potential approval of any action that is likely to have a significant impact on the ecological character of the site. In undertaking works, reference should be had to these guidelines and works conducted to date on the Moreton Bay Ramsar Site Ecological Character Description (ECD).

5.2.8 Heritage

Heritage items in the Study Area include heritage listed local, State and Federal levels as well as cultural heritage items, protected under the *Aboriginal Cultural Heritage Act 2003* (Qld).

Local Heritage

Local level heritage items are identified and protected under SC6.10: Planning scheme policy for heritage and character areas overlay code within the *Sunshine Coast Planning Scheme 2014*. The items in the Study Area are identified below.

Bribie Island World War 2 Fortifications (BRI1)

North end of Bribie Island (Lot 105 on NPW702)

‘Fortifications were constructed on Bribie Island between 1939 and 1942 as part of a network of defence installations to protect Moreton Bay. Fort Bribie was located on the northern end of the island and comprised two concrete gun emplacements; mine control huts (of concrete) and a camp for personnel. Both gun emplacements and the mine control huts survive as well as remnants of the camp.

‘The Bribie Island World War 2 fortifications are significant as evidence of the coastal defence measures developed between 1939 and 1942. These fortifications indicated the seriousness given to the possibility of enemy attack.’

Norfolk Pines Along Esplanade (CAL3)

Caloundra Esplanades: Bulcock beach esplanade

‘The tradition of planting Norfolk pines along the foreshore at certain seaside locations dates from the 19th century. Norfolk pines became a signature tree at seaside resorts, most notably at Manly in Sydney. The concept spread north and local authorities took up the practice along the Queensland coast, including Caloundra. These trees are now a distinctive part of the Caloundra landscape.

‘The Norfolk Pines along Caloundra esplanades are significant for their demonstration of a traditional approach to beach foreshore planting. The pines are a significant part of the landscape and contribute to the distinctive character of the Caloundra beaches…’

Tripcony Hibiscus Caravan Park (CAL4)

146 Bulcock Street, Caloundra (Lot 764 on SP239731 and Lot 765 on SP223350)

‘Tripcony Hibiscus Caravan Park is significant for demonstrating the pattern of development of the Sunshine Coast as well as its importance as a seaside tourist recreation and camping facility. It is also significant for its social [value] to the community as a longstanding place of holidaying and recreation.’

The Landsborough Tree (GBH2) 1 Worthington Lane, Golden Beach (Lot 1 on RP138246 and adjacent road reserve) 'This tree was planted as a seedling in 1880. It was planted by the Butler family, who had brought it from Kilcoy Station. 'The Landsborough Tree is significant for its association with William Landsborough and as a local landmark…'	
Military Jetty (GBH3) Keith Hill Park, the Esplanade, Golden Beach (Lot 576 on CG5004) 'This jetty was erected in 1941 to assist in the transportation of goods and personnel to Fort Bribie. It highlights the importance of Fort Bribie in the defence of Moreton Bay. Military jetty is significant as evidence of the use of the Caloundra district for military operations during World War 2.'	

Development in relation to these heritage areas will be assessed against the heritage and character overlay of the planning scheme. This overlay has the following purpose and overall outcome:

(1) The purpose of the heritage and character areas overlay code is to ensure that:-

  (a) development on or adjoining an identified heritage place is compatible with the heritage significance of the place; and

  (b) the *streetscape* character and significance of identified character areas is conserved and enhanced.

(2) The purpose of the heritage and character areas overlay code will be achieved through the following outcomes:-

  (a) the heritage of individual sites and places is conserved;

  (b) development on a *local heritage place* is compatible with the heritage significance of the place by:-

    (i) retaining the *local heritage place*, unless there is no prudent and feasible alternative to its demolition or removal;

    (ii) maintaining or encouraging, as far as practicable, the appropriate use (including adaptive reuse) of the *local heritage place* whilst protecting the amenity of adjacent uses;

    (iii) protecting, as far as practicable, the context and setting of the *local heritage place*; and

(iv) ensuring development on the *local heritage place* is compatible with the heritage significance of the place.

(c) development adjoining a local or *State heritage place* is sympathetic to the heritage significance of that place; and

(d) development in a neighbourhood character area:-

(i) is sympathetic and complementary to the *streetscape* character and heritage values of the area;

(ii) retains buildings, structures and other elements that contribute to the preferred character of the area through their age, form, style, siting and character; and

(iii) complements, rather than mimics or replicates, the predominant building styles in the street.

Queensland Heritage Register

Tripcony Hibiscus Caravan Park (Lot 900 on SP239524, Lot 764 on SP239731 and Lot 765 on SP223350) and the Bribie Island Second World War Fortifications are also listed on the Queensland Heritage Register under the *Queensland Heritage Act 1992*. These areas are listed as place 602708 and 601143, respectively.

Figure 5-6 Tripcony Hibiscus Caravan Park (photos from Queensland Heritage Register 2014)

Figure 5-7 Bribie Island Second World War Fortifications (photos from Queensland Heritage Register 2014)

Items on the Queensland Heritage Register are to be managed in accordance with the *Queensland Heritage Act 1992*. The Act provides that in assessing development applications involving State heritage places, the chief executive of DEHP is to refuse an application where the effect of the development 'would be to destroy or substantially reduce the cultural heritage significance of a State heritage place'. The cultural heritage significance of Tripcony Hibiscus Caravan Park and the Bribie Island Second World War Fortifications are recognised through listing on the Queensland Heritage Register on the basis of the criteria identified below.

Additional assessment criteria also apply in the cases of archaeological places (i.e. Bribie Island Second World War Fortifications).

Tripcony Hibiscus Caravan Park	**Bribie Island Second World War Fortifications**
Criterion A: the place is important in demonstrating the evolution or pattern of Queensland's history *Criterion D*: the place is important in demonstrating the principal characteristics of a particular class of cultural places	*Criterion A*: The place is important in demonstrating the evolution or pattern of Queensland's history *Criterion C*: The place has potential to yield information that will contribute to an understanding of Queensland's history *Criterion D*: the place is important in demonstrating the principal characteristics of a particular class of cultural places *Criterion E*: the place is important because of its aesthetic significance *Criterion H*: the place has a special association with the life or work of a particular person, group or organisation of importance in Queensland's history

Register of the National Estate

The Federal Government maintains an archive of locations previously protected as part of the Register of the National Estate. This register is no longer current, with heritage protected federally through the recognition of Commonwealth Heritage Properties under the EPBC Act or where the property is owned or leased by the Commonwealth. Items listed on the register, however, are still relevant in understanding the cultural heritage of a particular location.

Items within the Study Area that are on the Register of the National Estate include the following:

- 18883 Bribie Island Fortifications;
- 15837 Pumicestone Passage – Bribie Island; and
- (formerly) 8670 Bribie Area (now deregistered).

None of these places are Commonwealth Heritage Properties or owned/leased by the Commonwealth, so are not protected under the EPBC Act.

Aboriginal Cultural Heritage

Aboriginal cultural heritage is protected in Queensland through the *Aboriginal Cultural Heritage Act 2003*. This Act provides for a cultural heritage duty of care requiring all persons carrying out an activity to take all reasonable and practicable measures to ensure the activity does not harm Aboriginal cultural heritage.

A study conducted by Davies, Hall & Smith (1992) regarding cultural heritage in the Pumicestone Passage region predicted that Aboriginal cultural heritage sites would generally be found concentrated around estuaries and the immediate coast, with middens located along creeks, swamps and the margins of estuaries. Based on this broad assessment, the most likely areas for the occurrence of Aboriginal cultural heritage items would be around the mouth and margins of Bells Creek and Lamerough Canal (formerly a creek) as well as along the foreshore of the entire Study Area. No detailed identification of cultural heritage sites is known to have been conducted for Pumicestone Passage to date.

A cultural heritage study undertaken on Bribie Island for the (then) Department of Environment and Heritage in 1991 identifies a number of middens, stone artefact sites and canoe trees across Bribie Island (McQueen 1991). It is uncertain whether any of these items occur within the Study Area.

Relationship to Proposed Strategy

The nourishment of and development of a seawall along the shoreline between the Lamerough Canal and Bells Creek entrances may cause some impact on the Military Jetty (GBH3) located in the Keith Hill Park. In accordance with the *Sunshine Coast Planning Scheme 2014*, works are required to be *compatible* with the jetty. The location and preservation of the jetty, therefore, will need to be considered in the design of foreshore works. Erosion and a rise in water levels may lead to the diminished use and integrity of this structure, thereby requiring action to ensure that the Military Jetty is not lost. In addition, the potential occurrence of items of Aboriginal cultural heritage significance near the mouth of Lamerough Canal and Bells Creek requires the consideration of the cultural heritage duty of care under the ACH Act. This may be achieved by the preparation of a Cultural Heritage Management Plan or other management procedures.

5.2.9 Visual and Recreational Amenity

Pumicestone Passage, Bells Creek and Lamerough Canal have all been noted under the *Pumicestone Passage environmental values and water quality objectives* plan as supporting EVs for primary,[8] secondary and visual recreation. These EVs refer to the following:

- *Primary Recreation*: full body contact with the water, for example, diving, swimming, surfing, waterskiing and windsurfing;
- *Secondary Recreation*: contact other than full body contact with the water, including, for example, boating and fishing; and
- *Visual Recreation*: viewing the water without contact with it.

The association of all three of these EVs with Pumicestone Passage suggests the comprehensive use of the passage for a variety of recreational purposes.

Common recreational activities known to occur in the Study Area include:

- Fishing, particularly for whiting, beach mullet, Australian bass, bream, blue salmon, estuary cod, flathead, garfish, jewfish, luderick, mangrove jack, sea mullet, whiting, mud and sand crabs, and banana, eastern king, bay, school and greasyback prawns;
- Indigenous fishing;
- Boating and jet skiing, though towing behind a ship is restricted under the Maritime Safety Queensland restriction notice gazetted 28th February 1997. Boat and jet skiing are also required to no disturb shorebird roosting and feeding on the Caloundra Sandbanks (under the *Marine Park (Moreton Bay) Zoning Plan 2008*);
- Swimming; and
- Visual recreation, especially due to the view of Bribie Island from the mainland.

Relationship to the Proposed Strategy

Amenity and recreation impacts should be considered in the context of the EVs for the Study Area as well as visual amenity and access requirements under the *Sunshine Coast Planning Scheme 2014*, the Coastal Management Plan and the Coastal Protection SPRP.

5.2.10 Native Title

Based on a search of the Native Title Tribunal Register conducted 5th June 2014, the entire Study Area is subject to the Kabi Kabi First Nation claim (QC2013/003 and QUD280/2013). This claim has been accepted for registration (August 2013) but has not yet been finally determined by the Federal Court.

Where Native Title is found to exist, it applies to all non-freehold land where it has not been extinguished by past acts. This includes unallocated state land (i.e. below high water mark), reserves and national parks. On this basis, further consideration into Native Title matters may be need to be considered further closer to the date of development.

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[8] Tidal waters of Bells Creek and Lamerough Canal only

5.3 Approvals Approach

This Section describes the process for approvals recommended in line with the proposed strategy. The structure of permits in the context of the proposed strategy is shown in Figure 5-8 with further detail in Table 5-4

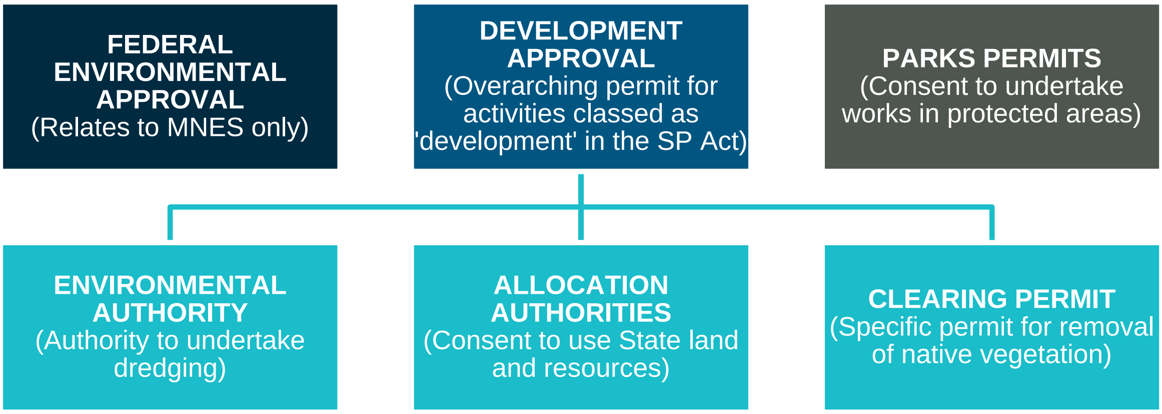

Figure 5-8 Structure of relevant approvals

As can be seen from Figure 5-8, there are three ‘streams’ of approvals required for the proposed strategy. The primary stream follows the Integrated Development Assessment System (IDAS) under the SP Act and includes the Development Approval, Environmental Authority, allocation authorities and Clearing Permit. Development Approvals are required for ‘development’ (i.e. material change of use, reconfiguring a lot, operational works, building works, plumbing and drainage works). The following permit and authorities are required as part of the overall Development Approval:

- Allocation authorities are required for the use of State resources (including land) prior for development.
- An Environmental Authority provides for a particular operator to undertake an Environmentally Relevant Activity (ERA) such as dredging.
- A Clearing Permit allows clearing activities not otherwise approved under a Development Approval.

The Federal Environmental Approval is required only where the Minister administering the EPBC Act believes the project may have a significant impact on MNES, as determined during the EPBC Act referral stage. It considers only those matters protected at a Federal level.

Parks Permits (for Marine or National Parks) are also separate from the Development Approval process.

Table 5-4 Summary of permits required for Study Area works

Permit	Administration	Activities covered	Intent	Governing instrument
Federal Environmental Approval	Minister administering the EPBC Act (i.e. DoE)	All activities that may have a significant impact on MNES (i.e. dredging in Pumicestone Passage)	Assessment and control of impacts to MNES including RAMSAR sites	EPBC Act and Policy Statements
Development Approval	Single Assessment and Referral Agency (of DSDIP), administering the SP Act and other legislation	Tidal works Damage, destruction or removal of marine plants Works in a FHA Concurrence ERAs	Integrated assessment of development by State Government	*Sunshine Coast Planning Scheme 2014* SDAP, SPP, Coastal Protection SPRP, Coastal Management Plan
Environmental Authority	DEHP under the EP Act	ERA 16	Registration of ERA operators	EP Act
Allocation Authority: Quarry Material	DEHP under the CPM Act	Allocation of quarry material	Supply of quarry material to proponent subject to royalties	CPM Act
Allocation Authority: State Land	State Land Asset Management (of DNRM) under the *Land Act*	Use of USL and reserve land	Control of use of State land	*Land Act*
Allocation Authority: FHAs	DAFF and DNPRSR under the *Fisheries Act*	Use of land within the Pumicestone Channel FHA	Assessment of works using FHA land	*Fisheries Act* and FHMOPs
Clearing Permit	DNRM under the NC Act	Taking of native vegetation other than under a Development Approval	Control of any clearing not covered under other permits	NC Act
Parks Permit: Marine Parks	DNPRSR under the MP Act	Activities within the Moreton Bay Marine Park	Assessment and control of all activities in a Marine Park	*Marine Parks (Moreton Bay) Zoning Plan 2008*
Parks Permit: National Park	DNPRSR under the NC Act	Activities within the Bribie Island National Park	Assessment and control of all activities in a National Park	Bribie Island National Park and Recreation Area Management Statement

Note – Existing approvals, discussed in Section 3.2, provide for the dredging and placement of up to 10,000m^3 of material at Golden Beach in a calendar year. The dredging is currently limited to 30 days in a calendar year and is to occur outside of shorebird roosting/feeding season and fish movement periods. The approvals include a Marine Parks Permit expiring in 2018 and a Federal Environmental Permit expiring in 2022.

5.3.1 Recommended Approach

As the proposed strategy relies upon trigger values to identify distinct phases of development, the Approvals and Stakeholder Consultation Plan has been divided based on the individual approval 'packages' involved in each set of works:

(1) Minor & Existing Works;

(2) Expanded Dredging & Nourishment Program; and

(3) Seawall Construction.

Minor and Existing Works

The proposed Stage 1 works consist of revegetation programs on Bribie Island and maintaining the existing dredging and nourishment programs currently being undertaken in the Pumicestone Passage and at Golden Beach. Where works on Bribie Island consist purely of revegetation, it is highly unlikely that a Development Approval or Park Permit will be required. However, where works consist of dune reprofiling, beach scraping or similar tidal works, a Development Approval for tidal works will be required as well as a National Parks Permit for works above the high water mark and a Marine Parks Permit for works below this line.

Dredging and nourishment works will be conducted under the existing approvals held by SCC (see note above), with any renewal required recommended to be included in the approvals package discussed below regarding dredging and nourishment for shoreline between Nelsen Street and Bells Creek.

Expanded Dredging and Nourishment Program and Commence Planning for Seawalls

The proposed expanded dredging and nourishment program would be undertaken once the first trigger level is reached (i.e. material required for beach nourishment exceeds the existing permitted volume of 10,000m^3/year). The intent of this program would be to access 40,000m^3 of material from the navigation channels of Pumicestone Passage for placement at Council-controlled shorelines between Nelson St and Bells Creek. The approvals required for these works include the following:

- Development Approval for prescribed tidal works, tidal works, removal of marine plants, and works in a FHA (if relevant);
- Environmental Authority to undertake ERA 16 (dredging);
- Quarry material allocation for use of sand;
- Owner's consent for use of State Land;
- Resource allocation authority for works in a FHA (if relevant);

- Clearing Permit for clearing activities not covered by the Development Approval;
- Marine Parks Permit; and
- Federal Environmental Permit.

In this context, the recommended process for obtaining approvals is shown below:

STEP 1: Initial Agency Meeting	• Present preliminary dredging and nourishment program to State agencies, including DNPRSR and SCC, with the intention of identifying concerns and mitigation measures to be included in an EPBC Act referral
STEP 2: EPBC Act Referral	• Conduct assessments and studies necessary to prepare EPBC Act referral • Draft and submit EPBC Act referral, seeking a decision that the project is 'not a controlled action'
STEP 3: Pre-lodgement Meeting	• Hold a pre-lodgement meeting with State IDAS agencies and DNPRSR to present DoE decision • Gain in-principle support for a Development Approval for dredging and nourishment works
STEP 4: Prepare and Submit Applications	• Prepare and submit first approvals package, including application for Development Approval, relevant allocation authoirties, Environmental Authority and Clearing Permit • Prepare and submit Marine Parks Permit application

The process would aim to achieve a decision by the Minister administering the EPBC Act that the dredging and nourishment program is ‘not a controlled action’ or ‘not a controlled action particular manner’. To achieve this, it will be necessary to provide a comprehensive referral with detailed mitigation actions demonstrating there will not be a significant impact on MNES (in accordance with the relevant EPBC Act Policy Statements).

Once a decision has been returned from DoE, a pre-lodgement meeting can be held with SARA and representatives of relevant government agencies regarding the Development Approval. These would include:

- SARA (DSDIP) representing all State interests;
- DEHP for coastal environment and heritage matters;
- DAFF for fisheries and marine plants issues;
- MSQ in relation to navigation and works in a coastal management district; and
- DNRM in relation to vegetation clearing and the use of State land.

If possible, it is advisable that DNPRSR also attend the meeting so that the DoE decision as it relates to Marine Parks can also be considered. Where the decision of the Minister is that the project is not a controlled action, the meeting can provide in-principle support for the dredging and nourishment program and identify any further information that may be needed to support the

Development Approval application. Where the Minister has identified the program as a controlled action, the pre-lodgement meeting will provide the basis for determining what integration of assessments may be possible at a State level.

Note – this advice has been identified based on the current process of EPBC Act referrals and assessments without regard to an Approvals Bilateral between the Federal and State governments. In the event that the Bilateral is finalised prior to the undertaking of the work above, this may have implications for any assessment required for the dredging and nourishment program, though is unlikely to affect the referral process.

Subsequent to the pre-lodgement meeting, relevant approval packages will need to be prepared. The first package will consist of the matters required under IDAS (Development Approval and allocation authority) and associated approvals (Environmental Authority and Clearing Permit), while the second will relate to the Marine Parks Permit. Both packages need to include the following:

- Construction methodology and footprint;
- Reports of environmental assessments, including seagrass surveys and studies identifying sand availability;
- Construction and Operational Environmental Management Plans (EMPs) for the program; and
- Assessments against relevant policy instruments, including the SDAP modules, the SPP interim development assessment provisions, the Coastal Protection SPRP, the Coastal Management Plan and the *Sunshine Coast Planning Scheme 2014* to the extent it applies to the project.

However, if the project is a controlled action, the studies required for the Federal Environmental Permit (if any), should be conducted prior to the submission of these State-level approval packages. Once the Federal approval is obtained, these assessments can be included in the approval applications.

Future seawall planning could also commence at this stage. The initial planning phase may include the development of conceptual designs and liaison with SARA regarding a preferred approvals strategy.

Seawall Planning and Construction

The seawall construction phase would be triggered by either:

(1) An unstainable volume of sand required for ongoing beach nourishment (to be determined via shoreline monitoring); and/or

(2) Significant changes to the tidal regime or mean sea level within Pumicestone Passage (to be determined via water level monitoring).

This stage of works will require the following approvals:

- Development Approval for prescribed tidal works, excavation and filling works and removal of marine plants;
- Owners consent for the use of State land;
- Quarry material allocation for any associated nourishment (where relevant);

- Clearing Permit for clearing activities not covered by the Development Approval; and
- Marine Parks Permit for works below high water mark.

The recommended process for obtaining these approvals is outlined below:

STEP 1: Pre-lodgement Meeting	• Hold a pre-lodgement meeting with the relevant State agencies to discuss the proposed works and gain in-principle support
STEP 2: Prepare and Submit Applications	• Prepare and submit first approvals package, including application for Development Approval, relevant allocation authoirties and Clearing Permit • Prepare and submit Marine Parks Permit application

As with the dredging and nourishment campaign, a pre-lodgement meeting should be held with all IDAS State agencies, with DNPRSR also in attendance to identify any Marine Parks based issues. The recommended agencies for the pre-lodgement meeting, therefore, are:

- SARA (DSDIP) representing all State interests;
- DEHP for coastal environment and heritage matters;
- DAFF for marine plants issues;
- MSQ in relation to works in a coastal management district; and
- DNRM in relation to vegetation clearing and the use of State land.

Both approvals packages to be presented will require the following:

- Construction methodology, footprint and EMP for the seawall;
- Reports of environmental assessments;
- As-constructed drawings of the seawall;
- Assessments against relevant policy instruments, including the SDAP modules, the SPP interim development assessment provisions, the Coastal Protection SPRP, the Coastal Management Plan and the *Sunshine Coast Planning Scheme 2014* to the extent it applies to the project; and
- Rehabilitation plan.

5.4 Stakeholder Consultation

Stakeholders for the proposed strategy include both government agencies that need to be consulted during the approvals process, and non-government agencies that may have an interest in the works. These stakeholders are considered in Table 5-5 below.

