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Maroochydore Beach Nourishment Feasibility Report

March 2012

Sunshine Coast Council

Maroochydore Beach Nourishment Feasibility

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Author :	Matthew Barnes
Synopsis :	This report provides details of a proposed beach nourishment program for Maroochydore Beach using material extracted from the lower Maroochy River.

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EXECUTIVE SUMMARY

This report concerns a 1.7km stretch of shoreline between Alexandra Headland and Maroochydore Surf Club referred to as 'Maroochydore Beach'. Presently the shoreline is in a severely eroded state. Design storm erosion calculations were performed at 16 locations with the predicted storm erosion width ranging between 24-62m, depending on the height and volume of material within the dune at each measured profile location. A number of significant assets with high economic and social value are located within the immediate design storm erosion zone, including:

- Aerodrome Road/Alexandra Parade (State controlled road);
- Alex Heads Surf Club and foreshore including skate park (currently protected by a low standard seawall);
- Sea Breeze Caravan Park;
- Maroochydore Surf Club;
- Public space including pedestrian and cycle pathways; and
- Beach access locations.

The feasibility of nourishing the shoreline with sand sourced from areas outside of the Fish Habitat Area within the lower Maroochy River is explored in this report. The aim of the proposed nourishment program is to widen the beach thereby increasing the coastal buffer zone and allowing the shoreline to respond to naturally occurring erosion events. The proposed works will also improve amenity and help to restore the economic and social values attributed to Maroochydore Beach.

Due to the limited volume of sand available from within the lower Maroochy River it is recognised that this shoreline protection option may not be viable in the long term. The initial proposed sand extraction and nourishment seeks to access 125,000m^3 of sand from the lower Maroochy River. This volume is estimated to provide enough material to construct a 20m wide beach berm along Maroochydore Beach and allow for some minor nourishment works along the Cotton Tree foreshore. It is emphasised that constructed sand berms typically reduce in width by two or three times as the nourishment material is redistributed throughout the nearshore area by coastal processes. The proposed nourishment works will increase the volume of material within the active beach system and enhance the natural beach recovery typically observed during the winter months.

Ideally a similar volume of nourishment material could be accessed from the lower Maroochy River in the following year, subject to the outcomes of environmental and shoreline monitoring programs. Progressively smaller volumes may be accessed over the enduring years if it can be demonstrated through monitoring that sand can be sustainably relocated from the lower Maroochy River to Maroochydore Beach on an annual basis. If viable, it is estimated that approximately 350,000m^3 of material added to the active system over a four year period would sufficiently widen beach, thereby removing significant assets from the immediate design storm erosion zone. This preliminary four year estimate should be reviewed annually since sand transport into or out of the beach system will vary from year to year, primarily due to the dependency on storm activity.

The works proposed in this document are recognised as an interim solution to shoreline protection for Maroochydore Beach. Considering the high value of assets along this shoreline, the lack of material support a major beach nourishment program and sea level rise projections adopted in the Queensland Coastal Plan (DERM, 2012), alternative shoreline protection solutions may be necessary within the 50-year planning period.

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GLOSSARY

Accretion	The build-up (of the beach) by the action of waterborne or airborne sand, either solely by the action of the forces of nature or induced by the action of man, such as by the action of groynes, breakwaters or beach nourishment.
Accreted Profile	The profile (cross-section) of a sandy beach that develops in the “calm” periods between major storm events. During such periods, swell waves move sediment from the offshore bar onto the beach to rebuild the beach berm.
Barometric Setup	The increase in mean sea level caused by a drop in barometric pressure.
Bathymetry	The measurement of depths of water, also information derived from such measurements.
Beach	The zone of unconsolidated sand that extends landward from the low water line to the place where there is a marked change in material or physiographic form, or to the line of permanent vegetation.
Beach Berm	That area of shoreline lying between the swash zone and the dune system.
Beach Erosion	The offshore movement of sand from the sub-aerial beach during storms.
Beach Nourishment	The artificial supply of sand to supplement the total net quantity of sand within an existing beach system and/or to build up an eroded beach or dune, with sand from another location.
Beach System	The zone of active sand movement and exchange, including the dunes, beach and nearshore profile, which covers the total extent of the continuum of both longshore and cross-shore sand transport by oceanic and wind forces associated with the existence of the beach.
Breaking Waves	As waves increase in height through the shoaling process, the crest of the wave tends to speed up relative to the rest of the wave. Waves break when the speed of the crest exceeds the speed of advance of wave as a whole. Waves can break in three modes: spilling, surging and plunging.
Buffer Zone	An appropriately managed and unalienated zone of unconsolidated land between beach and development, within which coastline fluctuations and hazards can be accommodated in order to minimise damage to the development.
Coastal Amenity	Those characteristics of the coastal zone, both natural and artificial, that are valued and utilized to varying degrees by the community, including intrinsic natural character and physical recreational opportunities.
Coastal Area	The land and sea area bordering the shoreline.
Coastal Hazard Area	Coastal land within erosion prone areas, at risk from storm tide inundation and/or permanent inundation due to sea level rise.
Coastal Structures	Those structures on the coastline designed to protect and rebuild the coastline and/or enhance coastal amenity and use.

Coastline Hazards	Detrimental impacts of coastal processes on the use, capability and amenity of the coastline. This study identifies seven coastline hazards: • Beach erosion • Shoreline recession • Entrance Instability • Sand drift • Coastal inundation by storm surge and Greenhouse sea level rise • Slope instability • Stormwater erosion
Council	Sunshine Coast Regional Council
DERM	Queensland Department of Environment and Resource Management
Diffraction	The "spreading" of waves into the lee of obstacles such as breakwaters by the transfer of wave energy along wave crests. Diffracted waves are lower in height than the incident waves.
Dunes	Ridges or mounds of loose sand at the back of the beach formed from wind-blown sand trapped and stabilised by dune vegetation.
Dune Maintenance	The management technique by which dunes, dune vegetation and dune protective structures are kept in good "working order"; activities may include weed/pest/fire control, replanting, fertilising, repair of fences and access ways, and publicity.
Dune Management	The general term describing all activities associated with the restoration and/or maintenance of the role and values of beach dune systems; dune management activities and techniques include planning, dune reconstruction, revegetation, dune protection, dune maintenance, and community involvement.
Ebb Tide	The outflow of coastal waters from bays and estuaries caused by the falling tide.
Erosion Prone Area	The width of the coast that is considered to be vulnerable to coastal erosion and tidal inundation over a 50 year planning period. Erosion prone areas are shown on the erosion prone area maps prepared by the Beach Protection Authority to accommodate physical coastal processes. Where reference is made to short term storm erosion this is called the storm erosion zone.
Flood Tide	The inflow of coastal waters into bays and estuaries caused by the rising tide.
Foredune	The larger and more mature dune lying between the incipient dune and hind dune area. Fore dune vegetation is characterised by grasses and shrubs. Fore dunes provide an essential reserve of sand to meet erosion demand during storm conditions. During storm events, the fore dune can be eroded back to produce a pronounced dune scarp.
Groynes	Low walls built attached and perpendicular to a shoreline to trap longshore sand transport. Typically, sand build-up on the up drift side of a groyne is offset by erosion on the down drift side.
Groyne Field	A system of regularly spaced groynes along a section of shoreline.
HAT	Highest Astronomical Tide. The highest tide that can occur from the influence of celestial bodies – this excludes local effects such as atmospheric pressure and wind effects.

Hind dunes	Sand dunes located to the rear of the Fore dune. Characterised by mature vegetation including trees and shrubs.
IDAS	Integrated Development Assessment System under the Queensland *Integrated Planning Act 1997*
Incipient Dune	The most seaward and immature dune of the dune system. Vegetation characterised by grasses. On an accreting coastline, the incipient dune will develop into a Fore dune.
Littoral Zone	Area of the coastline in which sediment movement by wave, current and wind action is prevalent. The littoral zone extends from the onshore dune system to the seaward limit of the offshore zone and possibly beyond.
Longshore Currents	Currents flowing parallel to the shore within the inshore and nearshore zones. Longshore currents are typically caused by waves approaching the beach at an angle. The “feeder” currents to rip cells are another example of longshore currents.
Mass Transport	The net shorewards current associated with the movement of waves through the nearshore and inshore zones. Sediment transport from the offshore bar by this current is responsible for the rebuilding of storm eroded beaches during inter-storm periods.
Natural Character	The character of the coastal zone representing the natural pristine qualities typically of sandy beaches, vegetated dunes and clean ocean waters, of intrinsic value to the community.
Nearshore Zone	Coastal waters between the offshore bar and the 60m depth contour. Swell waves in the nearshore zone are unbroken, but their behaviour is influenced by the presence of the seabed. (This definition is adopted for simplicity in this document and is based on wave motion considerations rather than sedimentology).
NES	Matters of National Environmental Significance as defined in the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
Offshore Bar	Also known as a longshore bar. Submerged sandbar formed offshore by the processes of beach erosion and accretion. Typically, swell waves break on the offshore bar.
Offshore Zone	Coastal waters to the seaward of the nearshore zone. Swell waves in the offshore zone are unbroken and their behaviour is not influenced by the presence of the seabed. (See note to “Nearshore Zone”).
Onshore/Offshore Transport	The process whereby sediment is moved onshore and offshore by wave, current and wind action.
QCP	Queensland Coastal Plan (2012)
Radiation Stress	Excess momentum flux exerted on the mean flow due to the presence of waves.
Reflected Wave	That part of an incident wave that is returned seaward when a wave impinges on a steep beach, barrier, or other reflecting surface.
Refraction	The tendency of wave crests to become parallel to bottom contours as waves move into shallower waters. This effect is caused by the shoaling processes which slow down waves in shallower waters.