It is recommended that consultation with government agencies be conducted as identified in 5.3.1 above. The extent to which other stakeholders should be consulted would need to be determined immediately prior and during the approvals process.

Table 5-5 Stakeholders with an interest in the proposed Strategy

Stakeholder	Interest
Government agencies	
DoE	MNES under the EPBC Act; Federal Environmental Permit
DSDIP (SARA)	Planning and approvals under IDAS
DEHP	Environment, heritage and coastal processes
DAFF	Fisheries and marine plants
DNRM	State Land and vegetation
DNPRSR (QPWS)	Moreton Bay Marine Park, Bribie Island National Park and Bribie Island Recreation Area
MSQ	Navigation and maritime safety
Non-government agencies	
Kabi Kabi First Nation Traditional Owner group	Native Title rights and cultural heritage
Sunshine Coast Environment Council	Umbrella environmental advocacy in Pumicestone Passage
Bribie Island Protection Agency	Environmental advocacy and volunteering for Bribie Island
Take Action for Pumicestone Passage	Environmental advocacy for Pumicestone Passage
Queensland Wader Study Group	Migratory shorebirds and waders in Pumicestone Passage
Caloundra Power Boat Club	Boating and fishing in Pumicestone Passage
Sunfish Queensland	Recreational fishing in Pumicestone Passage
Commercial fishermen	Commercial fishing in Pumicestone Passage

6 Action and Implementation Summary

The three key stages of the Plan are summarised in Table 6-1. The proposed management actions escalate from Stage 1 to Stage 2 following the realisation of the first trigger, namely:

(1) Material required for beach nourishment exceeds the existing permitted volume of 10,000m^3/year.

Stage 3 works would subsequently commence following the realisation of the second trigger(s):

(2) An unsustainable volume of sand required for ongoing beach nourishment to maintain shoreline position and mitigate coastal erosion and inundation risk (to be informed by shoreline monitoring); and/or

(3) An observed increase to the mean high water spring level and/or the mean sea level greater than 0.2m relative to 2014 levels.

The enhanced management activities focus on the shoreline in the southern half of the study area. This reflects the perceived increased coastal inundation risk to the southern shorelines associated with a Bribie Island breakthrough and the recent investment in shoreline and foreshore management throughout northern study area. It is proposed that capital investment planned for the northern study area is delayed in the short term until risk mitigation strategies in the south are implemented. Existing permitted activities consistent with the Sunshine Coast SEMP (SCC, 2014) are expected to continue, including but not limited to:

- Golden Beach Nourishment Project (up to 10,000m^3 of dredging and beach nourishment per year);
- Mangrove habitat protection; and
- Shoreline vegetation management and minor revegetation works.

The proposed beach profile surveys are intended to assess the benefit of any beach nourishment works and monitor any emerging erosion problems that have been initially identified through visual inspection. Analysis of repeated surveys (ideally undertaken biannually) will allow the beach condition to be assessed based on the estimated loss or gain of sediment at the profile location.

Regular airborne bathymetric surveys of the study area discussed in Section 4.2.1 have not been included in Table 6-1; however, this information is considered valuable and would supplement the other proposed shoreline monitoring activities. A long-term commitment to regular airborne bathymetric surveys may be cost prohibitive for Council, particularly in consideration of the relatively gradual morphological changes typically observed at Pumicestone Passage mainland shorelines.

Table 6-1 Key Stages of Proposed Shoreline Management Actions

Stage 1	**Period of Acceptable Risk**
Existing permitted activities	Undertake minor shoreline management works and existing permitted activities including revegetation works at Bribie Island
Shoreline monitoring	Undertake beach profile surveys: • Before, after and within six months following minor beach nourishment works • At six monthly intervals for emerging erosion areas identified through visual inspection
Water level monitoring	Installation of permanent tide gauge near the entrance to Lamerough Canal. Monitor changes to tidal regime and/or mean sea level within Pumicestone Passage
Lodge Development Application	Seek agency approval for Stage 2 expanded beach nourishment program
Stage 2	**Risk Approaching Unacceptability**
Trigger 1	The first trigger for enhanced management action is realised, namely: • Material required for beach nourishment exceeds the existing permitted volume
Expanded beach nourishment program	Expanded beach nourishment program (and potentially groyne installation) using 40,000m^3 of sand from within target dredge area. Sand placement to focus on: • Shoreline between Lamerough Canal and Bells Creek • Council-controlled land between Nelson Street and Lamerough Canal
Revegetation works	Stabilise placed sand with dune revegetation works
Existing permitted activities	Undertake minor shoreline management works and existing permitted activities
Shoreline monitoring	Undertake beach profile surveys: • Before, after and within six month following beach nourishment works • At six monthly intervals for emerging erosion areas identified through visual inspection
Water level monitoring	Ongoing analysis of water levels recorded by permanent tide gauge (data processed and managed by Queensland Government)
Lodge Development Application	Seek agency approval for Stage 3 enhanced management
Seawall planning	Commence planning for proposed rock revetment upgrades and extensions (i.e. concept design and preliminary approval)
Stage 3	**Unacceptable Risk**
Trigger 2	The second trigger for enhanced management action is realised, namely either: • An unsustainable volume required for ongoing beach nourishment • An observed increase to the mean sea level greater than 0.2m relative to 2014 levels
Seawall detailed design and construction	Implement Stage 3 enhanced shoreline management action: • Detailed design and construction of rock revetment extension between Lamerough Canal and the Caloundra Power Boat Club to provide an increased level of protection for the Council-controlled boat ramp car park and associated facilities • Detailed design and construction of rock revetment extension /upgrade between Keith Hill Park and Roy Street
Existing permitted activities	Undertake minor shoreline management works and existing permitted activities

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Appendix A Pumicestone Passage Advisory Task Force Erosion Fact Sheets

Sunshine Coast
Regional Council

Erosion
fact sheet
01

Erosion on the ocean side of Bribie Island

Figure 1
Retreat of the shoreline on the ocean side

Aerial photography 2007.

Why is Bribie Island eroding?

Bribie Island has been subject to natural coastal processes for thousands of years.

It was the process of erosion and sedimentation that built Bribie Island, and it is these forces that will continue to shape and change Bribie Island well into the future.

Erosion is a natural process. The erosion of the Bribie Island Spit occurs in episodes during severe storms, with rebuild-up of sand in between storms during calmer weather.

The entrance to the Pumicestone Passage is always subject to change. South of the entrance, retreat of the shoreline on the ocean side is greater than the Passage side. On the ocean side of northern Bribie Island, the long term trend of erosion is an average rate of 1 metre per year, but can be up to 10 metres during storm events (refer to Figure 1).

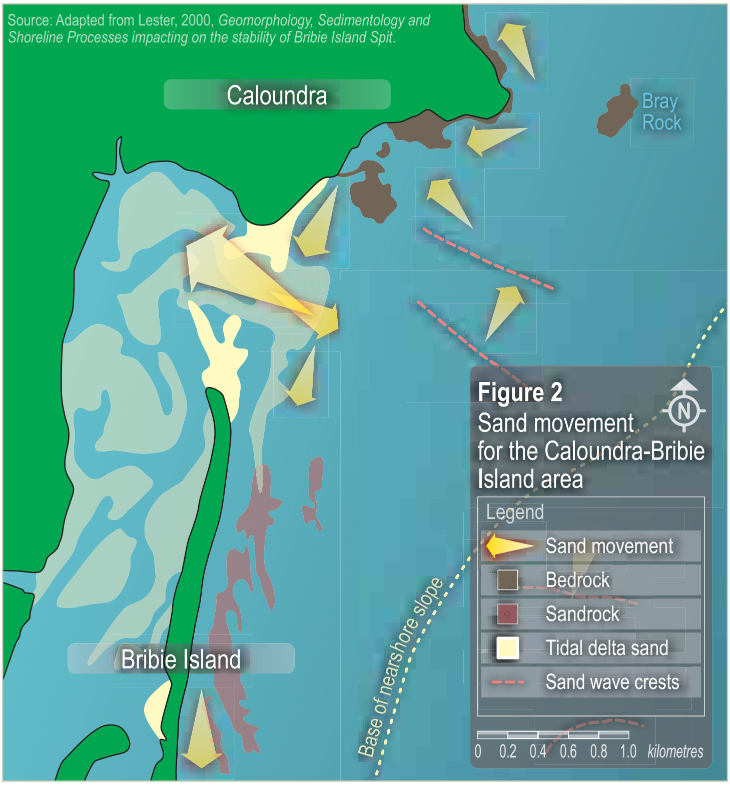
Beach erosion on the ocean side of Bribie Island

Sand eroded on the ocean side is lost by wave and tide action to the south, the north and into the Passage (refer Figure 2).

As there is no present day supply of sand from Moreton Bay or elsewhere to the shoreline of Bribie Island, inevitably – Bribie Island is eroding.

It is the erosion on the ocean side that is of most concern to a potential tidal breakthrough of northern Bribie Island, and this risk is amplified where the island is narrow and the dunes are low and subject to wave washover.

Figure 3
Areas of potential tidal breakthrough



Source: Adapted from Lester, 2000, *Geomorphology, Sedimentology and Shoreline Processes impacting on the stability of Bribie Island Spit.*

Figure 2
Sand movement for the Caloundra-Bribie Island area

Is sand dredging from Moreton Bay increasing the rate of erosion?

No.

Sand dredging of the Spitfire Channel is occurring some 28 kilometres to the south.

An independent scientific investigation of the impacts of this sand dredging operation clearly indicated that there is no impact on the beaches of northern Bribie Island.

What will happen if this erosion continues?

There are four narrow sections of Bribie Island where the dunes are also low (refer Figure 3). It is anticipated that in these areas, waves from the ocean side of Bribie Island will wash over the foredune and lower the sand surface level. The tides will then scour out a tidal channel in these lower lying areas.

Over time, a new tidal channel may widen, become the dominant channel and form a new entrance, and the existing inlet may close over. As the Bribie Island Spit continues to narrow, multiple entrances may form in the long term.

This scenario may be many years away, but it is dependent on the weather and particularly the intensity and frequency of severe storm events.

How will a new entrance south of the Caloundra bar affect Golden Beach?

If a new entrance were to form north of Lamerough Canal there would probably be very little impact on Golden Beach. The entrance has been well south of its existing position before (refer Figure 4).

If a new entrance were to form south of Lamerough Canal, it is not clear what the impact would be, but a risk assessment is currently in progress to provide further information.

Some have claimed that there will be big waves crashing on Golden Beach and we will need massive rock walls – is this true?

As is evident, there is little wave penetration through the existing entrance now and it would be the same for a new entrance. Similar to the existing entrance, a new entrance will also form sand bars which would limit waves entering the Pumicestone Passage. The existing wide shallow sand banks in the Passage will further protect Golden Beach and rock walls are not likely to be needed.

Sections of Golden Beach currently experience erosion and are maintained with groynes and sand renourishment.

Groynes and sand renourishment would continue to be preferred to the use of rock walls, so that a sandy beach environment is maintained.

Figure 4
Aerial photo
1967

Pumicestone Passage entrance shown well south of its present day location (opposite Golden Beach).

Pumicestone Passage looking west to Golden Beach.

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Erosion
fact sheet
01

Isn't the Environmental Protection Agency concerned about the loss of the environment?

Bribie Island is a designated Recreation Area and the Environmental Protection Agency is committed to conserving the dynamic landscape in its "natural state".

Bribie Island has been subject to natural coastal processes for thousands of years and will continue to change with the prevailing wind, waves and tides.

The Environmental Protection Agency views the erosion and an inevitable ocean breakthrough as a natural event.

Why don't we stop the erosion?

Natural coastal erosion processes should be recognised and generally allowed to occur without interference. Development protection works will only occur if there is a real threat to Golden Beach.

What is the Environmental Protection Agency and Council doing about the issue?

Council is monitoring the four areas of potential tidal breakthrough by aerial and ground surveys and site inspections.

In addition, Council has been successful in obtaining a grant from the Federal and State Government to undertake a risk assessment of a potential tidal breakthrough of northern Bribie Island and its implications to foreshore infrastructure and development along Golden Beach. This risk assessment is currently in progress.

The Environmental Protection Agency is also closely monitoring the situation and may undertake works to assist in dune recovery in critical areas until the potential impacts of a tidal breakthrough to the community is more clearly understood.

Further updates on the progress of this issue will be provided to the community.

The erosion on Bribie Island is a naturally occuring process.

The effects of wash through on Bribie Island.

Areas of potential breakthrough are being monitored by Council.

PUMICESTONE PASSAGE ADVISORY TASK FORCE

Prepared by Pumicestone Passage Advisory Task Force

Acknowledgments: Queensland Environmental Protection Agency.

All figures are indicative only.

This document is printed on environmentally responsible paper.

Sunshine Coast Regional Council

Caloundra Office
1 Omrah Avenue
T 07 5420 8200 F 07 5420 8900

Maroochydore Office
11 – 13 Ocean Street
T 07 5475 8501 F 07 5441 8338

Nambour Office
Cnr Currie and Bury Streets
T 07 5475 8501 F 07 5441 8338

Tewantin Office
9 Pelican Street
T 07 5449 5200 F 07 5447 1062

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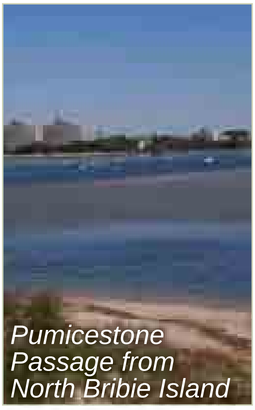
Erosion
fact sheet
02

Erosion on the Passage side of Bribie Island

Figure 1
Location
of Blue Hole



Pumicestone Passage from North Bribie Island

Oyster beds

Lamerough Canal

Has the placement of historic oyster beds within the Passage and the increased flows of Lamerough Canal increased the rate of erosion at the Blue Hole?

No.

Where the main tidal channel flows against Bribie Island, in the vicinity of the Blue Hole (refer Figure 1), active erosion of the banks can be seen and this has caused much community concern.

There have been some theories that the erosion occurring at the Blue Hole has been made worse by the historic placement of oyster beds within the Passage and the increased outflows of Lamerough Canal. The theory being that the oyster beds and increased flows have changed the nature of the sand banks within the Passage, causing a shift of the main tidal channel closer to the western side of Bribie Island, which in turn is accelerating the rate of erosion at the Blue Hole.

The Environmental Protection Agency provided an independent report to the previous Council which investigated these claims. The report found that these theories were incorrect.

Sunshine Coast
Regional Council

Erosion
fact sheet
02

The erosion on the Passage side of Bribie Island at the Blue Hole is considered to be a natural process. The channel has predominantly been at this location (refer Figures 2a and 2b) since first surveyed in 1865. In fact, the report showed the sandbars and channel in the Passage have been migrating north to south driven by slightly faster incoming tide flows (refer Figure 3).

In addition, a review of historical erosion of the area indicates that the present day rate of erosion on the Passage side of Bribie Island is relatively minor. As such the Environmental Protection Agency, which has responsibility over the day to day management of the Bribie Island Recreation Area has recommended that no action is required to control bank erosion in the vicinity of the Blue Hole at this time.

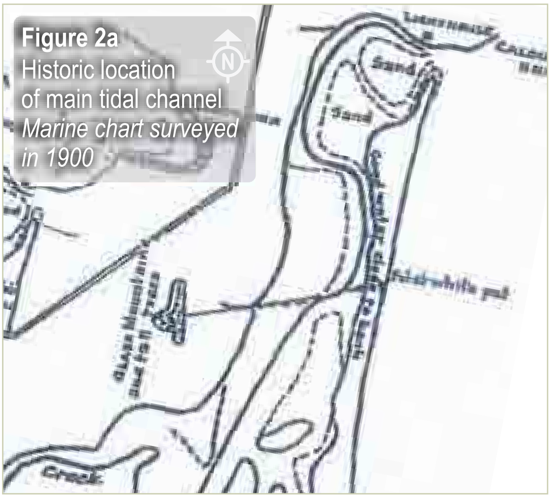


Figure 2a
Historic location of main tidal channel
Marine chart surveyed in 1900


Figure 2b
Location of main tidal channel
Aerial photograph 2007

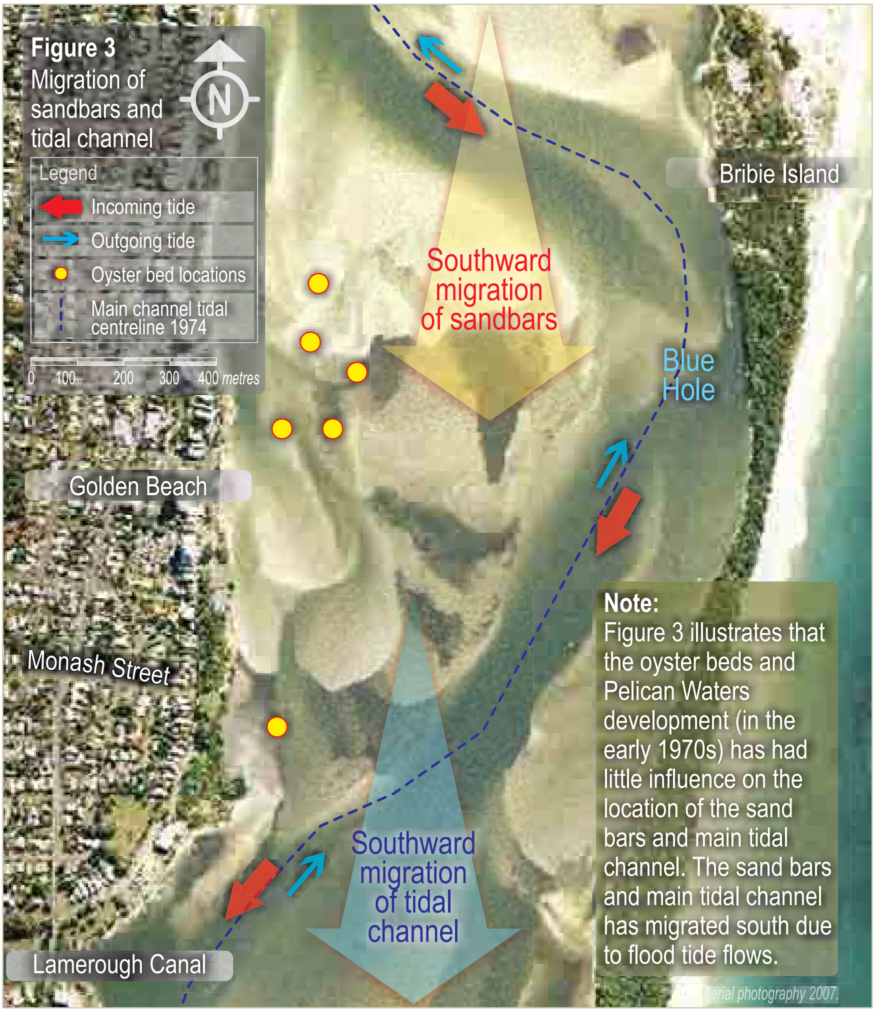


Figure 3
Migration of sandbars and tidal channel

Note:
Figure 3 illustrates that the oyster beds and Pelican Waters development (in the early 1970s) has had little influence on the location of the sand bars and main tidal channel. The sand bars and main tidal channel has migrated south due to flood tide flows.

Why were the oyster beds south of Monash Street removed?

As the oyster bed rubble piles south of Monash Street (refer Figure 3) were exposed at low tide, they were considered by the Environmental Protection Agency to pose a risk to public health and safety and have subsequently been partially removed by Council.

If you are interested in reading the full independent report prepared by the Environmental Protection Agency, you can download a copy from Council's website, visit: www.sunshinecoast.qld.gov.au or contact Environment Policy (Caloundra Office) on 07 5420 8200.

PUMICESTONE
PASSAGE
ADVISORY
TASK FORCE

Prepared by Pumicestone Passage Advisory Task Force

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PUMICESTONE PASSAGE
ADVISORY TASK FORCE

Erosion
fact sheet
03

Northern Bribie Island

What are the potential risks from a tidal breakthrough?

Northern Bribie Island looking south.

The impacts from a tidal breakthrough of northern Bribie Island on Golden Beach and Pelican Waters has caused some concern among the community.

The *Bribie Island Tidal Breakthrough Risk Assessment Study* was undertaken to gain a better understanding of the risk associated with a tidal breakthrough of northern Bribie Island. This is a summary of the key findings from the study.

The Pumicestone Passage Advisory Task Force was established to identify and prioritise issues impacting on the Pumicestone Passage between Bells Creek and the Caloundra Bar. The advisory task force is made up of representatives from local government, state government and the community and includes the state members for Caloundra and Glass House.

Figure 1
Aerial view of Pumicestone Passage from Caloundra Headland to Bells Creek

Pumicestone Passage is a narrow shallow estuary with approximately 80 per cent of the passage less than two metres deep.

Aerial photography October 2008.

What does the term 'tidal breakthrough' mean?

In this instance a tidal breakthrough is when storm waves wash across northern Bribie Island lowering the dunes. As the level lowers tidal flows can then continue to deepen the channel which forms a new deep entrance to Pumicestone Passage. The process may take days or years and is dependent on weather and tide conditions, especially storms and cyclones.

The natural environment — coastal processes

Bribie Island is a sandy barrier island separating Pumicestone Passage from the Coral Sea. Northern Bribie Island is a long narrow dune ridge with a pronounced mass of sand which has accumulated near the Caloundra Bar. Pumicestone Passage is a narrow shallow estuary with approximately 80 per cent of the passage less than two metres deep. Northern Bribie Island is recognised as being highly dynamic and has been evolving over thousands of years.

The northern five kilometres of Bribie Island has narrowed by up to 100 metres since 1948. The Department of Environment and Resource Management (DERM) states that the erosion appears to be a long-term natural process measured in the hundreds and perhaps thousands of years.

As this erosion continues the narrowest areas will become more vulnerable to wave overwash and tidal breakthrough which can create new channels.

This is described in *Erosion Fact Sheet 1*.

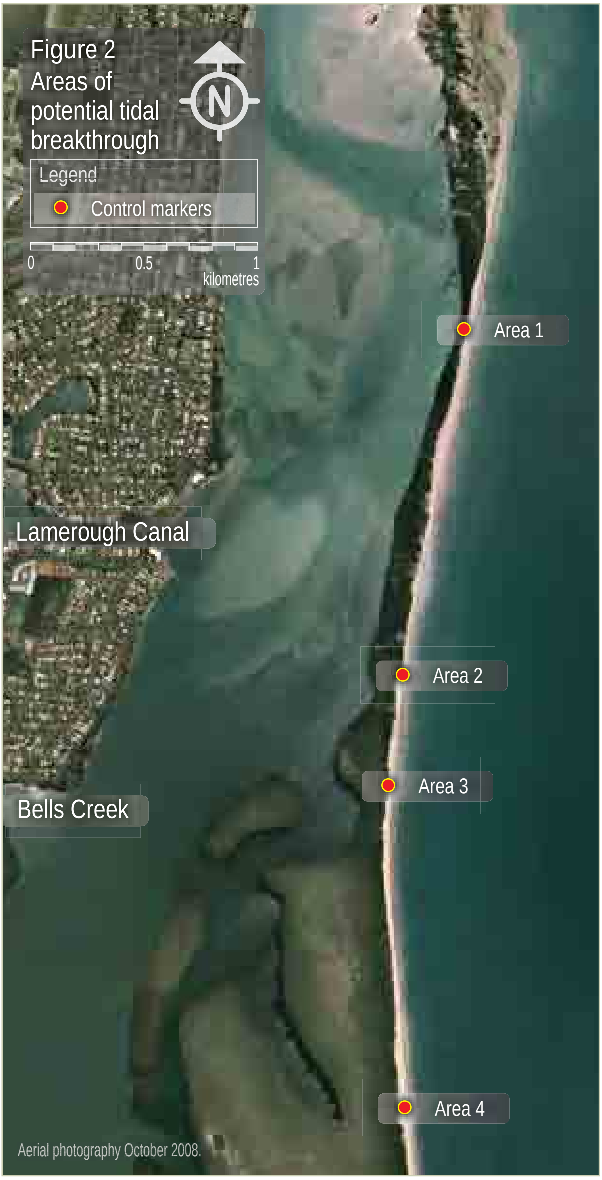

Figure 2
Areas of potential tidal breakthrough

Aerial photography October 2008.

Northern Bribie Island looking west over Lamerough canal and Bells Creek

Areas at risk of a breakthrough on northern Bribie Island

Along the northern end of Bribie Island four locations have been identified by DERM which are considered vulnerable to a breakthrough. The four locations are narrow with low dunes and have experienced major wave overtopping events in the last two years (refer to Figure 2).

The study highlights that a scenario of storm waves occurring with a high tide and/or storm surge event could result in one or several breakthroughs occurring at once.

Recognising the rate of recession of the beach on northern Bribie Island is around one metre per year and the width of the island in some areas is only 30 metres wide, it is highly likely that a tidal breakthrough will occur within the next 20-30 years, although a breakthrough may occur at any time in response to a significant storm event.

What causes these areas to be at risk of a breakthrough?

A breakthrough of northern Bribie Island is dependent on the dynamic balance of:

- oceanic swells and locally generated waves
- tidal currents
- storm surge (increase in water surface level during a storm)
- winds
- fresh water flows.

The primary cause of the erosion in this area is a long-term loss of sand to the north and south and into the passage. Furthermore, there is no modern day source of replenishment to balance this loss. Therefore the island will continue to erode and retreat westward until a shoreline position has been reached which is in balance with the local sand transport processes.

However, a breakthrough may occur from short-term processes that affect the island, such as a major storm event.

Washover on northern Bribie Island

Photo courtesy of DERM

What are the immediate threats from a breakthrough?

The risk assessment study used the scenario of a tidal breakthrough which resulted in the formation of a new entrance with a similar morphology to the existing northern entrance.

Immediate threats identified from a breakthrough included:

- increased tidal range of approximately 15 centimetres from Golden Beach through to Halls Creek i.e. an increase in height between the high and low tide resulting in higher levels of foreshore erosion and a potential increase in local flooding issues
- increased storm tide levels i.e. the sea level rise within the passage during a storm event will be greater
- loss of dune habitat
- shoaling (gradual shallowing) of the existing northern entrance
- sand inflow into the passage creating a new tidal delta
- increased wave propagation into the passage and onto the Golden Beach foreshore i.e. waves penetrate further within the passage.

What risks were identified if a breakthrough occurs?

- Risks associated with an increase in tidal range are high and considered a priority to be addressed.
- Risks associated with increases in mean sea level (associated with climate change) are considered more significant however would develop over time.
- Risks associated with increased storm surge is moderate.

The following five preferred risk treatment options were identified by the study:

Treatment options	
1	Monitoring and rehabilitation including surveys and restoration.
2	Remedial works following storm events such as site specific nourishment on northern Bribie Island.
3	Dredging and foreshore nourishment along designated areas of Golden Beach to provide additional erosion buffering.
4	Shore protection works for the foreshore area to the west of the island.
5	Improved policy and regulation to control development in areas potentially affected by sea level rise and climate change risks and/or risks associated with a breach in northern Bribie Island.


Erosion on northern Bribie Island


Northern Bribie Island
looking north to Caloundra

Pumicestone Passage looking west to Golden Beach

Erosion on northern Bribie Island

Pumicestone Passage looking north towards Bulcock Beach

The following additional steps were recommended by the study to determine which treatment options are suitable:

Actions
Develop a monitoring plan to determine 'where' and 'what' should be monitored including identifying roles and responsibilities for monitoring activities on Golden Beach and northern Bribie Island.
Develop a shoreline erosion management plan to identify the areas that require protection and nourishment and the type of protection appropriate.
Undertake a review of the existing policy and planning tools available to council to adequately control development in areas potentially affected by sea level rise and climate change risks and/or risks associated with a breach on northern Bribie Island.

Where to from here?

DERM and Sunshine Coast Regional Council are moving forward with the following actions identified:

Actions
DERM will coordinate an erosion monitoring plan for northern Bribie Island with support from council.
Council has commenced the development of a shoreline erosion management plan for the area between Caloundra Bar and Bells Creek to further understand the shoreline erosion issues along the passage and identify an agreed framework and management strategy for responding to the current and potential erosion issues.
Council intends to develop new policies and planning tools as part of its new regional planning scheme to reflect vulnerable coastal areas.

For further information on general coastal management and development control on the coastal zone visit:
www.epa.qld.gov.au

For further information on the Pumicestone Passage Advisory Task Force visit:
www.sunshinecoast.qld.gov.au

Sunshine Coast Regional Council
T 07 5475 7272 E mail@sunshinecoast.qld.gov.au

Department of Environment and Resource Management
T 1300 130 372 E info@epa.qld.gov.au

Prepared by: Pumicestone Passage Advisory Task Force

This project was partly funded under the Natural Disaster Mitigation Programme.
All figures are indicative only.

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Appendix B Historical Aerial Photos

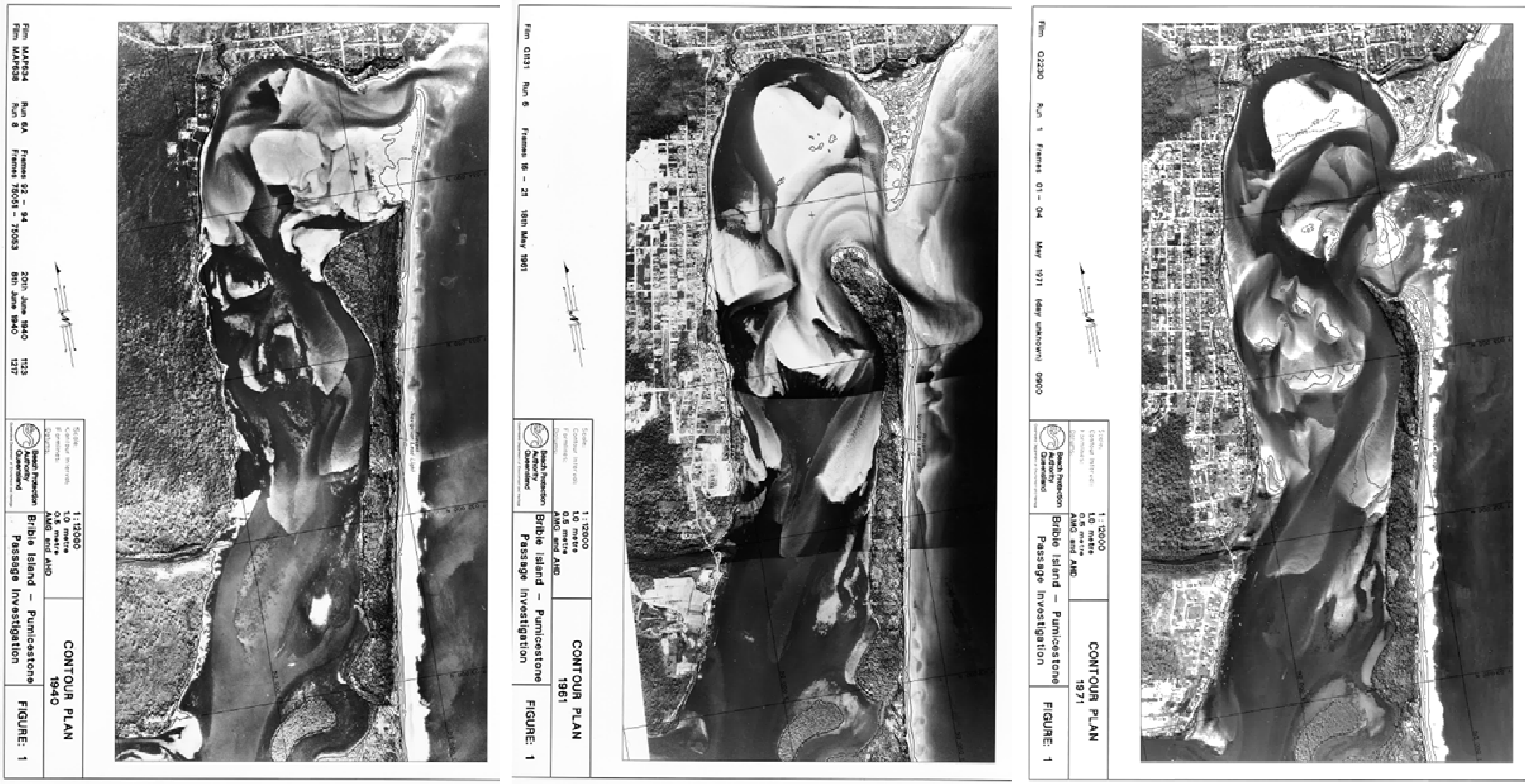

Figure B-1 Bells Creek to Caloundra Bar Aerial Photography (1940, 1961 and 1971)

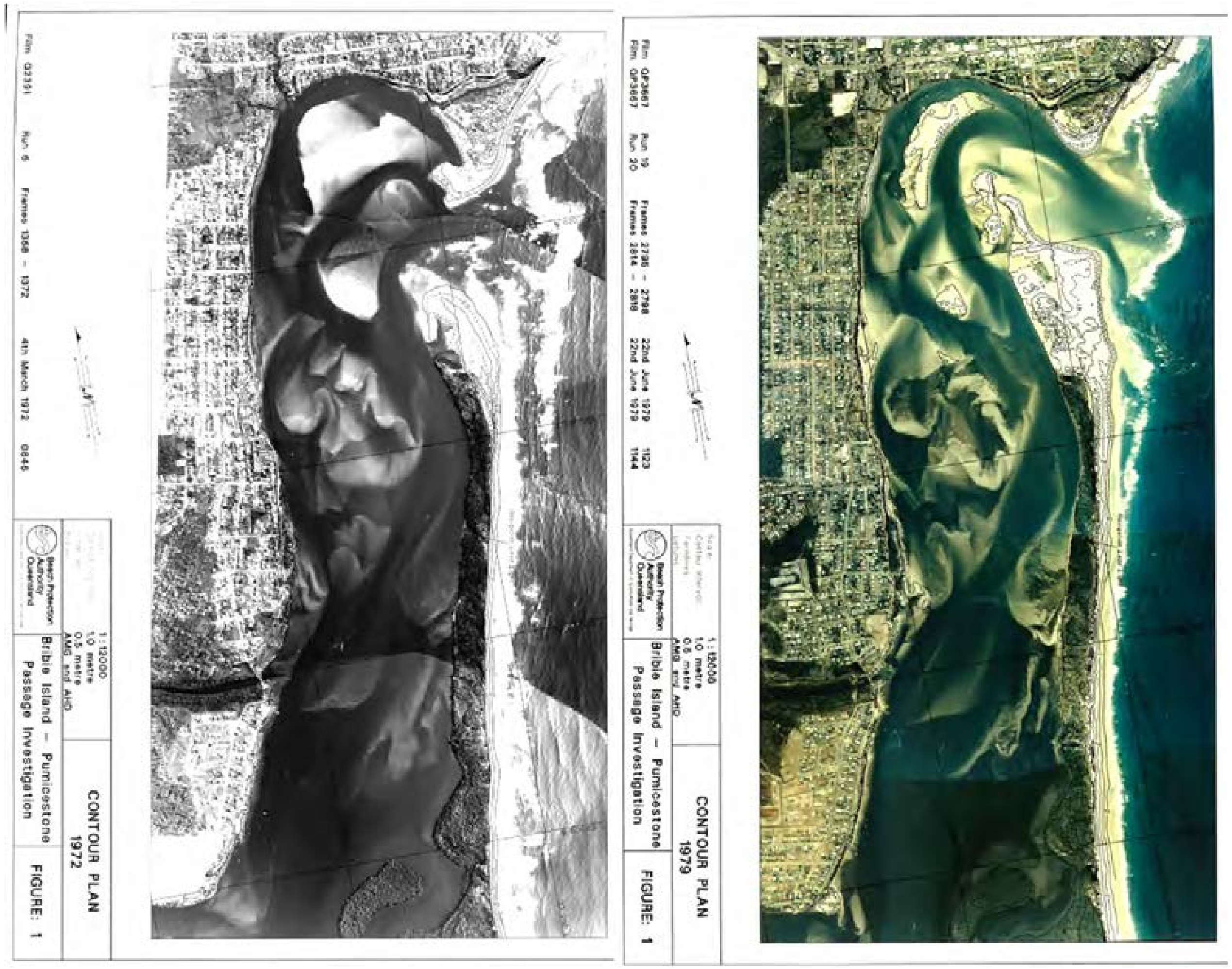

Figure B-2 Bells Creek to Caloundra Bar Aerial Photography (1972 and 1979)

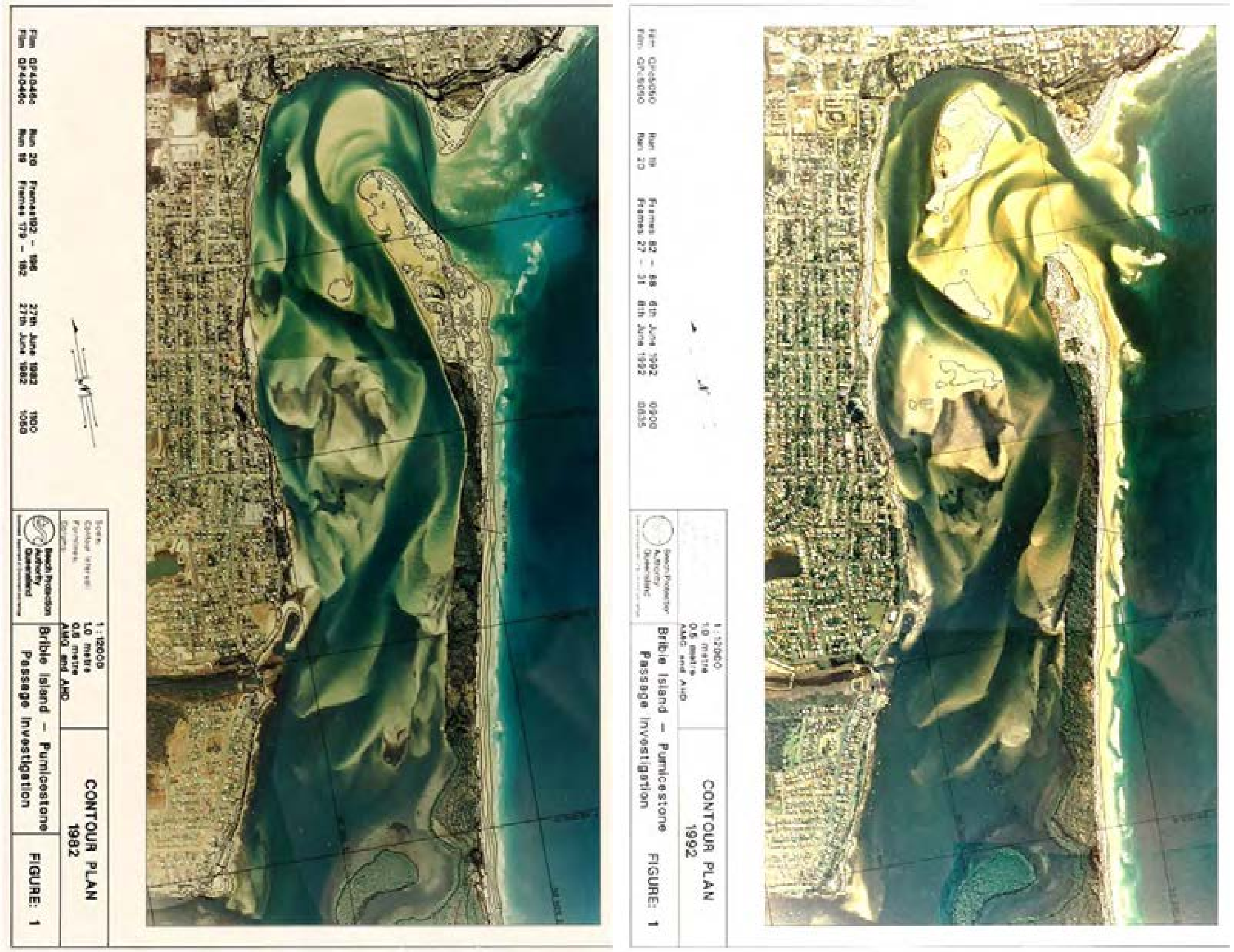

Figure B-3 Bells Creek to Caloundra Bar Aerial Photography (1982 and 1992)

Appendix C Pumicestone Passage Sediment Investigation Report

Pumicestone Passage Sediment Investigation Report

Job Number: 3747/P/158

Prepared for Sunshine Coast Council

Date: 23 December 2011

ABN 74 128 806 735
32 Hi-Tech Drive Kunda Park
Queensland 4556 Australia
Telephone: 07 5450 1544
Facsimile: 07 5450 1533
International: +61 7 5450 1544
bowler.ssc@cardno.com.au
www.cardnobowler.com.au

Document Control

Version	Date	Author		Reviewer	
1.0	23 December 2011	Paul Mayes	Pm	Matt Courtney	M

Executive Summary

Cardno Bowler Pty Ltd was engaged by Sunshine Coast Council to perform an investigation of the sediments in a section of the northern reaches of Pumicestone Passage to provide data to support an application to dredge this area for the purposes of a beach nourishment program.

A program of fieldwork and laboratory testing was designed and implemented with the aim of describing the nature of the sediments present within the proposed dredge area and to assess the extent and severity of any Acid Sulfate Soils within these sediments. Furthermore, three locations were sampled and tested for the presence and extent of contamination by metals and organic tins. These data could then be used to target dredging operations to areas likely to produce the best resource for a beach nourishment program. Supplementary to these sediment characterisations, a survey of the seagrass present within the area was also carried out to determine if the existing seagrass distribution would impact the selection of potential dredging sites.

A total of 20 boreholes were advanced during the investigation, with representative samples selected for particle size distribution and analytical laboratory testing for the presence of Acid Sulfate Soils. Subsurface strata at the site were dominated by fine to medium grained sands with varying, but generally very low, levels of silt. The results of the analytical laboratory testing on the samples collected support the presence of Acid Sulfate Soils within the material tested. As a result of intrinsic acid neutralising capacity held within the material tested, the potential acidity levels (as assessed by S_{Cr}) which ranged from nil to 0.849%S were often exceeded by acid neutralising capacity to give net acidity values for the majority of samples tested of nil. However, a total of three samples had net acidity values in excess of 0.03%S and as such liming rates were calculated to neutralise this acidity.

Paul Mayes (PhD.)
Principal Environmental Scientist

Table of Contents

List of Annexes

Glossary

Acid Sulfate Soil (ASS): Soil or sediment containing highly acidic soil horizons or layers affected by the oxidation of iron sulfides (actual ASS) and/or sediment containing iron sulfides or other sulfidic material that has not been exposed to air and oxidised (potential ASS). The term Acid Sulfate Soils generally includes both actual and potential Acid Sulfate Soils.

Agricultural Lime: A neutralising agent commonly used to treat acidic soils.

AHD (Australian Height Datum): The datum used for the determination of elevations in Australia.

Borehole: The actual hole created when an auger or push-tube is inserted into the soil body.

BSL (Below Surface Level): The depth as measured from the existing site surface level, generally recorded in metres.

Clay: Cohesive Soil with a particle size less than 0.02mm.

Groundwater: Subsurface water in the zone of saturation, including water below the water table and water occupying cavities, pores and openings in underlying soil and rock.

Leachate: The soil constituent that is washed out from a mixture of soil solids.

Oxidised: Process of chemical change involving the addition of oxygen following exposure to air.

Piezometer: A pipe of small diameter installed in a borehole that is used to measure the height (elevation) of the water table.

Pyrite: Pale bronze or pale yellow, isometric mineral: FeS_2 ; the most widespread and abundant of the sulfide minerals.

pH_F: The pH of the soil in soil/distilled water paste.

pH_{FOX}: The pH of the soil after the addition of a small quantity of Hydrogen Peroxide.

%S: Percentage oxidisable sulfur.

Sand: Non-cohesive soil with a particle size between 2.36mm and 0.075mm.

Silt: Non-cohesive soil with a particle size between 0.075mm and 0.02mm.

SPP 2/02: State Planning Policy 2/02: Planning and Managing Developments involving Acid Sulfate Soils.

Soil and Sediment: The natural accumulation of unconsolidated mineral particles (derived from weathered rocks) and organic matter that covers much of the earth's surface.

Water table: Portion of the ground saturated with water, often used specifically to refer to the upper limit of the saturated ground.

Introduction

The following report details the results of the Sediment Investigation performed within the northern reaches of the Pumicestone Passage in South East Queensland. It is understood that the works proposed for the site are to include the dredging of suitable sand resources from within the passage for the purposes of beach nourishment in the local area. The study area identified by council had an area of approximately 60 hectares and extended from Bells Creek in the south to approximately Jellicoe Street in the north and bordered the western bank of the passage. The scope of work covered in this investigation included the following:

- General description of the sediment profile at selected locations within study area;
- Particle size distribution testing of representative sediment samples;
- Acid Sulfate Soils testing of representative sediment samples; and
- A survey of the study area for the presence of seagrass beds greater than $50m^2$ in area.

The nature of the sediments present within the study area will be integral to the ultimate selection of the material to be dredged for two reasons:

- non-cohesive soils (ie sands) are logistically more suitable for dredging, and
- lightly coloured, clean sands will be more suitable for use in beach nourishment programs.

The Acid Sulfate Soils conditions within the areas proposed to be dredged may also be incorporated into the decision making process regarding which areas are most suitable to be used for the beach nourishment program. Acid Sulfate Soils are common in low-lying coastal areas of Queensland, especially in areas below 5.0 metres AHD. Such areas are often characterised by the presence of estuaries, swamps, floodplains, salt marshes and mangroves. The affected soils are characterised by iron sulfides, most frequently pyrite, and when these soils are maintained in anaerobic conditions these iron sulfides are unable to oxidise and therefore the Acid Sulfate Soils are stable. However, if a disturbance exposes the Acid Sulfate Soils to air, the iron sulfides can oxidise and form sulphuric acid, resulting in the soil becoming strongly acidic. This acidity has the potential to mobilise metals such as Iron, Aluminium and Manganese which are naturally present in the soil, thereby producing a leachate contaminated by both high levels of acidity and metals. Such leachate, if released into the environment, can have significant adverse effects including; degradation of the water quality in receiving areas, fish disease/kills, reduced crop productivity, corrosion of structures and health related issues. In view of these potential effects, it is critical that any development that occurs within an area likely to contain Acid Sulfate Soils is planned, managed and monitored appropriately so as to minimise or remove the risk of adverse environmental outcomes.