Revetment	Similar to a seawall but in a river (Refer to Seawall for definition).
Sand Dunes	Mounds or hills of sand lying to landward of the beach berm. Sand dunes are usually classified as an incipient dune, a fore dune or hind dunes. During storm conditions, incipient and fore dunes may be severely eroded by waves. During the intervals between storms, dunes are rebuilt by wave and wind effects. Dune vegetation is essential to prevent sand drift and associated problems.
Scarp	Also known as the Dune scarp and back beach erosion escarpment. The landward limit of erosion in the dune system caused by storm waves. At the end of a storm the scarp may be nearly vertical; as it dries out, the scarp slumps to a typical slope of 1V:1.5H.
Seawalls	Walls build parallel to the shoreline separating land and water areas, designed primarily to limit shoreline recession and other damage due to wave action.
Sea Waves	Waves in coastal waters resulting from the interaction of different wave trains and locally generated wind waves. Typically, sea waves are of short wavelength and of disordered appearance.
Sediment Budget	An accounting of the rate of sediment supply from all sources (credits) and the rate of sediment loss to all sinks (debits) from an area of coastline to obtain the net sediment supply.
Sediment Sink	A mode of sediment loss from the coastline, including longshore transport out of area, dredging, deposition in estuaries, windblown sand, etc.
Sediment Source	A mode of sediment supply to the coastline, including longshore transport into the area, beach nourishment, fluvial sediments from rivers, etc.
SEMP	Shoreline Erosion Management Plan
Shoaling	The influence of the seabed on wave behaviour. Such effects only become significant in water depths of 60m or less. Manifested as a reduction in wave speed, a shortening in wave length and an increase in wave height.
Shoreline Recession	A net long-term landward movement of the shoreline caused by a net loss in the sediment budget.
Shadow Area	Areas behind breakwaters and headlands in the lee of incident waves. Waves move into shadow areas by the process of diffraction.
Significant Wave Height	The average height of the highest one third of waves recorded in a given monitoring period. Also referred to as $H_{1/3}$ or H_s.
Storm Profile	The profile (cross-section) of a sandy beach that develops in response to storm wave attack. Considerable volumes of sediment from the beach berm, the incipient dune and the Fore dune can be eroded and deposited offshore. The landward limit of the storm profile is typically defined by a back beach erosion escarpment (dune scarp).
Storm Surge	The increase in coastal water level caused by the effects of storms. Storm surge consists of two components: the increase in water level caused by the reduction in barometric pressure (barometric set-up) and the increase in water level caused by the action of wind blowing over the sea surface (wind set-up).
Storm Bar	An offshore bar formed by sediments eroded from the beach during storm conditions.
Surf Zone	Coastal waters between the outer breaker zone and the swash zone characterised by broken swell waves moving shorewards in the form of bores.

Swash Zone	That area of the shoreline characterised by wave uprush and retreat.
Swell Waves	Wind waves remote from the area of generation (fetch) having a uniform and orderly appearance characterised by regularly spaced wave crests.
Tidal Prism	The volume of water stored in an estuary or tidal lake between the high and low tide levels; the volume of water that moves into and out of the estuary over a tidal cycle.
Tides	The regular rise and fall of sea level in response to the gravitational attraction of the sun, moon and planets. Tides along the SEQ coastline are semi-diurnal in nature, i.e. they have a period of about 12.5 hours.
Tombolo	A seaward progression of the shoreline behind an offshore island due to reduced longshore transport as a result of wave diffraction around the island.
Training Walls	Walls constructed at the entrances of estuaries and rivers to improve navigability.
Vegetation Degradation	The process by which coastal vegetation is "degraded" or damaged; this reduces the effectiveness of vegetation in protecting coastal landforms and increases the potential for erosion of underlying soil materials by wind (resulting in sand drift), water or waves.
Wave Height	The vertical distance between a wave trough and a wave crest.
Wave Hindcasting	The estimation of wave climate from meteorological data (barometric pressure, wind) as opposed to wave measurement.
Wave Length	The distance between consecutive wave crests or wave troughs.
Wave Period	The time taken for consecutive wave crests or wave troughs to pass a given point.
Wave Runup	The vertical distance above mean water level reached by the uprush of water from waves across a beach or up a structure.
Wave Set-up	The increase in water level within the surf zone above mean still water level caused by the breaking action of waves.
Wave Train	A series of waves originating from the same fetch with more or less the same wave characteristics.
Wind Set-up	The increase in mean sea level caused by the "piling up" of water on the coastline by the wind.
Wind Waves	The waves initially formed by the action of wind blowing over the sea surface. Wind waves are characterised by a range of heights, periods and wavelengths. As they leave the area of generation (fetch), wind waves develop a more ordered and uniform appearance and are referred to as swell or swell waves.
Windborne Sediment Transport	Sand transport by the wind. Sand can be moved by the processes of suspension (fine grains incorporated in the atmosphere), saltation (medium grains "hopping" along the surface) and traction (large grains rolled along the surface).

1 INTRODUCTION

This report considers the feasibility of nourishing Maroochydore Beach using sand extracted from the lower Maroochy River. The objective of the works is to widen the beach and thereby remove significant assets from the immediate design storm erosion zone. The proposed works will allow the shoreline to respond to natural erosion events and ensure the economic and social values of Maroochydore Beach are maintained. The report includes the following:

- Shoreline and asset vulnerability assessment (design storm erosion calculations);
- Beach nourishment volume estimates;
- Maroochy River sand reserve volume estimate;
- Longevity of the proposed works assessment;
- Predicted re-nourishment intervals;
- Shoreline and bathymetric monitoring recommendations;
- Summary of the proposed sand extraction and nourishment operations; and
- Environmental assessments.

The report focuses on the feasibility of initial nourishment works that seeks to deliver up to 125,000m^3 of material to Maroochydore Beach. Additional nourishment material may be accessed from the lower Maroochy River in the following years, subject to the outcomes of environmental and shoreline monitoring programs.

Outcomes from a community consultation program, undertaken in conjunction with the feasibility studies described in this report, are summarised in Appendix G.

1.1 The Study Area

This report concerns a 1.7km stretch of shoreline between Alexandra Headland and Maroochydore Surf Club, Sunshine Coast, Queensland. Figure 1-1 shows a shoreline characterised by a sandy beach with a relatively narrow dune and foreshore buffer that includes dune scrub vegetation and casuarinas. Between the Alexandra Heads Skate Park and Seabreeze Caravan Park the width between Alexandra Parade and the toe of the frontal dune (defined by DERM using 2009 aerial photography) ranges between 20-30m. North of the Seabreeze Caravan Park the dune and vegetation buffer gradually widens and is approximately 50m prior to reaching the Maroochydore Surf Club car park. The foreshore area is predominantly open space including pedestrian and cycle pathways and multiple beach access locations.

Beach profile cross-sections were measured in late 2010 within the study area (locations indicated in Figure 1-1: refer Appendix A for survey details). The profiles indicate the height of the main dune is typically less than 6mAHD and the elevation of the foreshore area (between the road and dune) is approximately 4mAHD. The slope of the upper beach profile is approximately 1 in 20 (between an elevation of 2mAHD and -2mAHD).

Exposed coffee rock is often visible in the nearshore area which may be indicative of a receding shoreline on a geological timescale (e.g. Jones, 1992 and Willmott, 2007). Recent storm events during the 2009, 2010 and 2011 summer periods have caused the beach to lower and much of the dune buffer has eroded. The erosion has also damaged beach access structures and exposed imported dune fill material (shown in Figure 1-2 and Figure 1-3), significantly impacting the ‘values’ or ‘desirable features’ of the area (refer Section 1.2). The fill material is likely to provide some stability to the shoreline however is not considered a suitable long-term shoreline protection measure.

When the shoreline is in an eroded state significant assets with high economic and social value have little protection to subsequent storm events. The threat to infrastructure, in particular Alexandra Parade, is greater within the southern section of the study area. The threat is relatively lower to the north of Seabreeze Caravan Park due to a wider dune and vegetation buffer.

Considering the high value of assets along this shoreline, and the lack of material to support major beach nourishment works, the long term recommendation for this shoreline is a rock seawall (revetment type structure) to protect the adjacent assets (BMT WBM, 2011a). The seawall would be located as far landward as possible and it is anticipated that the structure would be complemented with a beach and dune nourishment scheme (if viable and as required) to conceal the structure.

Interim shoreline protection measures have been previously considered for the shoreline between Alexandra Headland and Maroochydore (BMT WBM, 2011a), including minor beach nourishment, the enhancement of existing or the addition of new groynes and/or geofabric sand containers to improve beach amenity and protect locally eroded sections of shoreline. This report explores the feasibility of one such option and considers the installation a sand renourishment pipeline, with sand sourced from areas outside of the Fish Habitat Area within the Maroochy River mouth. Due to the limited volume sand available from this source it is recognised that this shoreline protection option may not be viable in the long term.

Title:

Maroochydore Beach Nourishment Study Area

Figure: 1-1

Rev: A

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0 125 250m

Approx. Scale

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Figure 1-2 Exposed Beach Fill and Coffee Rock Looking South toward Alex Heads Surf Club (Photo Courtesy of SCRC)

Figure 1-3 Exposed Coffee Rock Looking North toward Maroochydore Surf Club (Photo Courtesy of SCRC)

1.2 Maroochydore Beach to Alexandra Headland Beach Values

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 relevant to the coastal foreshore between Alexandra Headland and the Maroochy River mouth (the Study Area).

1.2.1 Ecological Values

Coastal foreshores of the Sunshine Coast contain important coastal ecosystems including coastal dunes and beaches, wetlands, mangroves and seagrass, rocky headlands and coastal lagoons. These systems also support unique species and habitat.

Significant habitats within the Study Area include shallow reefs which are known to support a high diversity of corals, molluscs and fish. 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 Sunshine Coast with nesting known to occur sporadically. Protected migratory birds also occur along the length of the Sunshine Coast, and are most commonly found around the river mouths, beaches and dunes.

1.2.2 Social Values

The major social values of 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.

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 peoples' choices in recreation and the involvement of community groups in environmental planning and management.

The open space of the coasts, beaches and conservation areas are easily accessed and provide residents and tourists with recreational opportunities. Key activities that are undertaken within the Study Area include socialising, relaxation and recreational activities including, kite surfing, surfing, ocean kayaking, fishing, swimming, snorkelling, walking, picnicking and riding. Combined with the coastal amenity and climate of the Sunshine Coast, these aspects create the lifestyle and opportunities that attract residents and visitors to the area.

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

1.2.3 Economic Values

In terms of profile and employment, tourism is the largest industry on the Sunshine Coast, attracting millions of visitors each year (for example, 3 million visitors in 2009). A significant 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 tourism industry.

2 DESCRIPTION OF PROPOSED NOURISHMENT WORKS

2.1 Maroochydore Beach Coastal Processes

The shoreline between the Alex Heads and Maroochydore Surf Clubs (Maroochydore Beach) is morphologically dynamic and fluctuations in shoreline position are the result of the prevailing coastal processes.

The wave climate at Maroochydore Beach is a combination of ocean swell and locally wind-generated ‘seas’. The swell waves are of long period (typically 7-12 seconds) and propagate to the shoreline from the deep ocean. Waves experience significant modification by refraction, bed friction and shoaling. Wind generated sea waves are of relatively very short period (generally less than 4 seconds) and are not substantially affected by the offshore bathymetry prior to breaking nearshore.