In response to the potential for such adverse environmental outcomes to occur as a result of the disturbance of Acid Sulfate Soils, the Queensland Department of Environment and Resource Management developed the “State Planning Policy 2/02: Planning and Managing Developments involving Acid Sulfate Soils: and its supporting guidelines”. The SPP 2/02 provides assistance and recommendations on best practice for developments involving Acid Sulfate Soils.

The State Planning Policy 2/02 applies to all land, soil or sediment at or below 5 metres AHD where the natural surface level is below 20 metres AHD and applies to development that would result in:

(a) the excavation of, or otherwise removing, 100m^3 or more of soil or sediment; or

(b) filling of land involving 500m^3 or more of material with an average depth of 0.5 of a metre or greater.

As the entire site has an existing surface level below AHD 5.0m any disturbance of soil or sediment within this area must consider the consequences of Acid Sulfate Soils when assessing the overall project risk. The preferred mechanism to circumvent potential adverse environmental outcomes concerning Acid Sulfate Soils is avoidance, that is, where possible, areas identified to contain Acid Sulfate Soils should not be disturbed. Where avoidance is not possible, appropriate management mechanisms must be implemented to reduce the risk of adverse environmental outcomes resulting from the disturbance of the Acid Sulfate Soils.

The aim of this sediment investigation was to make an assessment of the quality of the sediments present within the study area with respect to the use of these sediments as part of a beach nourishment program. The parameters considered integral to the potential use of the sediments were; the nature of the insitu sediments and the Acid Sulfate Soils content of these sediments along with proximity to existing seagrass beds.

It should be noted that this report is not intended to be, nor should it be attempted to be used as, a fully QASSIT compliant Acid Sulfate Soils investigation of the site to support a specific proposed soil disturbance. Rather, this investigation is intended to provide general information regarding the sediments present at the site with the goal of informing the decision making process regarding the overall beach nourishment project. Furthermore, it is recognised that there are numerous other factors that will be incorporated into the final selection of any dredging locations for this project.

This report should be read in conjunction with the attached “General Notes” and the ASFE publication “Important Information about your Geotechnical Report”.

Site Description

The subject site was located within the northern reaches of Pumicestone Passage from Bells Creek north to approximately Jellicoe Street and is shown in Annex A. See Figure 1 below for a locality plan of the study site.

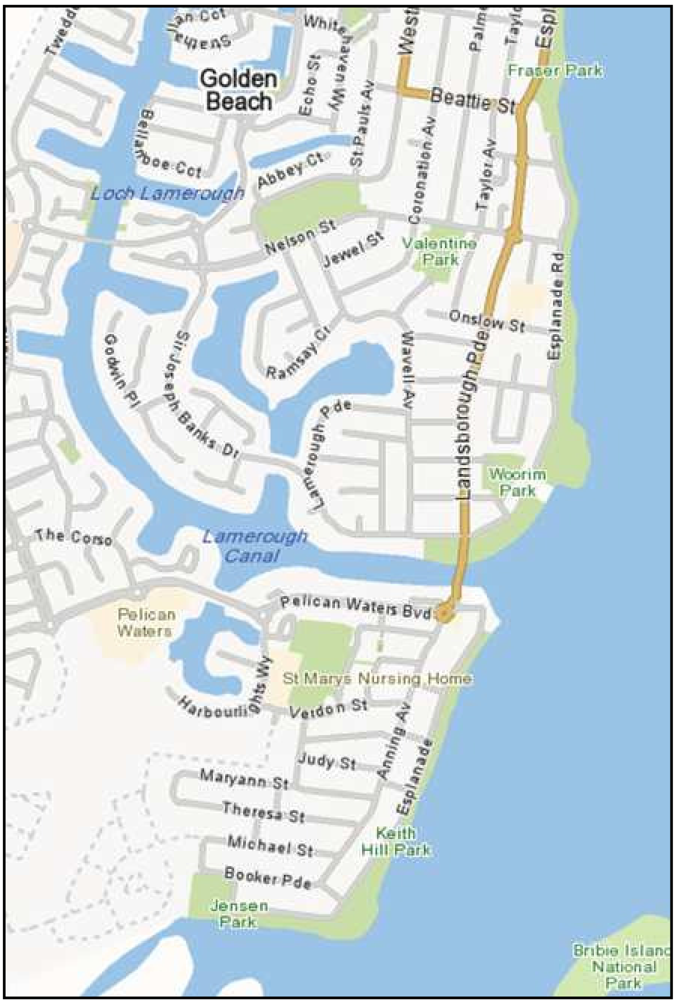

Figure 1: Locality Plan

The study site was heavily influenced by tidal flows. Water depths within the subject area was significantly influenced by tidal movements, with some areas completely exposed at low tide and maximum water depths in excess of 3.5m at high tide in other areas. This area of Pumicestone Passage is heavily utilised by recreational users for swimming, boating and fishing activities.

Methodology

Desktop Survey

Prior to the commencement of the fieldwork program, a review of the existing Acid Sulfate Soils maps produced by Department of Environment and Resource Management was performed. The results of this desktop survey are shown in the Results section below. Furthermore, a general assessment of the site was made by reviewing the available aerial photographs of the site and the Department of Mines and Energy geological maps.

Fieldwork

A total of 20 boreholes (BH01 to BH20) were advanced across the site. After a review of the available aerial photography and a visit to site, the boreholes were distributed to give representative information about the sediments throughout the study area, see Annex B for a plan showing the borehole locations and three specified metals and organic tin sampling locations.

The boreholes were advanced using a pneumatic vibracore drilling rig mounted on a self propelled working barge. The vibracore and barge were operated by Abyss Commercial Diving Services who are experienced in the collection of soft sediments in estuarine environments such as Pumicestone Passage. The vibracore rig collects a continuous core of the soft strata which is suitable for investigations of this nature. The target depth of the boreholes was 3.0 metres below the existing sediment surface level, however some boreholes were terminated prior to this target depth due to vibracore refusal in stiffer sediments. Detailed geotechnical boreholes logs of the material encountered at each location are shown in Annex C. The entire core from each location was retained and returned to our Kunda Park laboratory for the required laboratory analysis via AS1289 for particle size distribution testing and the Chromium Test Suite for Acid Sulfate Soils. Three additional locations were identified within the project brief for the collection of sediment samples for laboratory testing for metals and organic tin testing.

Borehole locations were initially selected digitally, using the provided site plans and aerial photographs to produce GPS co-ordinates for each borehole location. In the majority of cases these locations were accessible to the barge and could be drilled as selected, however, where necessary due to extremely shallow conditions, borehole locations were moved to allow successful completion of the fieldwork program.

The seagrass survey of the study area was undertaken in a systematic manner using GPS coordinates to divide the areas into a 25m grid to allow the identification of any seagrass patches present at the site. The seagrass survey was then undertaken using a small dingy and snorkelling equipment.

It should also be noted that the sampling locations and seagrass areas were identified with recreational quality GPS equipment, this equipment has an average accuracy of approximately 5m. Whilst this level of accuracy is considered sufficient for the purposes of this investigation, more accurate survey data may be required in the future, particularly in relation to the location and extent of the seagrass areas.

Laboratory Testing

Particle Size Distribution

Representative samples covering a variety of depths were selected and dried at 105^{o}C to a constant mass before testing. A single sample was selected from each borehole and the samples were isolated to 0.5m intervals from within borehole cores. The samples were tested to determine their particle size distribution via AS1289. The results of the particle size distribution testing are presented in Annex D.

Acid Sulfate Soils

Representative samples covering a variety of depths were selected from each borehole and dried at 85^{o}C to a constant mass before testing. Two samples were selected from each borehole and the samples were isolated to 0.5m intervals from within borehole cores. The samples were tested analytically via the Chromium Suite of testing. The results of the Acid Sulfate Soils testing are presented in Annex E.

Metal and Organic tin testing

Representative samples of the near-surface sediments were collected at each of the three locations identified in the project brief, the locations were numbered 1 through 3 from north to south. These samples were submitted to the Australian Laboratory Services testing laboratory for analytical testing for the concentrations of 13 heavy metals and organic tine compounds. The results of this testing are summarised in the results section below with the full test certificate presented in Annex F.

Results and Discussion

Desktop Survey

The Queensland Government Department of Environment and Resources Management "Acid Sulfate Soils-Maroochy Caloundra Acid Sulfate Sustainable Land Management Project" Map 2, does not specifically provide information regarding the sediments within the Pumicestone Passage bed itself. And map limits do not include the entire study area. However, this map does indicate that disturbed land on the western bank of Pumicestone Passage is likely to contain Acid Sulfate Soils. Whilst not definitive, these data tend to support a high probability of the presence of Acid Sulfate Soils within the subject site.

The Queensland Government Department of Mines and Energy 'NAMBOUR SPECIAL' geological map sheet 9444 and part 9544 scale 1:100,000, classifies the sediments of the site as "estuarine channel and banks; sandy mud, muddy sand, minor gravels".

Subsurface Conditions

Detailed logs for the boreholes advanced during this investigation are shown in Annex C. The subsurface strata encountered at the site were dominated by poorly fine to medium grained sands with generally low silt contents.

Analytical Laboratory Analysis

Particle Size Distribution

The samples of material tested for particle size distribution showed a relatively consistent pattern of composition across all 20 borehole locations. The subsurface strata are dominated by fine to medium grained sands with generally low silt contents. Particles larger than 1.18mm were very rare and when present were often shell fragments rather than sand particles or gravel. Furthermore, the proportion of material smaller than 0.075mm in the samples tested was also very small, generally not exceeding 5% by mass of the total. These extremely low proportions of material passing the 0.075mm sieve negated the need to undertake additional testing on the silt and clay fractions in all but one of the samples tested. The AS1289 method specifically excludes samples which have less than 10% passing 0.075mm from the hydrometer based portion of the test method.

Acid Sulfate Soils

The maximum S_{Cr} level detected in the samples tested during this investigation was 0.849% oxidisable sulfur, with a small number of samples returning results in the 0.1%S to 0.5%S range, while the remaining samples returned low levels of S_{Cr}, at or around the 0.03%S level (often below the detection limit of the test method), see Annex D. These results confirm the presence of Acid Sulfate Soils within the samples tested during this investigation.

However, the results also showed that only three of the 40 samples tested had a net acidity value in excess of the 0.03% oxidisable sulfur threshold for coarse grained soils such as those encountered at the subject site. This result is due to a combination of the presence of intrinsic acid neutralising capacity (ANC) and the generally low levels of oxidisable sulfur within the majority of samples tested. As such, the testing indicates that for the majority of samples tested no further treatment would be required. The extent to which this trend is applicable to the sediments present within the entire study area is a function of the degree to which the samples tested during this investigation are representative of the material to be disturbed as a whole. To this end, it is recommended that a detailed management plan outlining appropriate best practice techniques to deal with any acidity generated during the works be developed prior to the commencement of any dredging operations.

Metals and Organic Tins

The results of the analytical laboratory testing (see Annex F) are summarised in the table below.

Parameter	**LOR**	**units**	**Location 1**	**Location 2**	**Location 3**
Metals					
Arsenic	5	mg/kg	<5	14	<5
Barium	10	mg/kg	<10	20	<10
Beryllium	1	mg/kg	<1	<1	<1
Cadmium	1	mg/kg	<1	<1	<1
Chromium	2	mg/kg	<2	30	<2
Cobalt	2	mg/kg	<2	8	<2
Copper	5	mg/kg	<5	11	<5
Lead	5	mg/kg	<5	13	<5
Manganese	5	mg/kg	<5	197	9
Nickel	2	mg/kg	<2	14	<2
Vanadium	5	mg/kg	<5	43	<5
Zinc	5	mg/kg	<5	58	<5
Mercury	0.1	mg/kg	<0.1	<0.1	<0.1
Organic Tins					
Monobutyltin	1	µgSn/kg	<1	<1	<1
Dibutyltin	1	µgSn/kg	<1	<1	<1
Tributyltin	0.5	µgSn/kg	<0.5	<0.5	<0.5

Locations 1 and 3 generally showed levels of the 13 metals examined during this investigation below the detection limits for the selected test methods. Conversely, Location 2 showed detectable levels of the majority of parameters tested. Organic tin levels for the three samples tested during this investigation were all below the detection limits of the test methods.

Material Quality

The quality of the material present at each borehole location, in terms of its use in a beach nourishment program, was assessed on the basis of a combination of the information shown on the geotechnical logs and the particle size distribution. The particle size distribution testing suggests that there is limited variation in the sediments encountered at the 20 boreholes, with the exception of borehole 2 which has a relatively high proportion of fine material passing 0.075mm. This material may be less suitable for a dredging program given this higher proportion of fine material.

Whilst the particle size distribution of the sediments tested from the southern sections of the study area (borehole 1 through 12) would generally be suitable for the logistics of the dredging process and would also provide the non-cohesive materials generally sort for beach nourishment programs, this material is of variable make up. Colour and silt content, along with strata depth in this section are significantly more variable than in the northern section of the study area.

The soil profiles at the boreholes from the northern sampling locations (borehole 13 through 20) were generally more uniform and the material was generally paler in colour than that sampled from the southern borehole locations. These data suggest the sediments present within the northern section of study area would be the best quality (of those tested throughout this investigation) for the purposes of beach nourishment programs and it is recommended that this area be the primary source of the resource for the intended dredging program.

If the logistics of transporting the dredged material to destinations within the Pumicestone Passage are problematic and/or additional material is required, there may be opportunity to recover some smaller quantities of suitable material from the southern section of the study area, however the data presented here suggest that these opportunities would not yield the same quantity or quality of resource for beach nourishment purposes as the sediments from the northern sections of the study area. Furthermore, the distribution of seagrass within the southern section of the study area would also need to be considered prior to any decision to dredge within this area.

Seagrass Survey

The seagrass survey of the study area revealed significant patches of seagrass (greater than $50m^2$ in area) present at a number locations within the study area, see Annex G for a site plan showing the seagrass patches identified during the survey. Significant areas of seagrass were identified in the shallow waters fringing the southern portion of the study area and also towards the north of the study area, adjacent to Monash Street and the Power Boat Club.

Consistent with the general scientific consensus regarding the importance of seagrass beds in terms of the habitat they provide within estuarine ecosystems, all seagrass beds identified during this investigation were observed to support significant marine life, including molluscs, crustaceans and fish species.

The locations of these seagrass patches will need to be considered when determining what if any sections of the study area are appropriate sources of material for the proposed beach nourishment program.

Two significant patches of seagrass were also identified adjacent to the study area at its northern boundary (see Annex G). Whilst not strictly within the identified study area, given the proximity of these seagrass patches to the boundary of a potential dredging zone it is considered that their location should inform the final selection of areas to be dredged for the beach nourishment program and/or management techniques to be implemented during the dredging program.

Summary

The following points summarise the findings of the sediment investigation of Pumicestone Passage.

- Sediments tested at the selected sampling locations were generally quite consistent and were dominated by sands with generally low levels of silt.

- In general, the southern section of the study area showed more variable soil profiles with darker materials closer to the surface than those identified in the northern sections.

- Soil profiles at the northern boreholes were generally more uniform and paler in colour.

- Acid Sulfate Soils were identified at the site within the areas proposed to be disturbed, however intrinsic acid neutralising capacity exceeded potential acidity in all but three of the samples tested.

- Significant seagrass patches were identified during this investigation, particularly in the shallow waters of the study area. The location of these seagrass patches will need to be considered when identifying potential dredge sites.

- It is recommended that the northern section of the study area (between the Power Boat club and Jellicoe Street be used as the primary source of material for the beach nourishment program/s.

Annex A - Site Plan

Study Area for Proposed Dredging - Pumicestone Passage

Moreton Bay Marine Park Legend

Entry and use guide	General use zone	Habitat protection zone	Conservation park zone	Marine national park zone
Boating	Yes	Yes	Yes	Yes
Line fishing	Yes	Yes	Yes[a]	No[b]
Crabbing	Yes	Yes	Yes[c]	No[b]
Trolling	Yes	Yes	Yes	No[b]
Bait gathering	Yes	Yes	Yes	No[b]
Bait netting	Yes	Yes	Yes	No[b]
Netting (other than bait netting)	Yes	Yes	No[b]	No[b]
Limited spearfishing	Yes	Yes	Yes	No[b]
Limited collecting	Yes[c]	Yes[d]	Yes[d]	No[b]
Trawling	Yes	No[b]	No[b]	No[b]

Legend

▨ Study area for proposed dredging

🟩 Protected Areas of Queensland (estate)

☐ FishHabitatAreas

● Proposed Heavy Metal Testing Site

Please Note: Distances on map are indicative only.

N
W E
S

1:7,936

At Paper Size A3

0 65 130 260 390 520 Metres

Sunshine Coast Council

Locked Bag 72
Sunshine Coast Mail Centre
Qld 4560
[T] 1300 00 7272
[E] mapping@sunshinecoast.qld.gov.au
[W] www.sunshinecoast.qld.gov.au

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Last Printed on September 8, 2011

Path: W:\SCC\RP\EP\6WATERWAYS\WATERWAYS NEW\5 COASTAL MGT O.4212\Shoreline Erosion Management Plans\Sand sourcing study

Annex B – Sampling Locations

PUMISTONE PASSAGE - MAINTENANCE DREDGING AREA

50 0 50 100 150 200 250m

1:5000 - A1 1:10000 - A3

BOREHOLES

Pumicestone Locations.DWG

CARDNO BOWLER

Revision A

Annex C – Borehole Logs

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32 Hi-Tech Drive
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BOREHOLE LOG SHEET

BOREHOLE No: 3747-P158-BH01

SHEET: 1 of 1

DATE STARTED 11/11/11 **COMPLETED** 11/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 510921 7031064

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 0.3m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine to medium grained, brown, trace silt, shell fragments present, ALLUVIAL		
			0.5					
			1.0		SP	**SAND**, fine to medium grained, grey to dark grey, trace silt, shell fragments present, ALLUVIAL		
			1.5					
			2.0		SP	**SAND**, fine to medium grained, dark grey, ALLUVIAL		
			2.5					
			3.0			Borehole 3747-P158-BH01 terminated at 3m		
			3.5					

BOREHOLE LOG SHEET

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BOREHOLE No: 3747-P158-BH02

SHEET: 1 of 1

DATE STARTED 11/11/11 **COMPLETED** 11/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 511276 7031058

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 2.5m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5	▨	SP	**SAND**, fine to medium grained, dark grey, trace silt, shell fragments present, ALLUVIAL		
			1.0 1.5 2.0 2.5	▨	SP	**SAND**, fine to medium grained, very dark brown, trace low plasticity clay, ALLUVIAL		
			3.0 3.5			Borehole 3747-P158-BH02 terminated at 2.5m		Borehole terminated due to vibracore refusal.

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BOREHOLE No: 3747-P158-BH03

SHEET: 1 of 1

DATE STARTED 11/11/11 **COMPLETED** 11/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 511532 7031099

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 0.5m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine to medium grained, grey-brown, shell fragments present, ALLUVIAL		
			0.5					
			1.0					
			1.5					
			2.0		SP	**SAND**, fine to medium grained, grey to dark grey, trace silt, ALLUVIAL		
			2.5		SP	**SAND**, fine to medium grained, dark grey, dark brown, trace silt, ALLUVIAL		
			3.0			Borehole 3747-P158-BH03 terminated at 3m		
			3.5					

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BOREHOLE No: 3747-P158-BH04
SHEET: 1 of 1

DATE STARTED 11/11/11 **COMPLETED** 11/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 511658 7031214
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 1.7m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0	▨	SP	**SAND**, fine to medium grained, grey, trace silt, shell fragments present, ALLUVIAL		
			1.5 2.0	▨	SP	**SAND**, fine to medium grained, pale grey, shell fragments present, ALLUVIAL		
			2.5 3.0	▨	SP	**SAND**, fine to medium grained, pale grey, ALLUVIAL		
			3.5			Borehole 3747-P158-BH04 terminated at 3m		

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BOREHOLE No: 3747-P158-BH05

SHEET: 1 of 1

DATE STARTED 11/11/11 **COMPLETED** 11/11/11 **R.L. SURFACE** ____ **DATUM** ____

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 511747 7031363

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 2.1m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0 1.5 2.0	▨	SP	**SAND**, fine to medium grained, grey-brown, shell fragments present, ALLUVIAL		
			2.5	▨	SP	**SAND**, fine to medium grained, dark to very dark brown, trace silt, ALLUVIAL		
			3.0 3.5			Borehole 3747-P158-BH05 terminated at 2.7m		Borehole terminated due to vibracore refusal.

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BOREHOLE No: 3747-P158-BH06

SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 511876 7031572

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 2.3m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine to medium grained, grey-brown, trace silt, shell fragments present, ALLUVIAL		
			0.5		SP	**SAND**, fine to medium grained, pale grey, shell fragments present, ALLUVIAL		
			1.0					
			1.5					
			2.0					
			2.5					
			3.0			Borehole 3747-P158-BH06 terminated at 3m		
			3.5					

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BOREHOLE No: 3747-P158-BH07
SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** ______ **DATUM** ______
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 511980 7031850
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 1.3m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0		SP	**SAND**, fine to medium grained, pale brown to brown, ALLUVIAL		
			1.5		SP	**SAND**, fine to medium grained, grey, trace silt, shell fragments present, ALLUVIAL		
			2.0 2.5		SP	**SAND**, fine to medium grained, grey-brown, trace silt, shell fragments present, ALLUVIAL		
			3.0 3.5			Borehole 3747-P158-BH07 terminated at 2.9m		Borehole terminated due to vibracore refusal.

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BOREHOLE No: 3747-P158-BH08

SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512078 7032061

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 1.3m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5	░	SP	**SAND**, fine to medium grained, brown, trace silt, shell fragments present, ALLUVIAL		
			1.0 1.5	░	SP	**SAND**, fine to medium grained, grey, shell fragments present, ALLUVIAL		
			2.0 2.5 3.0	░	SP	**SAND**, fine to medium grained, pale grey, ALLUVIAL		
			3.5			Borehole 3747-P158-BH08 terminated at 3m		

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BOREHOLE No: 3747-P158-BH09

SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 511799 7032180

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 3.5m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5		SP	**SAND**, fine to medium grained, brown, shell fragments present, ALLUVIAL		
			1.0		SP	**SAND**, fine to medium grained, grey-brown, trace silt, shell fragments present, ALLUVIAL		
			1.5 2.0 2.5		SP	**SAND**, fine to medium grained, very dark brown, trace silt, ALLUVIAL		
			3.0 3.5			Borehole 3747-P158-BH09 terminated at 2.5m		Borehole terminated due to vibracore refusal.