The waves have four key effects on sand transport, namely:

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

Currents provide the primary mechanism for the transport of the sand that has been mobilised and put into suspension by the wave/current action. The currents also impose a bed shear stress that may mobilise the seabed sand. The total bed shear stress results from a complex, non-linear interaction between waves and currents. During prevailing, non-storm conditions the longshore current generated by waves breaking at an angle to the shoreline is the dominant sediment transport mechanism at Maroochydore Beach. The longshore sand transport is distributed across the surf zone and typically peaks near the wave break point where the wave height, longshore current and bed shear are greatest.

Where there are differentials in the rates of longshore transport (that is, the difference in the volume of material transported into and out of the beach unit) the beach will erode or accrete in response. Coastal processes studies undertaken as part of the Sunshine Coast SEMP (BMT WBM, 2011b) calculated relatively low net longshore transport rates (annual average less than 10,000m^3/yr) toward the north at Maroochydore Beach. Very low longshore transport differentials indicated that no significant long term shoreline recession could be attributed to the contemporary longshore processes. However, 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 (cross shore) erosion occurs, and less sand is subsequently returned to the beach/dune than was previously there.

Historically the sandy beach between the Alex Heads and Maroochydore Surf Clubs has been observed to naturally erode and accrete in response to the prevailing coastal processes. At the time of writing (March 2012), the beach is in an eroded state with vast areas of exposed indurated sand (coffee rock) and the dune/foreshore buffer reduced to approximately 20m at some locations (measured landward from the toe of the frontal dune). At present the Maroochydore shoreline values and the adjacent assets that rely on erosion protection offered by the foreshore are vulnerable to subsequent erosion events.

2.2 Shoreline and Asset Vulnerability

Coastal processes studies undertaken as part of the Sunshine Coast SEMP (BMT WBM 2011b) calculated a 50-year planning period design storm erosion width of approximately 50m for the Maroochydore Beach unit. Design storm erosion widths were recalculated at 16 locations as part of the present study, utilising updated beach profile measurements (refer Figure 2-1) and following the storm profile model of Vellinga (1983). The assessment adopted inputs considered appropriate for a study area, including:

- 16 beach cross-sectional profile measurements obtained in December 2010 (odd numbered cross-sections indicated in Figure 2-1) and sediment characteristics;
- 50 year ARI wave conditions (obtained from BMT WBM 2011b);
- 100 year ARI storm surge conditions (obtained from Connell Wager, 2005); and
- Contribution of wave setup to the design water level (assumed to be 12.5% of the design wave height).

Figure 2-2 provides an example of the predicted storm erosion profile at a given location within the study area. Table 2-4 summarises the predicted storm erosion volume and width at the 16 measured profile locations. The calculations assume that the upper beach profile and dune system consist of sand only and therefore the estimates are likely to be conservative in areas where coffee rock or other less erosive materials exist. Cross-sectional figures showing the predicted storm erosion profile for each section are provided in Appendix B.

Title:

Beach Profile Cross-Section Locations Measured December 2010

Figure: **2-1**

Rev: **A**

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0 125 250m

Approx. Scale

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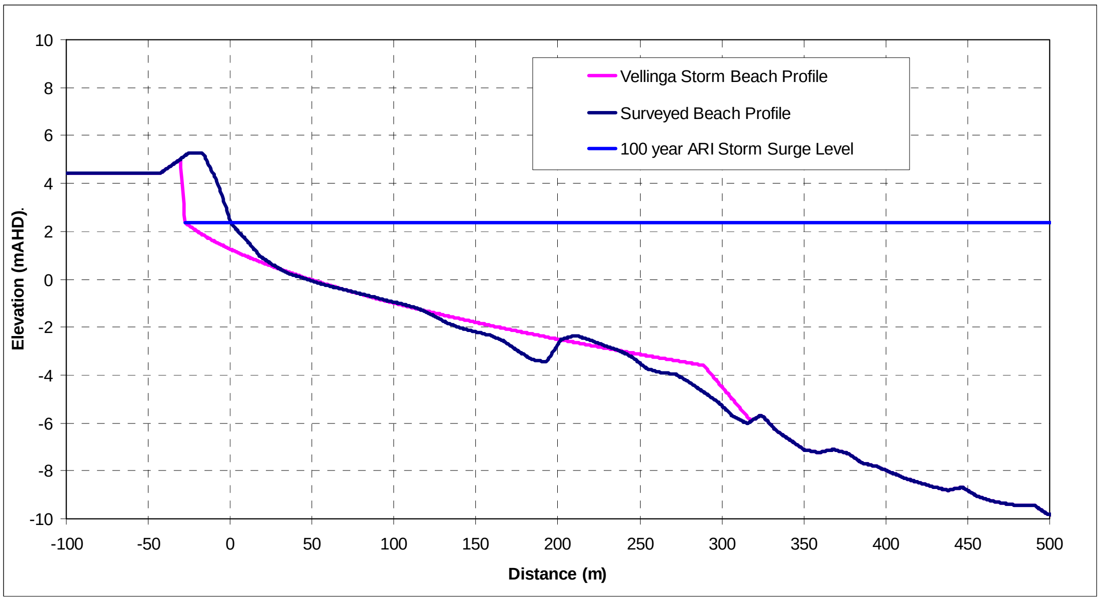