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BOREHOLE No: 3747-P158-BH10

SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512170 7032267

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 2.0m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0		SP	**SAND**, fine to medium grained, pale brown to brown, shell fragments present, ALLUVIAL		
			1.5 2.0 2.5		SP	**SAND**, fine to medium grained, grey, shell fragments present, ALLUVIAL		
			3.0 3.5			Borehole 3747-P158-BH10 terminated at 2.9m		Borehole terminated due to vibracore refusal.

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BOREHOLE No: 3747-P158-BH11

SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512033 7032332

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 1.0m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5		SP	**SAND**, fine to medium grained, brown, shell fragments present, ALLUVIAL		
			1.0		SP	**SAND**, fine to medium grained, dark grey, ALLUVIAL		
			1.5 2.0		SP	**SAND**, fine to medium grained, pale grey to grey, shells present, ALLUVIAL		
			2.5 3.0		SP	**SAND**, fine to medium grained, very dark grey, with silt, ALLUVIAL		
			3.5			Borehole 3747-P158-BH11 terminated at 3m		

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BOREHOLE No: 3747-P158-BH12

SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512131 7032480

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 0.3m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5		SP	**SAND**, fine to medium grained, grey, trace silt, shell fragments present, ALLUVIAL		
			1.0		SP	**SAND**, fine to medium grained, grey, ALLUVIAL		
			1.5		SP	**SAND**, fine to medium grained, grey, ALLUVIAL		
			2.0 2.5 3.0		SP	**SAND**, fine to medium grained, pale grey, trace silt, ALLUVIAL		
			3.5			Borehole 3747-P158-BH12 terminated at 3m		

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BOREHOLE No: 3747-P158-BH13

SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512166 7032591

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 1.1m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0		SP	**SAND**, fine to medium grained, pale grey to grey, shell fragments present, ALLUVIAL		
			1.5 2.0 2.5 3.0		SP	**SAND**, fine to medium grained, pale grey, ALLUVIAL		
			3.5			Borehole 3747-P158-BH13 terminated at 3m		

BOREHOLE LOG SHEET

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BOREHOLE No: 3747-P158-BH14
SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512160 7032712
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 0.5m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				▨	SP	**SAND**, fine to medium grained, very pale grey to pale grey, ALLUVIAL		
			0.5	▨				
			1.0	▨				
			1.5	▨				
			2.0	▨				
			2.5	▨				
			3.0	▨				
						Borehole 3747-P158-BH14 terminated at 3m		
			3.5					

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BOREHOLE No: 3747-P158-BH15
SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512145 7032820
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 0.5m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5		SP	**SAND**, fine to medium grained, vey pale brown to brown, shell fragments present, ALLUVIAL		
			1.0		SP	**SAND**, fine to medium grained, pale grey to grey, trace silt, ALLUVIAL		
			1.5 2.0 2.5 3.0		SP	**SAND**, fine to medium grained, very pale grey to grey, ALLUVIAL		
			3.5			Borehole 3747-P158-BH15 terminated at 3m		

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BOREHOLE No: 3747-P158-BH16

SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512156 7032951

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 0.8m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				▨	SP	**SAND**, fine to medium grained, vey pale grey to grey, ALLUVIAL		
			0.5	▨				
			1.0	▨				
			1.5	▨				
			2.0	▨				
			2.5	▨				
			3.0	▨				
						Borehole 3747-P158-BH16 terminated at 3m		
			3.5					

BOREHOLE LOG SHEET

32 Hi-Tech Drive
Kunda Park/QLD/4556
Telephone: +61 7 54501544
Fax: +61 7 54051533

BOREHOLE No: 3747-P158-BH17
SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512153 7033050
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 0.9m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine to medium grained, pale grey, ALLUVIAL		
			0.5					
			1.0					
			1.5		SP	**SAND**, fine to medium grained, dark grey, trace silt, ALLUVIAL		
			2.0					
			2.5					
			3.0			Borehole 3747-P158-BH17 terminated at 3m		
			3.5					

BOREHOLE LOG SHEET

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Telephone: +61 7 54501544
Fax: +61 7 54051533

BOREHOLE No: 3747-P158-BH18

SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**

DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512166 7033146

HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC

NOTES Water depth 1.5m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0 1.5 2.0 2.5 3.0	▨	SP	**SAND**, fine to medium grained, very pale grey to grey, shell fragments present, ALLUVIAL		
			3.5			Borehole 3747-P158-BH18 terminated at 3m		

BOREHOLE LOG SHEET

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Telephone: +61 7 54501544
Fax: +61 7 54051533

BOREHOLE No: 3747-P158-BH19
SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512150 7033247
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 2.0m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine to medium grained, very pale grey to grey, ALLUVIAL		
			0.5					
			1.0					
			1.5					
			2.0		SP	**SAND**, fine to medium grained, dark grey, trace silt, ALLUVIAL		
			2.5					
			3.0			Borehole 3747-P158-BH19 terminated at 3m		
			3.5					

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BOREHOLE LOG SHEET

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BOREHOLE No: 3747-P158-BH20
SHEET: 1 of 1

DATE STARTED 10/11/11 **COMPLETED** 10/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 512138 7033343
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water depth 2.0m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine to medium grained, pale grey to grey, ALLUVIAL		
			0.5					
			1.0					
			1.5					
			2.0		SP	**SAND**, fine to medium grained, pale grey to grey, trace silt, ALLUVIAL		
			2.5					
						Borehole 3747-P158-BH20 terminated at 2.7m		
			3.0					
			3.5					

Annex D - Particle Size Distribution Test Results

Cardno Bowler Pty Ltd
ABN 74 128 806 735

Telephone:
(07) 5450 1544

Facsimile:
(07) 5450 1533

Address:
32 Hi-Tech Drive
Kunda Park Qld 4556

Email: cardnobowlerkp@cardno.com.au
Website: www.cardno.com.au

Cardno Bowler Offices:
Brisbane, Cairns, Townsville, Mackay, Rockhampton, Bundaberg, Sunshine Coast, Gold Coast,
Sydney, Deniliquin, Melbourne, Bendigo, Dandenong

Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

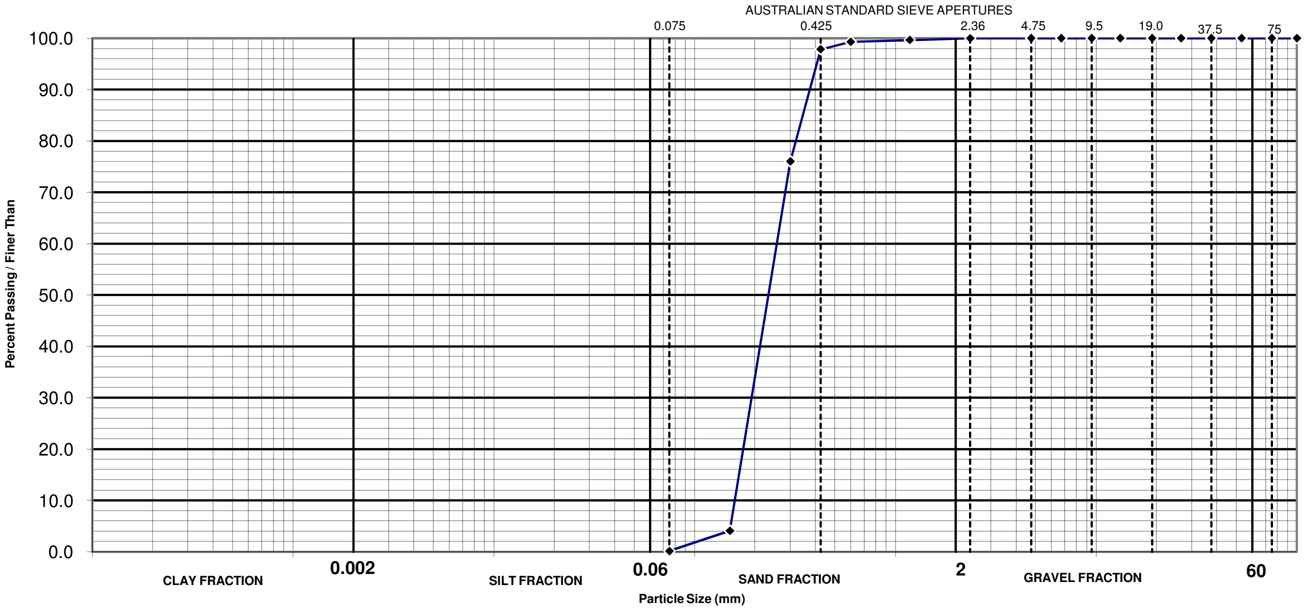
Sample Number: **3747-S-12633**
Sample Identification: **BH1: 0.0-0.5**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12633Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	98		
37.5		0.300	76		
26.5		0.150	4		
19.0		0.075	0		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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ABN 74 128 806 735

Telephone:
(07) 5450 1544

Facsimile:
(07) 5450 1533

Address:
32 Hi-Tech Drive
Kunda Park Qld 4556

Email: cardnobowlerkp@cardno.com.au
Website: www.cardno.com.au

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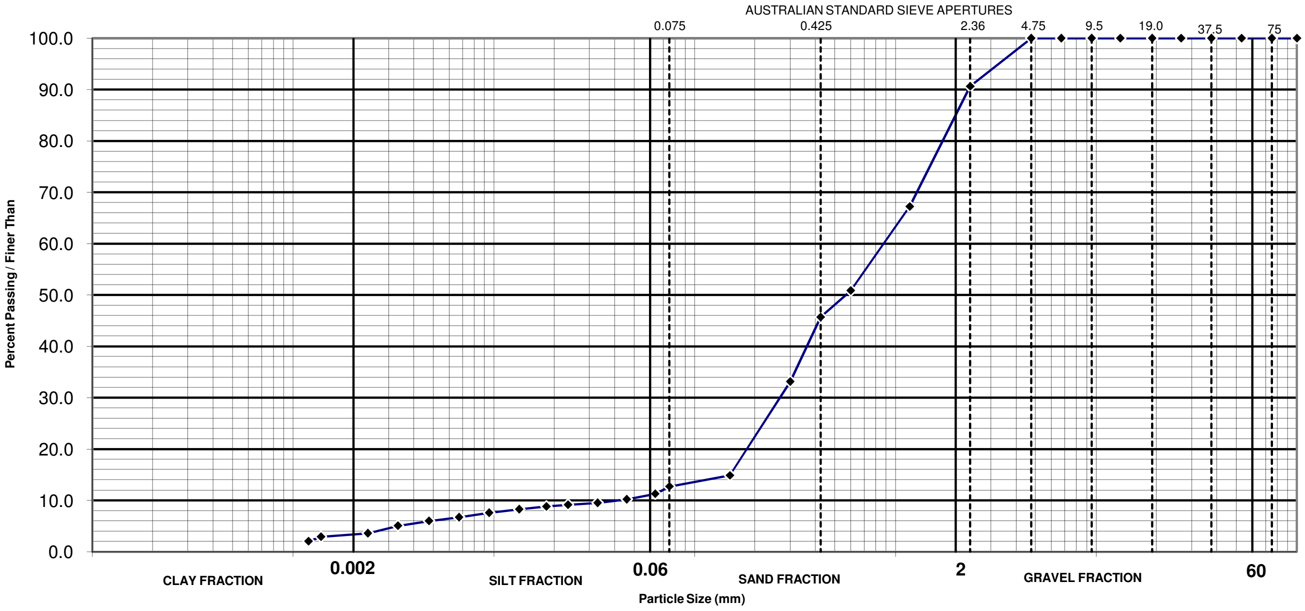
Particle Size Distribution-Hydrometer

Client:	**Sunshine Coast Council**	Report Number:	**3747-S-12642Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/158**
Project:	**Pumicestone Passage Sediment Investigation**	Report Date:	**29/11/2011**
		Test Methods:	**AS1289.3.6.3**
Sample Number:	**3747-S-12642**		**AS1289.3.6.2**
Sample Identification:	**BH2: 1.5-2.0**	Pre-treatment Loss:	**n/a**
Date Sampled:	**10/11/2011**	Dispersion Method:	**mechanical**
		Hydrometer Type:	**grams/Litre**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	67	0.0134	8
75		0.600	51	0.0095	8
53		0.425	46	0.0067	7
37.5		0.300	33	0.0048	6
26.5		0.150	15	0.0033	5
19.0		0.075	13	0.0024	4
13.2		0.064	11	0.0014	3
9.5		0.046	10		
6.7		0.033	9		
4.75	100	0.023	9		
2.36	91	0.018	9		

PARTICLE SIZE DISTRIBUTION - HYDROMETER



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Cardno Bowler Pty Ltd
ABN 74 128 806 735

Telephone:
(07) 5450 1544

Facsimile:
(07) 5450 1533

Address:
32 Hi-Tech Drive
Kunda Park Qld 4556

Email: cardnobowlerkp@cardno.com.au
Website: www.cardno.com.au

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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

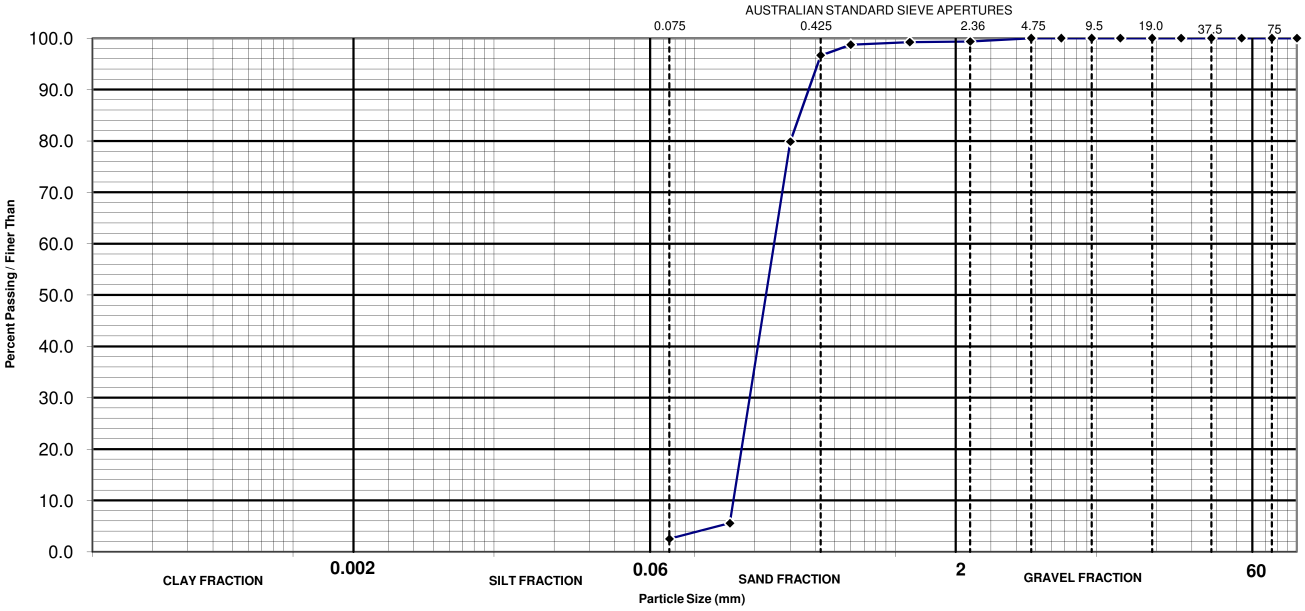
Sample Number: **3747-S-12645**
Sample Identification: **BH3: 0.0-0.5**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12645Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing
100	
75	
53	
37.5	
26.5	
19.0	
13.2	
9.5	
6.7	
4.75	100
2.36	99
1.180	99
0.600	99
0.425	97
0.300	80
0.150	6
0.075	2

PARTICLE SIZE DISTRIBUTION



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Cardno Bowler Pty Ltd
ABN 74 128 806 735

Telephone:
(07) 5450 1544

Facsimile:
(07) 5450 1533

Address:
32 Hi-Tech Drive
Kunda Park Qld 4556

Email: cardnobowlerkp@cardno.com.au
Website: www.cardno.com.au

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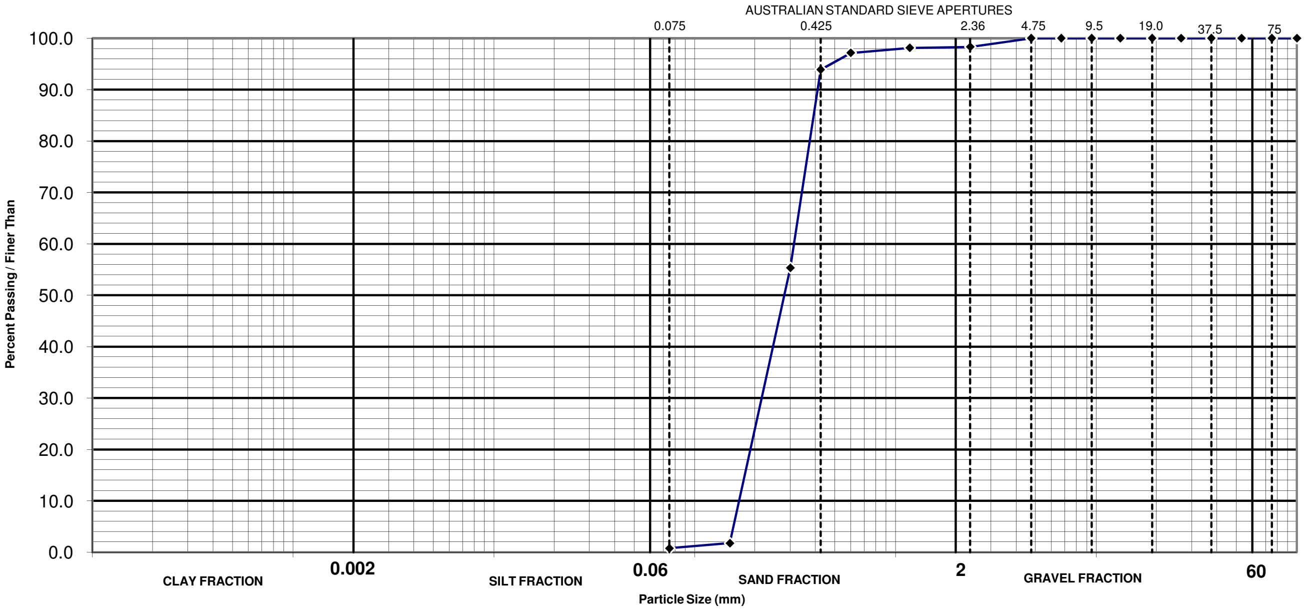
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747-S-12655Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/158**
Project:	**Pumicestone Passage Sediment Investigation**	Report Date:	**29/11/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747-S-12655**		
Sample Identification:	**BH4: 2.0-2.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**10/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	98		
75		0.600	97		
53		0.425	94		
37.5		0.300	55		
26.5		0.150	2		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	98				

PARTICLE SIZE DISTRIBUTION



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ABN 74 128 806 735

Telephone:
(07) 5450 1544

Facsimile:
(07) 5450 1533

Address:
32 Hi-Tech Drive
Kunda Park Qld 4556

Email: cardnobowlerkp@cardno.com.au
Website: www.cardno.com.au

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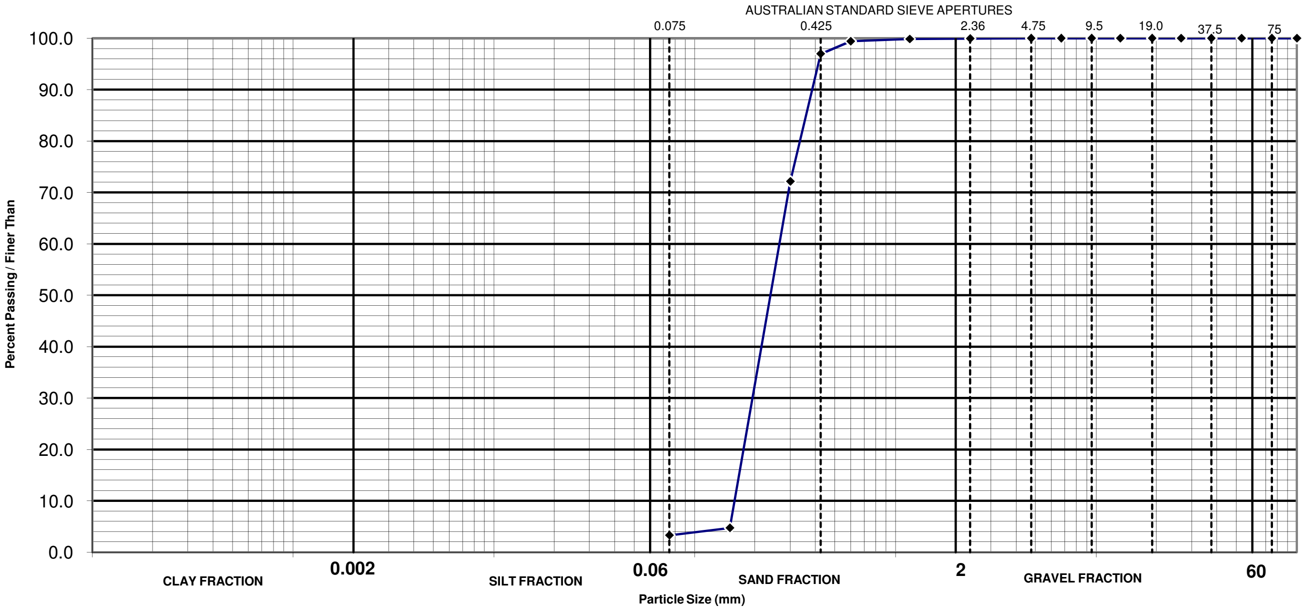
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747-S-12657Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/158**
Project:	**Pumicestone Passage Sediment Investigation**	Report Date:	**29/11/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747-S-12657**		
Sample Identification:	**BH5: 0.0-0.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**10/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	97		
37.5		0.300	72		
26.5		0.150	5		
19.0		0.075	3		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION - HYDROMETER



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Cardno Bowler Pty Ltd
ABN 74 128 806 735

Telephone:
(07) 5450 1544

Facsimile:
(07) 5450 1533

Address:
32 Hi-Tech Drive
Kunda Park Qld 4556

Email: cardnobowlerkp@cardno.com.au
Website: www.cardno.com.au

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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

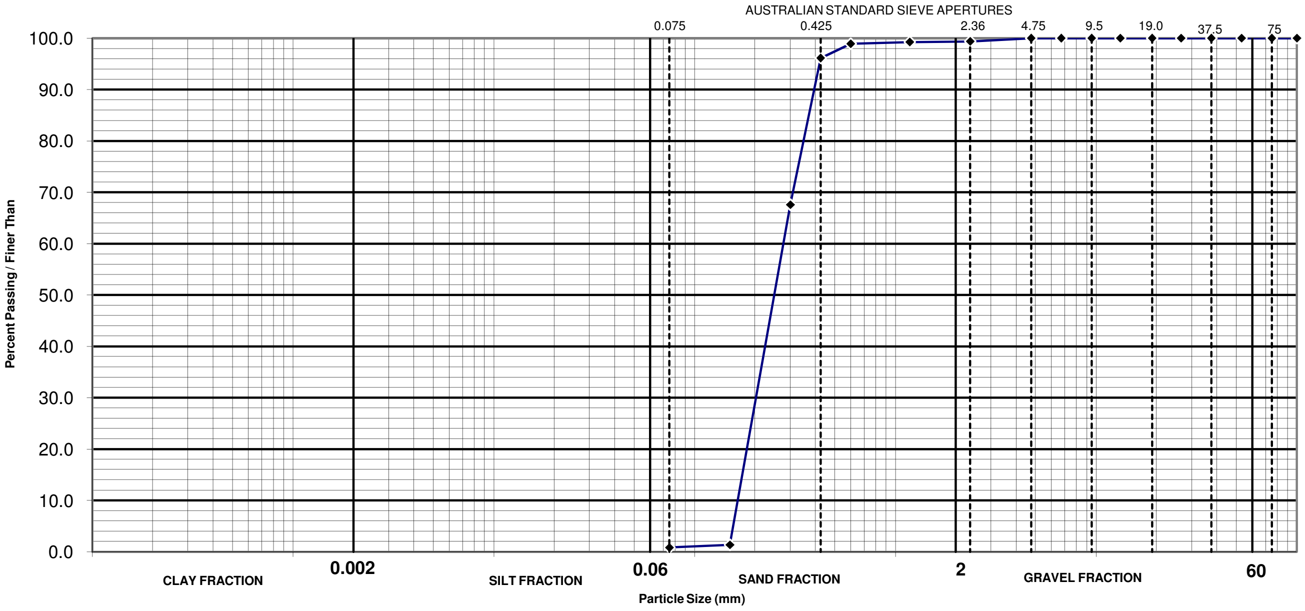
Sample Number: **3747-S-12668**
Sample Identification: **BH6: 2.5-3.0**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12668Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	99		
75		0.600	99		
53		0.425	96		
37.5		0.300	68		
26.5		0.150	1		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	99				

PARTICLE SIZE DISTRIBUTION



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ABN 74 128 806 735

Telephone:
(07) 5450 1544

Facsimile:
(07) 5450 1533

Address:
32 Hi-Tech Drive
Kunda Park Qld 4556

Email: cardnobowlerkp@cardno.com.au
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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

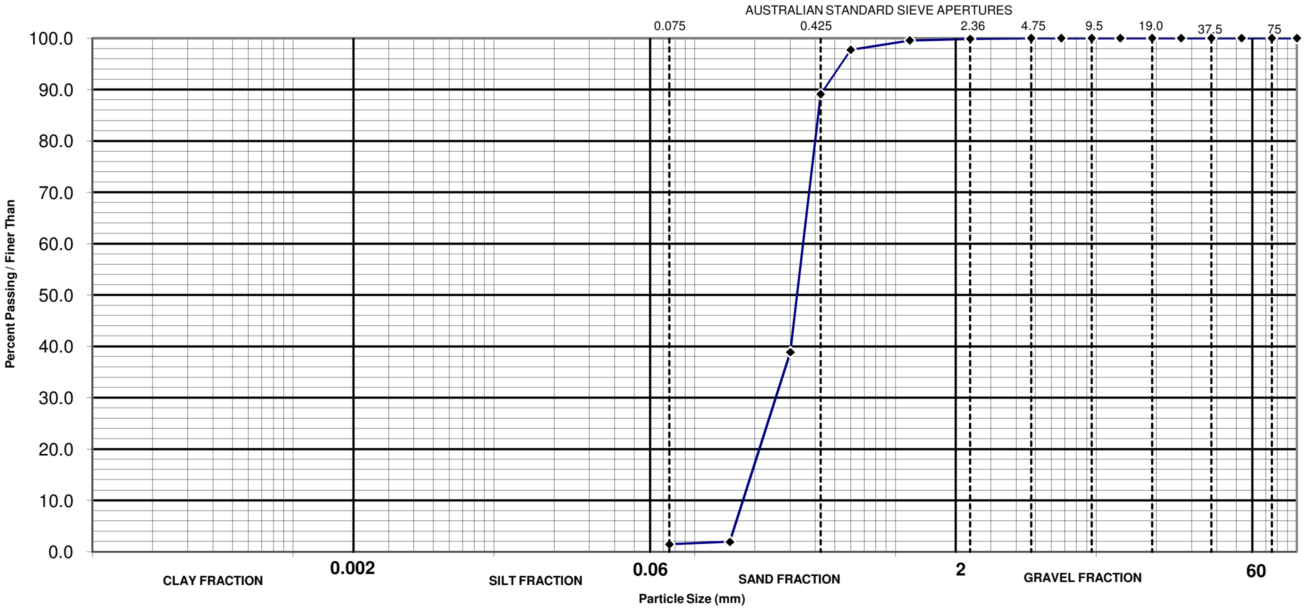
Sample Number: **3747-S-12670**
Sample Identification: **BH7: 0.5-1.0**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12670Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	98		
53		0.425	89		
37.5		0.300	39		
26.5		0.150	2		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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ABN 74 128 806 735

Telephone:
(07) 5450 1544

Facsimile:
(07) 5450 1533

Address:
32 Hi-Tech Drive
Kunda Park Qld 4556

Email: cardnobowlerkp@cardno.com.au
Website: www.cardno.com.au

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Shaping the Future

Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

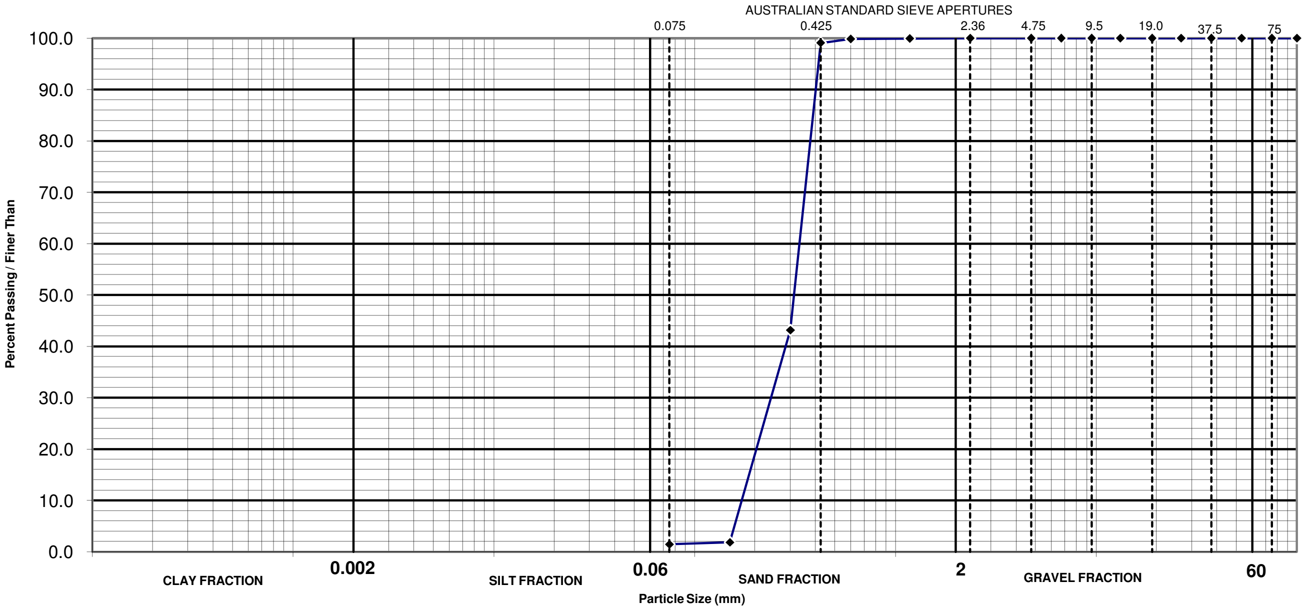
Sample Number: **3747-S-12679**
Sample Identification: **BH8: 2.0-2.5**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12679Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	100		
53		0.425	99		
37.5		0.300	43		
26.5		0.150	2		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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ABN 74 128 806 735

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(07) 5450 1544

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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

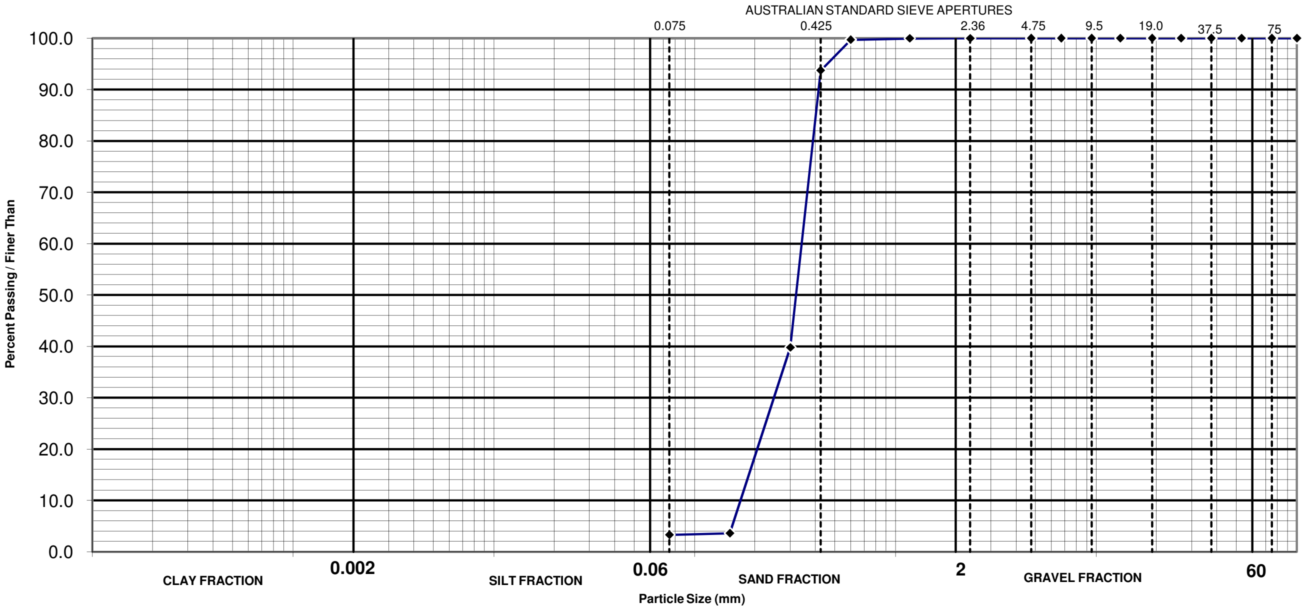
Sample Number: **3747-S-12683**
Sample Identification: **BH9: 1.0-1.5**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12683Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	100		
53		0.425	94		
37.5		0.300	40		
26.5		0.150	4		
19.0		0.075	3		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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ABN 74 128 806 735

Telephone:
(07) 5450 1544

Facsimile:
(07) 5450 1533

Address:
32 Hi-Tech Drive
Kunda Park Qld 4556

Email: cardnobowlerkp@cardno.com.au
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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

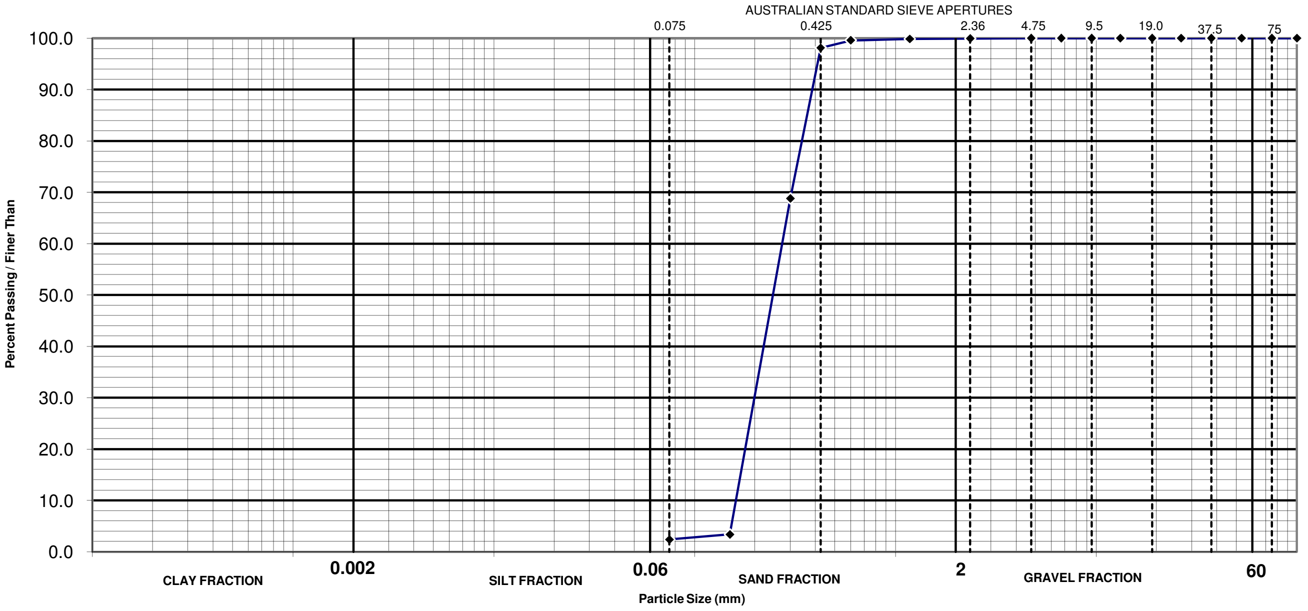
Sample Number: **3747-S-12688**
Sample Identification: **BH10: 0.5-1.0**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12688Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	100		
53		0.425	98		
37.5		0.300	69		
26.5		0.150	3		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Cardno Bowler Pty Ltd
ABN 74 128 806 735

Telephone:
(07) 5450 1544

Facsimile:
(07) 5450 1533

Address:
32 Hi-Tech Drive
Kunda Park Qld 4556

Email: cardnobowlerkp@cardno.com.au
Website: www.cardno.com.au

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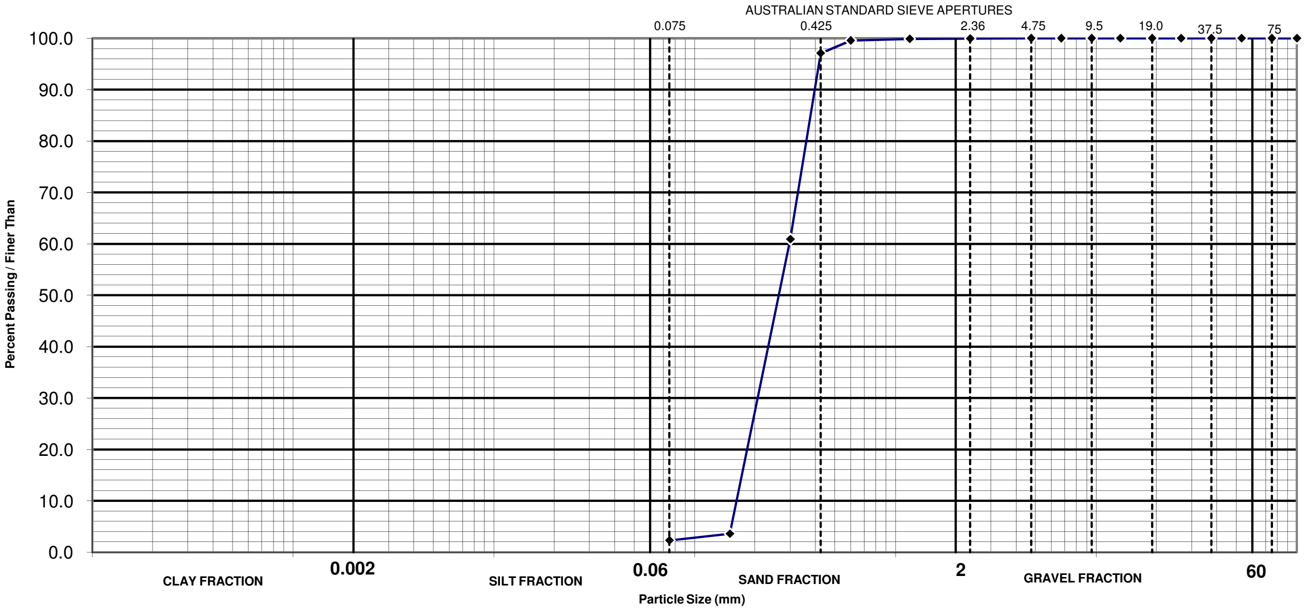
Brisbane, Cairns, Townsville, Mackay, Rockhampton, Bundaberg, Sunshine Coast, Gold Coast, Sydney, Deniliquin, Melbourne, Bendigo, Dandenong

Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747-S-12693Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/158**
Project:	**Pumicestone Passage Sediment Investigation**	Report Date:	**29/11/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747-S-12693**		
Sample Identification:	**BH11: 0.0-0.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**10/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	100		
53		0.425	97		
37.5		0.300	61		
26.5		0.150	4		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Facsimile:
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Kunda Park Qld 4556

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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

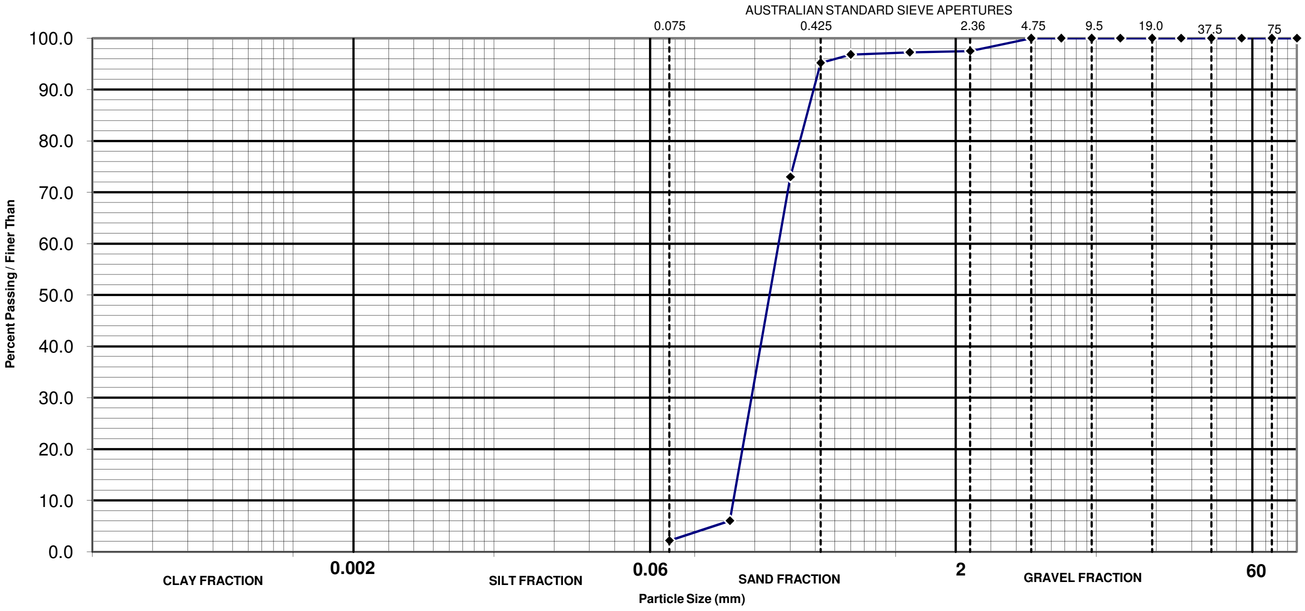
Sample Number: **3747-S-12700**
Sample Identification: **BH12: 0.5-1.0**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12700Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	97		
75		0.600	97		
53		0.425	95		
37.5		0.300	73		
26.5		0.150	6		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
2.36	97				

PARTICLE SIZE DISTRIBUTION



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Cardno Bowler Pty Ltd
ABN 74 128 806 735

Telephone:
(07) 5450 1544

Facsimile:
(07) 5450 1533

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Kunda Park Qld 4556

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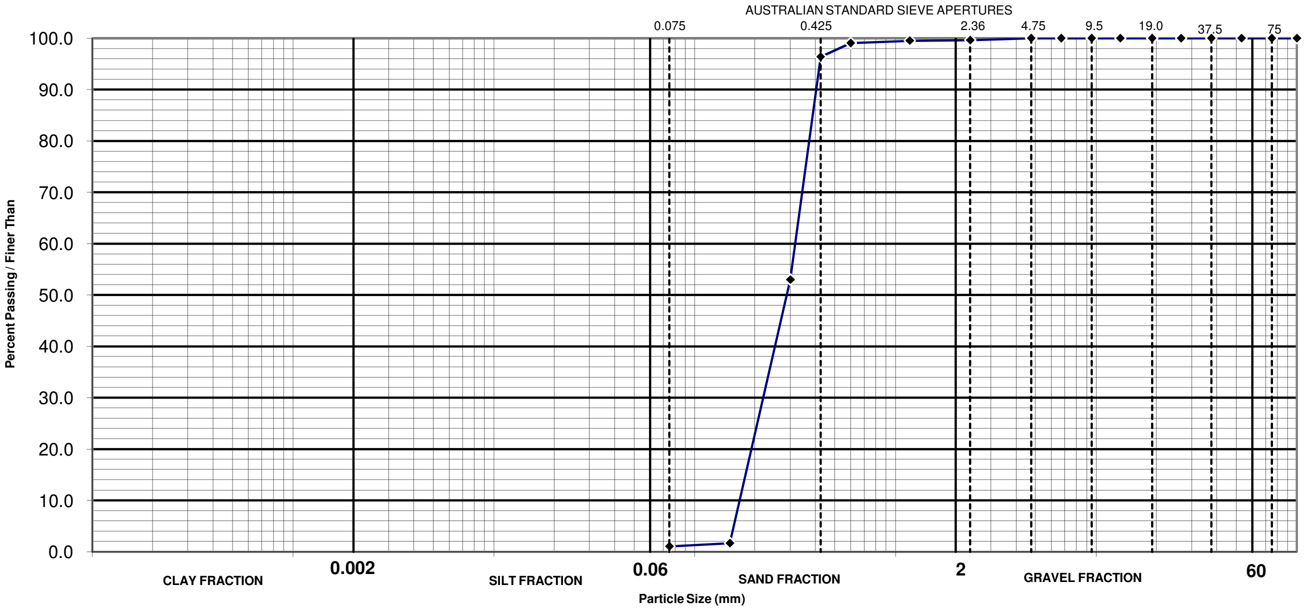
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747-S-12707Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/158**
Project:	**Pumicestone Passage Sediment Investigation**	Report Date:	**29/11/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747-S-12707**		
Sample Identification:	**BH13: 1.0-1.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**10/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	96		
37.5		0.300	53		
26.5		0.150	2		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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ABN 74 128 806 735

Telephone:
(07) 5450 1544

Facsimile:
(07) 5450 1533

Address:
32 Hi-Tech Drive
Kunda Park Qld 4556

Email: cardnobowlerkp@cardno.com.au
Website: www.cardno.com.au

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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