Figure 2-2 Example of Predicted Storm Erosion Profile

Table 2-1 Summary of Design Storm Erosion Widths between Alex Heads and Maroochydore Surf Clubs

Section (refer Figure 1-1)	Design Storm Erosion Volume (m^3/m)	Design Storm Erosion Width (m)
1	135	44
3	196	62
5	180	59
7	176	58
9	196	61
11	183	58
13	194	58
15	213	56
17	145	40
19	139	38
21	135	37
23	119	36
25	93	25
27	93	28
29	94	26
31	97	36
Average	**149 m^3/m**	**45 m**

The predicted design storm erosion volume for Maroochydore Beach ranged between 93-213m^3 per metre of shoreline. By summing the design storm erosion volumes and multiplying by a standard unit length of 100m (the approximate distance between each section) the total design storm erosion volume for Maroochydore Beach is estimated to be 240,000m^3. It is noted that the volume of material eroded during a storm is not necessarily lost from the beach system but rather relocated from the upper beach to the offshore areas. During extended periods of low energy conditions most of the material deposited offshore is expected to slowly migrate back onshore.

The predicted storm erosion widths ranged between 24-62m, depending on the height and volume of material within the dune at each measured profile location, with an average width of 45m. A number of significant assets with high economic and social value are located within the immediate design storm erosion zone, including:

- Aerodrome Road/Alexandra Parade (State controlled road);
- Alex Heads Surf Club and foreshore including skate park (currently protected by a low standard seawall);
- Sea Breeze Caravan Park;
- Maroochydore Surf Club;
- Public space including pedestrian and cycle pathways; and
- Beach access locations.

Seawalls exist at some locations within the study area. The design standard of these is not known and it is assumed the existing structures would fail during a design storm event and therefore the adjacent assets remain vulnerable to erosion.

2.2.1 Storm Erosion Sensitivity

Sensitivity testing of the predicted short term erosion widths and volumes for an additional eight storms was undertaken. The storms were characterised by different combinations of wave height and water level parameters that are summarised in Table 2-2.

Table 2-2 Storm Erosion Sensitivity Parameters

ARI	Significant Wave Height (m) (BMT WBM, 2011b)	Surge Water Level (m) (Connell Wagner, 2005)
20	5.60	1.55
50	5.97	1.60
100	6.25	1.63

Storm erosion sensitivity results are summarised in Table 2-3 and shows the predicted erosion volume ranging between approximately 200,000m^3 and 265,000m^3 for the different storm parameter combinations (bold indicates the design storm adopted assessment described in Section 2.2). These erosion estimates are discussed in the context of the nourishment volume being proposed for Maroochydore Beach in Section 4.

Table 2-3 Storm Erosion Sensitivity Results

Wave Height ARI	Surge Level ARI	Mean Erosion Width (m)	Erosion Volume (m^3)
20	20	35	198153
20	50	38	202916
20	100	39	205770
50	20	43	231895
50	50	44	236331
50	**100**	**45**	**238953**
100	20	47	258264
100	50	49	262662
100	100	50	265244

2.3 Beach Nourishment Requirements

The beach nourishment project proposed for the shoreline between Alex Heads and Maroochy Surf Clubs involves the direct placement of sand on the beach to create a wider sand buffer for dissipating wave energy. For this project, the amount of additional width will be determined based on the desired level of storm protection, the availability of material from the Maroochy River mouth and the target renourishment interval.

On sandy shorelines berms are formed naturally due to landward sediment transport driven by nearshore wave and swash action. The berm is typically located between the swash zone and dune system and develops under normal, prevailing wave and tidal conditions. The berm represents the recreationally valuable or 'useable' part of the beach and is illustrated in Figure 2-3. On wide beaches, several berms may be noticeable at slightly higher elevations on the beach and are typically visible as remnant scarps left behind following an erosion event. The elevated berms are associated with storm events when the beach is exposed to higher wave energy and water levels than normal.

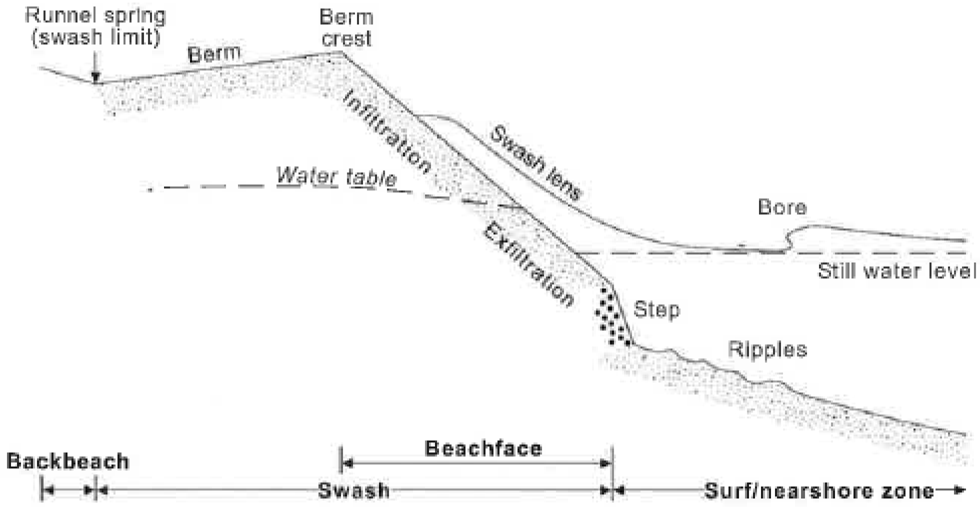

Figure 2-3 Schematic Diagram of Swash Zone and Beachface Morphology (from Hughes and Turner, 1999)

Beaches in a severely eroded condition might have little or no berm, a condition recently observed within the study area (refer Figure 2-4). A beach without a berm has low social value and a reduced capacity to dissipate wave energy, therefore providing little storm protection to adjacent assets. Enhancing and widening the beach berm within the study area, in order to improve the level of storm protection, is the primary objective of the proposed sand extraction and beach nourishment project.