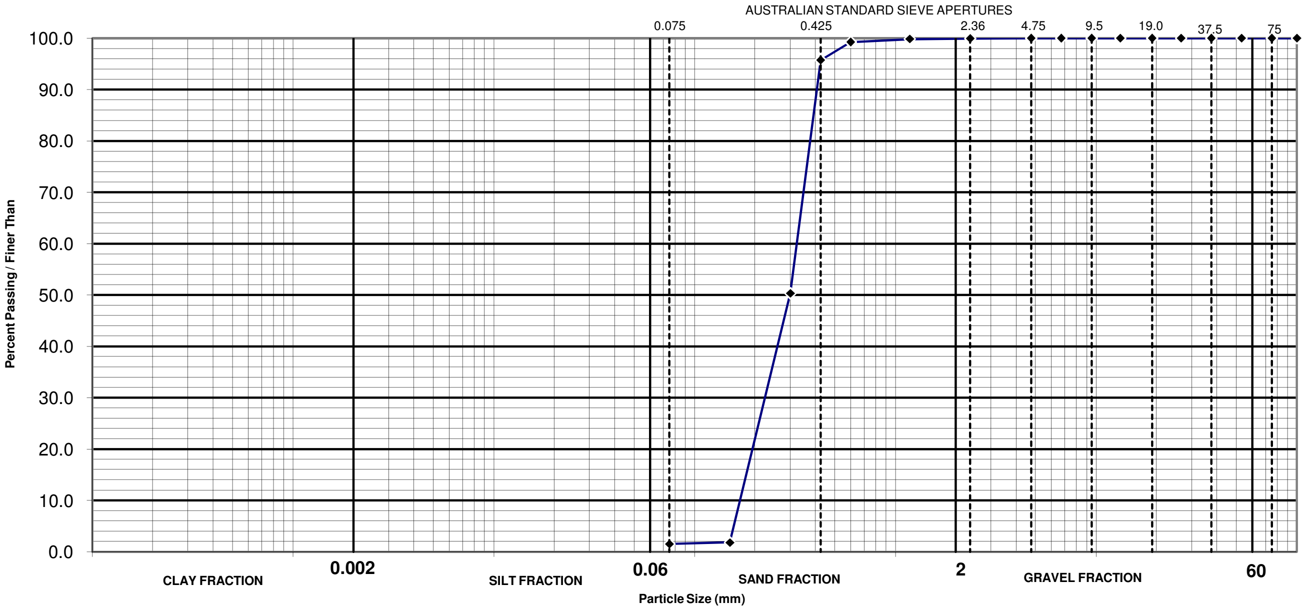
Sample Number: **3747-S-12714**
Sample Identification: **BH14: 1.5-2.0**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12714Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	96		
37.5		0.300	50		
26.5		0.150	2		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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ABN 74 128 806 735

Telephone:
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Facsimile:
(07) 5450 1533

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Kunda Park Qld 4556

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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

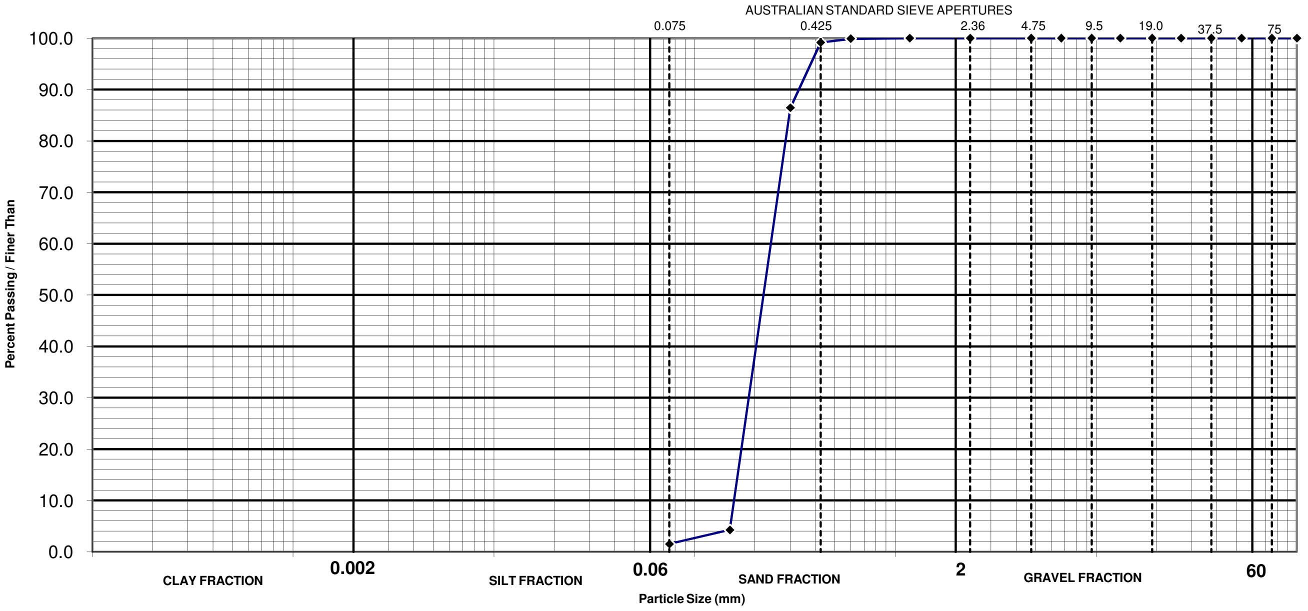
Sample Number: **3747-S-12721**
Sample Identification: **BH15: 2.0-2.5**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12721Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	100		
53		0.425	99		
37.5		0.300	86		
26.5		0.150	4		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75					
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

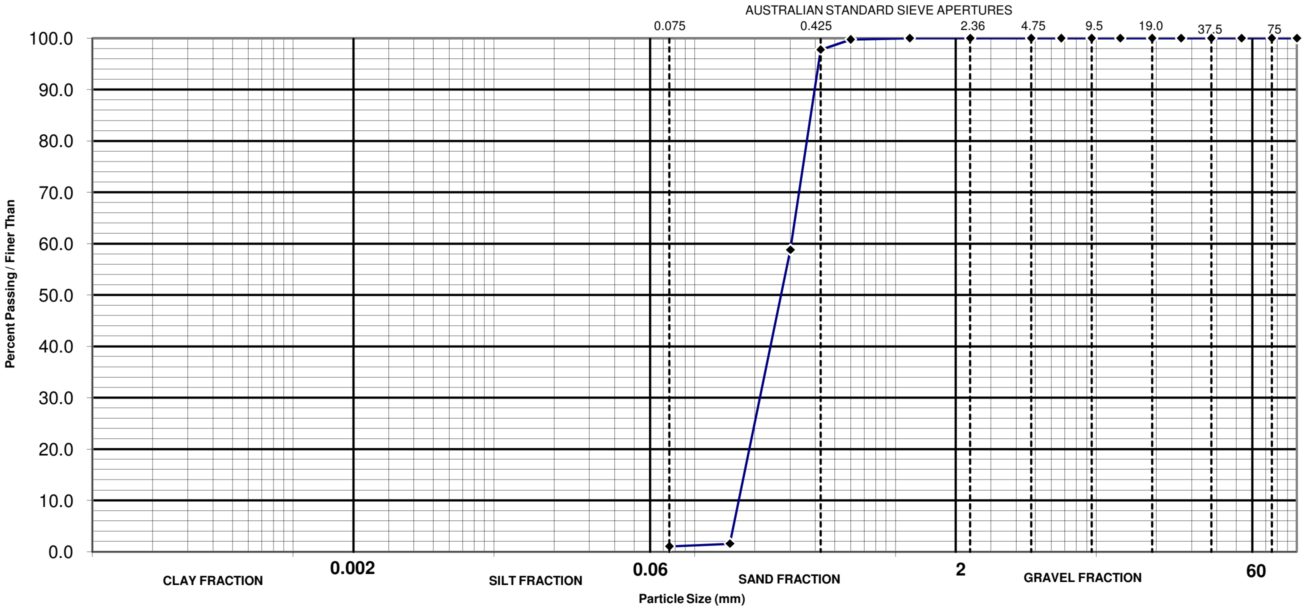
Sample Number: **3747-S-12728**
Sample Identification: **BH16: 2.5-3.0**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12728Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	100		
53		0.425	98		
37.5		0.300	59		
26.5		0.150	2		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75					
2.36	100				

PARTICLE SIZE DISTRIBUTION



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SIGNATORY: Paul Mayes

Cardno Bowler Pty Ltd
ABN 74 128 806 735

Telephone:
(07) 5450 1544

Facsimile:
(07) 5450 1533

Address:
32 Hi-Tech Drive
Kunda Park Qld 4556

Email: cardnobowlerkp@cardno.com.au
Website: www.cardno.com.au

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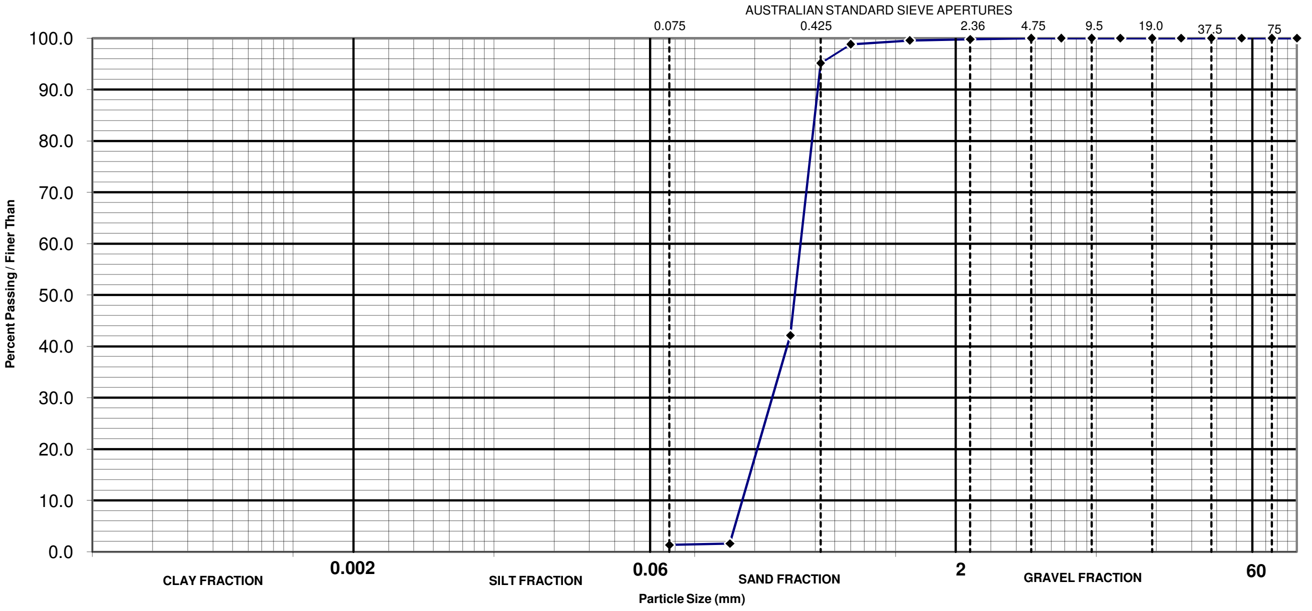
Brisbane, Cairns, Townsville, Mackay, Rockhampton, Bundaberg, Sunshine Coast, Gold Coast, Sydney, Deniliquin, Melbourne, Bendigo, Dandenong

Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747-S-12730Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/158**
Project:	**Pumicestone Passage Sediment Investigation**	Report Date:	**29/11/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747-S-12730**		
Sample Identification:	**BH17: 0.5-1.0**	Pre-treatment Loss:	**n/a**
Date Sampled:	**10/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	95		
37.5		0.300	42		
26.5		0.150	2		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Cardno Bowler Pty Ltd
ABN 74 128 806 735

Telephone:
(07) 5450 1544

Facsimile:
(07) 5450 1533

Address:
32 Hi-Tech Drive
Kunda Park Qld 4556

Email: cardnobowlerkp@cardno.com.au
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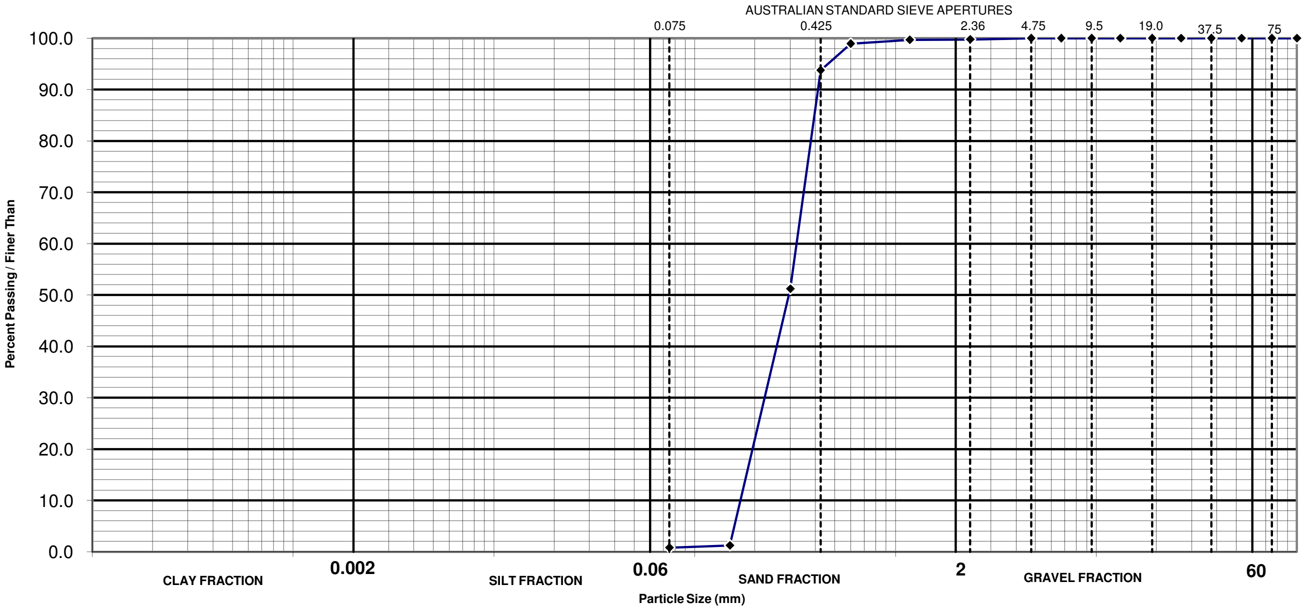
Brisbane, Cairns, Townsville, Mackay, Rockhampton, Bundaberg, Sunshine Coast, Gold Coast, Sydney, Deniliquin, Melbourne, Bendigo, Dandenong

Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747-S-12735Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/158**
Project:	**Pumicestone Passage Sediment Investigation**	Report Date:	**29/11/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747-S-12735**		
Sample Identification:	**BH18: 0.0-0.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**10/11/2011**	Dispersion Method:	**n/a**
		Hydrometer Type:	**n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	100		
75		0.600	99		
53		0.425	94		
37.5		0.300	51		
26.5		0.150	1		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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ABN 74 128 806 735

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Facsimile:
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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

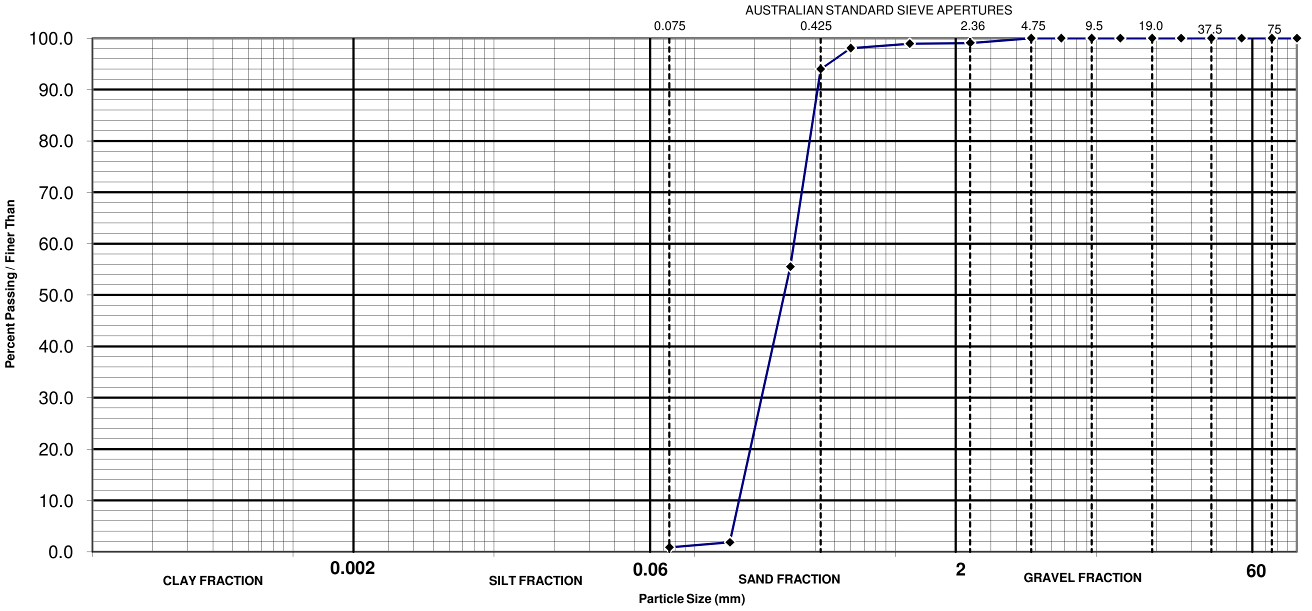
Sample Number: **3747-S-12743**
Sample Identification: **BH19: 1.0-1.5**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12743Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	99		
75		0.600	98		
53		0.425	94		
37.5		0.300	55		
26.5		0.150	2		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	99				

PARTICLE SIZE DISTRIBUTION



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Facsimile:
(07) 5450 1533

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Particle Size Distribution

Client: **Sunshine Coast Council**
Clients Address: **Locked Bag 72, SCMC 4560**
Project: **Pumicestone Passage Sediment Investigation**

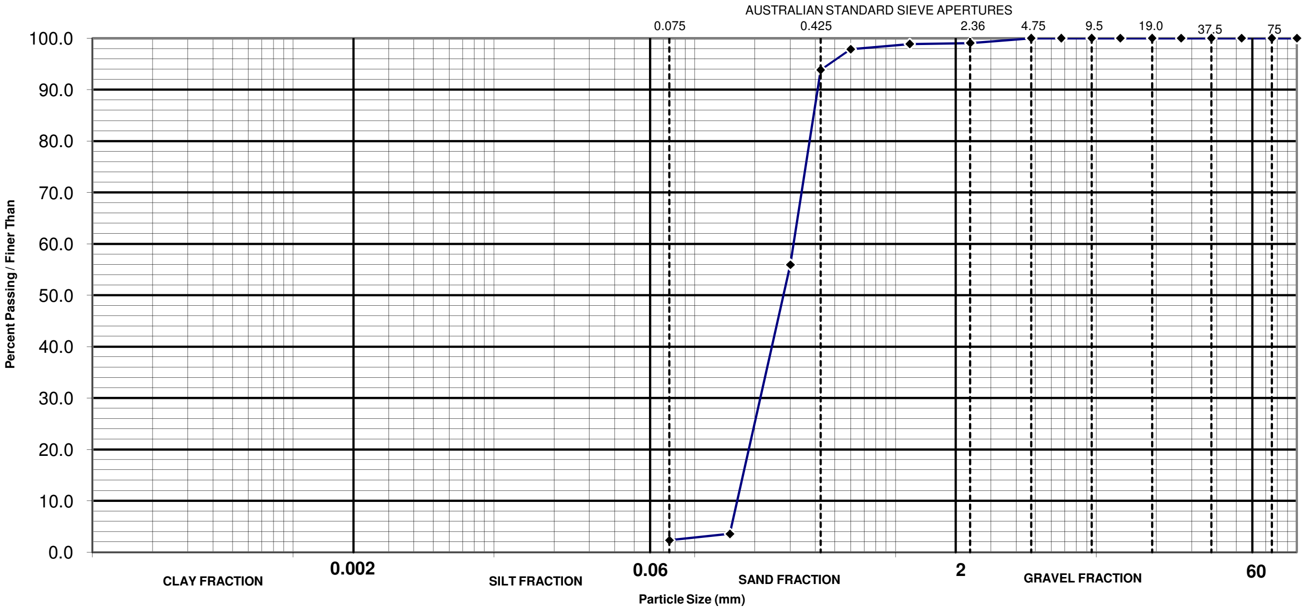
Sample Number: **3747-S-12748**
Sample Identification: **BH20: 0.5-1.0**
Date Sampled: **10/11/2011**

Report Number: **3747-S-12748Hyd**
Job Number: **3747/P/158**
Report Date: **29/11/2011**
Test Methods: **AS1289.3.6.1**

Pre-treatment Loss: **n/a**
Dispersion Method: **n/a**
Hydrometer Type: **n/a**

Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing	Particle Size (mm)	Cummulative Percent Passing
100		1.180	99		
75		0.600	98		
53		0.425	94		
37.5		0.300	56		
26.5		0.150	4		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
2.36	99				

PARTICLE SIZE DISTRIBUTION



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Annex E – Acid Sulfate Soils Test Results

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Cardno Bowler Pty Ltd
ABN 74 128 806 735

Telephone:
(07) 5450 1544

Facsimile:
(07) 5450 1533

Address:
32 Hi-Tech Drive
Kunda Park Qld 4556

Email: cardnobowlerkp@cardno.com.au
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CHROMIUM SUITE TEST REPORT

Report Number: 3747/S/12633CRS
Client: Sunshine Coast Council
Client Address: Locked Bag 72, Sunshine Coast Mail Centre
Project: Pumicestone Passage Sediment Investigation
Job no. 3747/P/1
Sampled by: Cardno Bowler (Sunshine Coast)
Date Sampled: 10/11/2011
Date Received: 10/11/2011
Date Tested: 2/12/2011
Date Reported: 5/12/2011
Methods: AS 4969.0, .1, .2, .4, .7, .8, .11, .13, .14

Laboratory Number	Sample Location	pH_{KCl}	TAA	TAA	S_{KCl}	S_{Cr}	S_{NAS}	ANC_{BT}	Net Acidity	Net Acidity	Recommended Liming Rate
	units:	-	(H^+mol/t)	(% S)	(% S) [a]	(% S)	(% S)	(%$CaCO_3$) [#]	(H^+mol/t)	(% S)	(kg of lime per cubic metre)
	LOR:	0.1	1	0.001	0.007	0.02	0.001	0.01	1	0.001	0.1
3747/S/12633	Borehole 1 0.0-0.5	6.6	0	0.000	0.011	<0.02	nr	0.55	-228	-0.366	No Liming Required
3747/S/12636	Borehole 1 1.5-2.0	6.7	0	0.000	0.023	0.112	nr	0.49	-134	-0.215	No Liming Required
3747/S/12639	Borehole 2 0.0-0.5	7.4	0	0.000	0.055	0.341	nr	0.59	-34	-0.054	No Liming Required
3747/S/12642	Borehole 2 1.5-2.0	6.8	0	0.000	0.023	0.518	nr	0.63	60	0.096	8.5
3747/S/12645	Borehole 3 0.0-0.5	9.1	0	0.000	<0.007	0.051	nr	0.39	-131	-0.209	No Liming Required
3747/S/12649	Borehole 3 2.0-2.5	5.2	17	0.027	0.066	0.549	nr	nr	359	0.575	50.9
3747/S/12653	Borehole 4 1.0-1.5	9.3	0	0.000	<0.007	0.038	nr	0.53	-195	-0.313	No Liming Required
3747/S/12655	Borehole 4 2.0-2.5	8.1	0	0.000	<0.007	<0.02	nr	0.34	-143	-0.229	No Liming Required
3747/S/12657	Borehole 5 0.0-0.5	8.6	0	0.000	0.010	0.044	nr	0.46	-163	-0.261	No Liming Required
3747/S/12661	Borehole 5 2.0-2.5	7.7	0	0.000	<0.007	0.117	nr	0.47	-120	-0.193	No Liming Required
3747/S/12665	Borehole 6 1.0-1.5	9.3	0	0.000	<0.007	0.033	nr	0.58	-221	-0.355	No Liming Required
3747/S/12668	Borehole 6 2.5-3.0	9.1	0	0.000	<0.007	<0.02	nr	0.46	-190	-0.304	No Liming Required
3747/S/12670	Borehole 7 0.5-1.0	9.3	0	0.000	<0.007	<0.02	nr	0.50	-206	-0.330	No Liming Required
3747/S/12673	Borehole 7 2.0-2.5	8.6	0	0.000	<0.007	0.566	nr	0.84	5	0.008	No Liming Required
3747/S/12676	Borehole 8 0.5-1.0	9.1	0	0.000	0.044	0.130	nr	0.56	-153	-0.246	No Liming Required
3747/S/12679	Borehole 8 2.0-2.5	8.2	0	0.000	0.018	0.030	nr	0.43	-161	-0.258	No Liming Required
3747/S/12681	Borehole 9 0.0-0.5	8.5	0	0.000	0.013	<0.02	nr	0.46	-193	-0.310	No Liming Required
3747/S/12683	Borehole 9 1.0-1.5	7.6	0	0.000	<0.007	<0.02	nr	0.30	-127	-0.203	No Liming Required
Blank		5.5	0.5	0.001							

Notes:
nr: not required, pH trigger not met.
LOR: Limit of Reporting
[#] if pH_{KCl} <6.5 it must be assumed that effective ANC is zero.
[a] S_{KCl} determined as sulfate by turbidimetric method.
Where liming is specified, lime should be fine grained agricultural lime of at least 90% purity.
Any liming rate provided is a recommended rate only, and is based on the total of TAA Equivalent % Oxidisable Sulphur plus Potential Acidity (S_{Cr}) plus Retained Acidity (S_{NAS}) minus effective ANC; with a factor of safety of 1.5.
Any recommended liming rate is based on the 0.03%S action criteria.
A placed dry density of 1.7 tonnes/cubic metre has been used in calculating liming rate/s.
The recommended liming rate is derived from a mathematical equation and will need to be field validated.
Cardno Bowler Pty Ltd accepts no responsibility for any loss associated with use of the calculated liming rate/s.