Figure 2-4 Severe Erosion Observed between Alex Heads and Maroochydore Surf Clubs (Photo Courtesy of SCRC)

2.3.1 Beach Nourishment Volume Estimates

Nearshore berm creation and widening of a beach is intended to mimic a shoreline’s natural defence to storm-driven erosion. The width and elevation of the constructed berm are important design considerations and are generally dictated by practical and economic factors.

A design berm is typically constructed at an elevation close to the natural berm elevation using standard earth-moving equipment that distributes the beach nourishment material from an initial discharge or placement location. Following this approach the constructed beach berm is typically two or three times wider than the ‘target design’ (USACE, 2002). Over time the material that forms the initial, overbuilt berm will be redistributed seaward by coastal processes and subsequently the target berm adjusts to a more landward position. This process will commence during operations (i.e. the instant the material is placed on the beach) and will be most evident following a storm event.

The required volume to widen the beach between Alex Heads and Maroochydore Surf Clubs has been estimated for 10m, 20m and 40m constructed berm design profiles. It is noted that the constructed berm design profiles have been idealised for the purpose estimating nourishment volumes and are not design specifications. The estimates are based on the following:

- 16 beach profile cross-section measurements obtained in December 2010 (odd numbered cross-sections in Figure 2-1);
- 2mAHD constructed berm elevation (the approximate elevation where the natural berm would form); and
- 1 in 20 constructed berm profile slope (the approximate slope of the natural upper beach profile).

For the 16 profile locations the cross-sectional area between the measured profile and each design profile was calculated. The cross-sectional areas were multiplied by a standard unit length of 100m, the approximate distance between the neighbouring odd numbered profiles (refer Figure 1-1), to obtain an estimate of the required nourishment volume. Figure 2-5 provides an example of the measured beach profile and each constructed berm profile at a given location. Table 2-4 summarises the calculated cross-sectional area and design volume for each constructed berm width at the 16 beach profile locations. Cross-sectional figures for each section are provided in Appendix C.

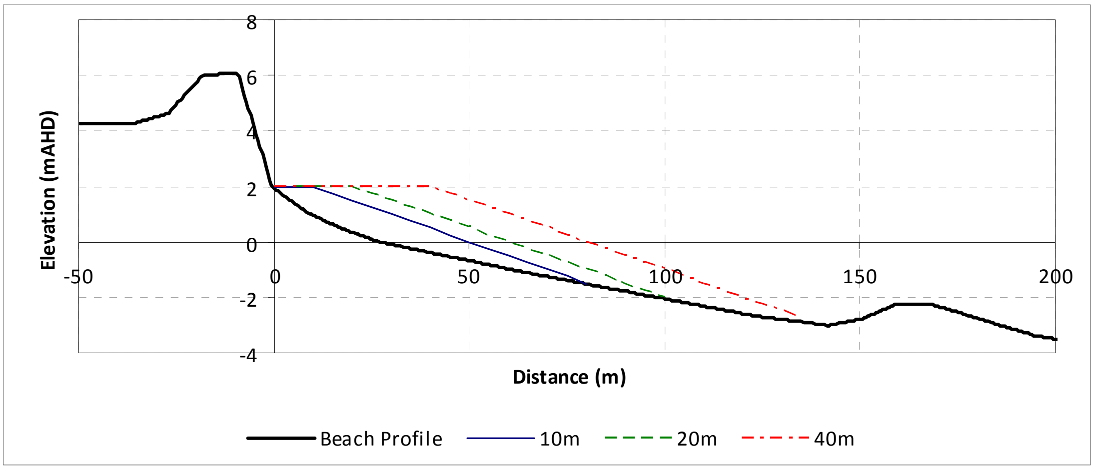

Figure 2-5 Measured Beach Profile and 10m, 20m and 40m Design Berm Profiles

Table 2-4 Summary of Design Berm Volume Requirements

	Design cross-sectional area (m^2)			Design volume per unit length (m^3)		
Section	**10m berm**	**20m berm**	**40m berm**	**10m berm**	**20m berm**	**40m berm**
1	38	65	143	3800	6500	14300
3	65	109	185	6500	10900	18500
5	57	84	148	5700	8400	14800
7	55	85	149	5500	8500	14900
9	55	97	190	5500	9700	19000
11	57	87	156	5700	8700	15600
13	47	77	150	4700	7700	15000
15	57	95	187	5700	9500	18700
17	44	74	143	4400	7400	14300
19	45	75	146	4500	7500	14600
21	47	77	147	4700	7700	14700
23	50	85	148	5000	8500	14800
25	39	66	127	3900	6600	12700
27	30	54	109	3000	5400	10900
29	29	56	119	2900	5600	11900
31	33	60	149	3300	6000	14900
Total design volume requirement (m^3)				**74800**	**124600**	**239600**

Total design volume estimates provided in Table 2-4 suggest a 10m, 20m and 40m wide constructed berm at an elevation of 2mAHD and a slope of 1 in 20 would require approximately 75,000m^3, 125,000m^3 and 240,000m^3 of nourishment material respectively. As noted above, over time the constructed berm width may be reduced by two or three times as the nourishment material is redistributed throughout the nearshore area by coastal processes. Furthermore, it is noted that the estimates provided in Table 2-4 are based on beach profile measurements obtained in December 2010. Recent erosion events during December 2011 and January 2012 appear to have lowered the beach beyond the level measured in late 2010 and therefore a greater volume of material may be required to achieve the desired constructed berm width.