Cardno Bowler Pty Ltd
ABN 74 128 806 735

Telephone:
(07) 5450 1544

Facsimile:
(07) 5450 1533

Address:
32 Hi-Tech Drive
Kunda Park Qld 4556

Email: cardnobowlerkp@cardno.com.au
Website: www.cardno.com.au

Cardno Bowler Offices:
Brisbane, Cairns, Townsville, Mackay, Rockhampton, Bundaberg, Sunshine Coast, Gold Coast,
Sydney, Deniliquin, Melbourne, Bendigo, Dandenong

CHROMIUM SUITE TEST REPORT

Report Number: 3747/S/12688CRS
Client: Sunshine Coast Council
Client Address: Locked Bag 72, Sunshine Coast Mail Centre
Project: Pumicestone Passage Sediment Investigation
Job no. 3747/P/158
Sampled by: Cardno Bowler (Sunshine Coast)
Methods: AS 4969.0, .1, .2, .4, .7, .8, .11, .13, .14

Date Sampled: 10/11/2011
Date Received: 10/11/2011
Date Tested: 5/12/2011
Date Reported: 5/12/2011

Laboratory Number	Sample Location	pH_{KCl}	TAA	TAA	S_{KCl}	S_{Cr}	S_{NAS}	ANC_{BT}	Net Acidity	Net Acidity	Recommended Liming Rate
	units:	-	(H^+mol/t)	(% S)	(% S) [a]	(% S)	(% S)	(%$CaCO_3$) [#]	(H^+mol/t)	(% S)	(kg of lime per cubic metre)
	LOR:	0.1	1	0.001	0.007	0.02	0.001	0.01	1	0.001	0.1
3747/S/12688	Borehole 10 0.5-1.0	9.0	0	0.000	<0.007	0.050	nr	0.53	-190	-0.304	No Liming Required
3747/S/12692	Borehole 10 2.5-3.0	9.3	0	0.000	<0.007	0.036	nr	0.98	-385	-0.618	No Liming Required
3747/S/12693	Borehole 11 0.0-0.5	8.7	0	0.000	<0.007	0.044	nr	0.59	-218	-0.350	No Liming Required
3747/S/12696	Borehole 11 1.5-2.0	9.3	0	0.000	<0.007	0.094	nr	1.06	-382	-0.612	No Liming Required
3747/S/12700	Borehole 12 0.5-1.0	9.0	0	0.000	0.016	0.158	nr	0.59	-145	-0.233	No Liming Required
3747/S/12704	Borehole 12 2.5-3.0	8.3	0	0.000	<0.007	0.023	nr	0.50	-193	-0.310	No Liming Required
3747/S/12707	Borehole 13 1.0-1.5	9.3	0	0.000	<0.007	0.029	nr	0.54	-205	-0.329	No Liming Required
3747/S/12710	Borehole 13 2.5-3.0	9.3	0	0.000	<0.007	0.029	nr	0.53	-201	-0.322	No Liming Required
3747/S/12711	Borehole 14 0.0-0.5	7.7	0	0.000	<0.007	<0.02	nr	0.48	-199	-0.319	No Liming Required
3747/S/12714	Borehole 14 1.5-2.0	8.9	0	0.000	<0.007	<0.02	nr	0.52	-217	-0.348	No Liming Required
3747/S/12717	Borehole 15 0.0-0.5	7.8	0	0.000	<0.007	<0.02	nr	0.43	-179	-0.287	No Liming Required
3747/S/12721	Borehole 15 2.0-2.5	7.0	0	0.000	<0.007	0.025	nr	0.27	-97	-0.155	No Liming Required
3747/S/12724	Borehole 16 0.5-1.0	7.1	0	0.000	<0.007	0.024	nr	0.46	-176	-0.283	No Liming Required
3747/S/12728	Borehole 16 2.5-3.0	6.7	0	0.000	<0.007	<0.02	nr	0.31	-128	-0.205	No Liming Required
3747/S/12730	Borehole 17 0.5-1.0	9.2	0	0.000	<0.007	0.021	nr	0.43	-164	-0.263	No Liming Required
3747/S/12734	Borehole 17 2.5-3.0	8.4	0	0.000	0.019	0.849	nr	0.94	138	0.221	19.6
3747/S/12735	Borehole 18 0.0-0.5	8.7	0	0.000	<0.007	<0.02	nr	0.45	-189	-0.302	No Liming Required
3747/S/12739	Borehole 18 2.0-2.5	7.3	0	0.000	<0.007	0.051	nr	0.49	-173	-0.278	No Liming Required
Blank		5.3	3.9	0.006							

Notes:
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Cardno Bowler
Shaping the Future

Cardno Bowler Pty Ltd
ABN 74 128 806 735

Telephone:
(07) 5450 1544

Facsimile:
(07) 5450 1533

Address:
32 Hi-Tech Drive
Kunda Park Qld 4556

Email: cardnobowlerkp@cardno.com.au
Website: www.cardno.com.au

Cardno Bowler Offices:
Brisbane, Cairns, Townsville, Mackay, Rockhampton, Bundaberg, Sunshine Coast, Gold Coast,
Sydney, Deniliquin, Melbourne, Bendigo, Dandenong

CHROMIUM SUITE TEST REPORT

Report Number: 3747/S/12743CRS
Client: Sunshine Coast Council
Client Address: Locked Bag 72, Sunshine Coast Mail Centre
Project: Pumicestone Passage Sediment Investigation
Job no. 3747/P/158
Sampled by: Cardno Bowler (Sunshine Coast)
Methods: AS 4969.0, .1, .2, .4, .7, .8, .11, .13, .14

Date Sampled: 10/11/2011
Date Received: 10/11/2011
Date Tested: 5/12/2011
Date Reported: 5/12/2011

Laboratory Number	Sample Location	pH_{KCl}	TAA	TAA	S_{KCl}	S_{Cr}	S_{NAS}	ANC_{BT}	Net Acidity	Net Acidity	Recommended Liming Rate
	units:	-	(H$^+$mol/t)	(% S)	(% S) [a]	(% S)	(% S)	(%$CaCO_3$) [#]	(H$^+$mol/t)	(% S)	(kg of lime per cubic metre)
	LOR:	0.1	1	0.001	0.007	0.02	0.001	0.01	1	0.001	0.1
3747/S/12743	BH19 1.0-1.5	9.3	0	0.000	<0.007	0.044	nr	0.52	-187	-0.300	No Liming Required
3747/S/12744	BH19 1.5-2.0	7.0	0	0.000	0.017	0.069	nr	0.40	-125	-0.201	No Liming Required
3747/S/12748	BH20 0.5-1.0	6.9	0	0.000	<0.007	0.084	nr	0.40	-113	-0.181	No Liming Required
3747/S/12752	BH20 2.5-3.0	7.1	0	0.000	<0.007	0.062	nr	0.49	-167	-0.268	No Liming Required
Blank		6.4	0.0	0.000							

Notes:
nr: not required, pH trigger not met.
LOR: Limit of Reporting
[#] if pH_{KCl} <6.5 it must be assumed that effective ANC is zero.
[a] S_{KCl} determined as sulfate by turbidimetric method.
Where liming is specified, lime should be fine grained agricultural lime of at least 90% purity.
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Annex F – Metal and Organic Tin Test Results

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1125708**	Page	: 1 of 4
Client	: **CARDNO BOWLER- SUNSHINE COAST**	Laboratory	: Environmental Division Brisbane
Contact	: MR PAUL MAYES	Contact	: Customer Services
Address	: 32 HI-TECH DRIVE KUNDA PARK QLD, AUSTRALIA 4556	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: paul.mayes@cardno.com.au	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 54501544	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 54501533	Facsimile	: +61 7 3243 7218
Project	: ----	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 01-DEC-2011
Sampler	: Paul Mayes	Issue Date	: 13-DEC-2011
Site	: ----		
		No. of samples received	: 3
Quote number	: EN/024/10	No. of samples analysed	: 3

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Matheson	Senior Organic Instrument Chemist	Brisbane Inorganics
Matt Frost	Senior Organic Chemist	Brisbane Inorganics
Matt Frost	Senior Organic Chemist	Brisbane Organics
Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EG005T (Total Metals) - Sample EB1125623-072 shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.**
- **Organotins: Sample Location 2 shows poor matrix spike recovery due to matrix interference. Confirmed by re-extraction and re-analysis.**

Analytical Results

Sub-Matrix: **SEDIMENT**				*Client sample ID*	**Location 1**	**Location 2**	**Location 3**	----	----
				Client sampling date / time	29-NOV-2011 14:30	29-NOV-2011 15:00	29-NOV-2011 15:30	----	----
Compound	*CAS Number*	*LOR*	*Unit*		**EB1125708-001**	**EB1125708-002**	**EB1125708-003**	**----**	**----**
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1.0	%		**17.0**	**68.8**	**23.4**	----	----
EG005T: Total Metals by ICP-AES									
Arsenic	7440-38-2	5	mg/kg		<5	**14**	<5	----	----
Barium	7440-39-3	10	mg/kg		<10	**20**	<10	----	----
Beryllium	7440-41-7	1	mg/kg		<1	<1	<1	----	----
Cadmium	7440-43-9	1	mg/kg		<1	<1	<1	----	----
Chromium	7440-47-3	2	mg/kg		<2	**30**	<2	----	----
Cobalt	7440-48-4	2	mg/kg		<2	**8**	<2	----	----
Copper	7440-50-8	5	mg/kg		<5	**11**	<5	----	----
Lead	7439-92-1	5	mg/kg		<5	**13**	<5	----	----
Manganese	7439-96-5	5	mg/kg		<5	**197**	**9**	----	----
Nickel	7440-02-0	2	mg/kg		<2	**14**	<2	----	----
Vanadium	7440-62-2	5	mg/kg		<5	**43**	<5	----	----
Zinc	7440-66-6	5	mg/kg		<5	**58**	<5	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	----	----
EP090: Organotin Compounds									
Monobutyltin	78763-54-9	1	µgSn/kg		<1	<1	<1	----	----
Dibutyltin	1002-53-5	1	µgSn/kg		<1	<1	<1	----	----
Tributyltin	56573-85-4	0.5	µgSn/kg		<0.5	<0.5	<0.5	----	----
EP090S: Organotin Surrogate									
Tripropyltin	----	0.1	%		**87.5**	**65.2**	**91.9**	----	----

Surrogate Control Limits

Sub-Matrix: **SEDIMENT**

Compound	CAS Number	Recovery Limits (%)	
		Low	High
EP090S: Organotin Surrogate			
Tripropyltin	----	35	130

Annex G – Seagrass Survey Results

PUMISTONE PASSAGE - MAINTENANCE DREDGING AREA

SEAGRASS LOCATIONS

Pumicestone Locations.DWG

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Revision A

IMPORTANT INFORMATION
ABOUT YOUR
GEOTECHNICAL ENGINEERING REPORT

More construction problems are caused by site subsurface conditions that any other factor. As troublesome as subsurface problems can be, their frequency and extent have been lessened considerably in recent years, due in large measure to programs and publications of ASFE / The Association of Engineering Firms Practicing in the Geosciences.

The following suggestions and observations are offered to help you reduce the geotechnical-related delays cost-overruns and other costly headaches that can occur during a construction project.

A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

A geotechnical engineering report is based on subsurface exploration plan designed to incorporate a unique set of project-specific factors. These typically include the general nature of the structure involved, its size and configuration; the location of the structure on the site and its orientation; physical concomitants such as access roads, parking lots and underground utilities, and the level of additional risk which the client assumed by virtue of limitations imposed upon the exploratory program. To help avoid costly problems, consult the geotechnical engineer to determine how any factors which change subsequent to the date of the report may affect its recommendations.

Unless your consulting geotechnical engineer indicates otherwise, *your geotechnical engineering report should not be used:*

- When the nature of the proposed structure is changed, for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one;
- when the size or configuration of the proposed structure is altered;
- when the location or orientation of the proposed structure is modified;
- when there is a change of ownership, or
- for application to an adjacent site.

Geotechnical engineers cannot accept responsibility for problems which may develop if they are not consulted after factors considered in their report's development have changed.

MOST GEOTECHNICAL "FINDINGS" ARE PROFESSIONAL ESTIMATES

Site exploration identifies actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent testing are extrapolated by geotechnical engineers who then render an opinion about overall subsurface conditions, their likely reaction to proposed construction activity and appropriate foundation design. Even under optimal circumstances actual conditions may differ from those inferred to exist, because no geotechnical engineer, no matter how qualified, and no subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predications. *Nothing can be done to prevent the unanticipated, but steps can be taken to help minimise their impact.* For this reason, *most experienced owners retain their geotechnical consultants through the construction stage,* to identify variances, conduct additional tests which may be needed, and to recommend solutions to problems encountered on site.

SUBSURFACE CONDITIONS
CAN CHANGE

Subsurface conditions may be modified by constantly changing natural forces. Because a geotechnical engineering report is based on conditions which existed at the time of subsurface exploration, *construction decisions should not be based on a geotechnical engineering report whose adequacy may have been affected by time.* Speak with the geotechnical consultant to learn if additional tests are advisable before construction starts.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations may also affect subsurface conditions and thus, the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept apprised of any such events, and should be consulted to determine if additional test are necessary.

GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND PERSONS

Geotechnical engineers' reports are prepared to meet the specific needs of specific individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor, or even some other consulting civil engineer. Unless indicated otherwise, this report was prepared expressly for the client involved and expressly for purposes indicated by the client. Use by any other persons for any purpose, or by the client for a different purpose, may result in problems. *No individual other than the client should apply this report for its intended purpose without first conferring with the geotechnical engineer. No person should apply this report for any purpose other than that originally contemplated without first conferring with the geotechnical engineer.*

A GEOTECHNICAL ENGINEERING REPORT IS SUBJECT TO MISINTERPRETATION

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a geotechnical engineering report. To help avoid these problems, the geotechnical engineer should be retained to work with other appropriate design professionals to explain relevant geotechnical findings and to review the adequacy of their plans and specifications relative to geotechnical issues.

BORING LOGS SHOULD NOT BE SEPARATED FROM THE ENGINEERING REPORT

Final boring logs are developed by geotechnical engineers based upon their interpretation of field logs (assembled by site personnel) and laboratory evaluation of field samples. Only final boring logs customarily are included in geotechnical engineering reports. *These logs should not under any circumstances be redrawn* for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process. Although photographic reproduction eliminates this problem, it does nothing to minimize the possibility of contractors misinterpreting the logs during bid preparation. When this occurs, delays, disputes and unanticipated costs are the all-too-frequent result.

To minimize the likelihood of boring log misinterpretation, *give contractors ready access to the complete geotechnical engineering report* prepared or authorized for their use*. Those who do not provide such access may proceed under the *mistaken* impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes which aggravate them to disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY

Because geotechnical engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against geotechnical consultants. To help prevent this problem, geotechnical engineers have developed model clauses for use in written transmittals. These are *not* exculpatory clauses designed to foist geotechnical engineers' liabilities onto someone else. Rather, they are definitive clauses which identify where geotechnical engineers' responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your geotechnical engineering report, and you are encouraged to read them closely. Your geotechnical engineer will be pleased to give full and frank answers to your questions.

OTHER STEPS YOU CAN TAKE TO REDUCE RISK

Your consulting geotechnical engineer will be pleased to discuss other techniques which can be employed to mitigate risk. In addition, ASFE has developed a variety of materials which may be beneficial. Contact ASFE for a complimentary copy of its publications directory.

---

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical Information in Construction Contracts" published by The Institution of Engineers Australia, National Headquarters, Canberra, 1987.

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PRACTICING IN THE GEOSCIENCES

8811 Colesville Road / Suite G106 / Silver Spring Maryland 20910/(301) 565-2733

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GENERAL NOTES

GENERAL

This report comprises the results of an investigation carried out for a specific purpose and client as defined in the document. The report should not be used by other parties or for other purposes, as it may not contain adequate or appropriate information.

TEST HOLE LOGGING

The information on the test hole logs has been based on a visual and tactile assessment, except at the discrete locations where test information is available (field and/or laboratory results).

GROUNDWATER

Unless otherwise indicated, the water levels given on the test hole logs are the levels of free water or seepage in the test hole recorded at the given time of measuring. The actual groundwater level may differ from this recorded level, depending on material permeabilities. Further variations of this level could occur with time due to such effects as seasonal and tidal fluctuations or construction activities. Final confirmation of levels can only be made by appropriate instrumentation techniques and programmes.

INTERPRETATION OF RESULTS

The discussion/recommendations contained in this report are normally based on site evaluation from discrete test hole data. Generalised or idealised subsurface conditions (including any cross-sections contained in this report) have been assumed or prepared by interpolation/extrapolation of these data. As such, these conditions are an interpretation, and must be considered as a guide only.

CHANGE IN CONDITIONS

Local variations or anomalies in the generalised ground conditions used for this report can occur, particularly between discreet test hole locations. Furthermore, certain design or construction procedures may have been assumed in assessing the soil-structure interaction behaviour of the site.

Any change in design, in construction methods, or in ground conditions as noted during construction, from those assumed in this report should be referred to this firm for appropriate assessment and comment.

FOUNDATION DEPTH

Where referred to in the report, the recommended depth of any foundation (piles, caissons, footings, etc) is an engineering estimate of the depth to which they should be constructed. The estimate is influenced and perhaps limited by the fieldwork method and testing carried out in connection with the site investigation, and other pertinent information as has been made available. The depth remains, however, an *estimate* and is therefore liable to variations to the final depth depending on the ground conditions at each point of support.

REPRODUCTION OF REPORTS

Where it is desired to reproduce the information contained in this report for the inclusion in the contract documents or engineering specification of the subject development, such reproduction should include at least all of the relevant trial hole and test data, together with the appropriate standard description sheets and remarks made in the written report of a factual or descriptive nature.

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BMT WBM

BMT WBM Bangalow
6/20 Byron Street, Bangalow 2479
Tel +61 2 6687 0466 Fax +61 2 66870422
Email bmtwbm@bmtwbm.com.au
Web www.bmtwbm.com.au

BMT WBM Brisbane
Level 8, 200 Creek Street, Brisbane 4000
PO Box 203, Spring Hill QLD 4004
Tel +61 7 3831 6744 Fax +61 7 3832 3627
Email bmtwbm@bmtwbm.com.au
Web www.bmtwbm.com.au

BMT WBM Denver
8200 S. Akron Street, #B120
Centennial, Denver Colorado 80112 USA
Tel +1 303 792 9814 Fax +1 303 792 9742
Email denver@bmtwbm.com
Web www.bmtwbm.com

BMT WBM London
International House, 1st Floor
St Katharine's Way, London E1W 1AY
Email london@bmtwbm.co.uk
Web www.bmtwbm.com

BMT WBM Mackay
PO Box 4447, Mackay QLD 4740
Tel +61 7 4953 5144 Fax +61 7 4953 5132
Email mackay@bmtwbm.com.au
Web www.bmtwbm.com.au

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

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

BMT WBM Perth
Level 3, 20 Parkland Road, Osborne, WA 6017
PO Box 1027, Innaloo WA 6918
Tel +61 8 9328 2029 Fax +61 8 9486 7588
Email perth@bmtwbm.com.au
Web www.bmtwbm.com.au

BMT WBM Sydney
Level 1, 256-258 Norton Street, Leichhardt 2040
PO Box 194, Leichhardt NSW 2040
Tel +61 2 8987 2900 Fax +61 2 8987 2999
Email sydney@bmtwbm.com.au
Web www.bmtwbm.com.au

BMT WBM Vancouver
Suite 401, 611 Alexander Street
Vancouver British Columbia V6A 1E1 Canada
Tel +1 604 683 5777 Fax +1 604 608 3232
Email vancouver@bmtwbm.com
Web www.bmtwbm.com