Many beach nourishment projects have been incorrectly judged a failure when the constructed berm adjusts landward during the following storm season. Generally the nourishment material is not lost from the beach system but rather redistributed throughout the nearshore zone, most of which will return to the beach during extended periods of low wave energy conditions (typically experienced during the winter months at Maroochydore Beach). The Coastal Engineering Manual (USACE, 2002) highlights the need for community education programs prior to undertaking beach nourishment works, particularly concerning the expected reworking of the nourishment material by the prevailing coastal processes.

3 DESCRIPTION OF THE MAROOCHY ESTUARY SAND RESOURCE

3.1 Maroochy River Mouth Dynamics

Historically, the Maroochy River mouth has been very mobile with the entrance being located both to the north and the south of Pincushion Island. During the early 1990s, the southern channel became very dominant and erosive pressure on the river bank near the Cotton Tree Caravan Park resulted in the construction of two geotextile groynes in 1995.

Continued erosive pressure resulted in a breakthrough of the entrance south of Pincushion Island in 1999, and the subsequent threat to the Cotton Tree Caravan Park from shoreline recession resulted in the construction of the southern geotextile groyne and some geotextile seawall sections in 2001. Three additional geotextile groynes and seawalls were subsequently constructed in 2003. The intention of these groynes and seawalls was to protect the Caravan Park whilst maintaining some amenity on the beaches between the groynes.

Currently the lower estuary, downstream of Channel and Goat Islands, contains a significant amount of sand that was eroded from the frontal dunes and beach that were once connected to Pincushion Island. In a similar cycle in the 1960-1970’s, sand from the same location closed off the southern entrance of the Maroochy River forcing all flow through the northern channel and eroded the inside of the northern spit to such an extent that it caused the channel to eventually breakthrough just south of Twin Waters. Since this time the mouth has predominantly migrated in a southerly direction and is presently located between Cotton Tree and Pincushion Island. A collection of historical photos provided by DERM that show the entrance and lower estuary dynamics between 1958 and 2005 are included in Appendix D.

3.2 Sediment Characteristics and Suitability for Beach Nourishment

A Maroochy River mouth sediment investigation was completed in December 2011 by Cardno Bowler Pty Ltd on behalf of the SCRC. The investigation targeted potential areas to extract sand for the purpose beach nourishment shown by the red hashed areas (Area 1, Area 2, Area 3 and Area 4) in Figure 3-1. Cardno Bowler (2011) note that Area 2 as defined in Figure 3-1 was indicative only and due to the existing site conditions the sample locations were relocated. In addition, the logistics of sample collection (and potentially sand extraction operations) restricted the sample locations within Area 4, with exposure to wave energy and/or shallow areas cited as complicating factors. Figure 3-2 shows the ultimate sediment sample locations. Samples were laboratory analysed for Particle Size Distribution (PSD) and Acid Sulfate Soils. The sediment investigation report including borehole logs and laboratory analysis results are provided in Appendix E. Findings relevant to the present project are summarised below:

- The target depth for sediment boreholes was 3m below the existing sediment surface level however some boreholes were terminated slightly above this depth due to the presence of stiff clays. It is therefore assumed that any sand extraction operation for the purpose of beach nourishment would not exceed a dredge depth of 3m.

- PSD analysis identified a dominance of non-cohesive sand material and a high proportion of particles with a diameter between 0.150-0.425mm. This range in grain size is consistent with the beach material found on shoreline between Alex Heads and Maroochydore Surf Clubs where the median sand grain size diameter (D_{50}) is approximately D_{50} = 0.2mm.
- The presence of Acid Sulfate Soils was detected however the in the majority of samples the levels of acidity were very low and in all cases the material intrinsic acid neutralising capacity exceeds the potential of the material to generate acidity. As such no further treatment of the materials tested would be required (Cardno Bowler, 2011).
- While the dominant particle size is consistent with that typically sort for beach nourishment purposes, the material quality present at the sample Areas 1, 2 and 3 would not be suitable for nourishment of the shoreline between Alex Heads and Maroochydore Surf Clubs (Cardno Bowler, 2011). This is based on the variable make up of the material including colour and silt content. This material may be more suitable for the proposed nourishment of shorelines within the Maroochy River such as Chambers Island (subject to further investigation).
- The sampled sediment within the western section of Area 4 was generally more uniform and paler in colour. Cardno Bowler (2011) recommends this area is targeted as the primary source of material for beach nourishment purposes.

LEGEND

▨ Resource Investigation Area

Title:

Resource Investigation Area - Maroochy River (Indicated by SCRC)

Figure:
3-1

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A

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0m 100 200
Approx. Scale

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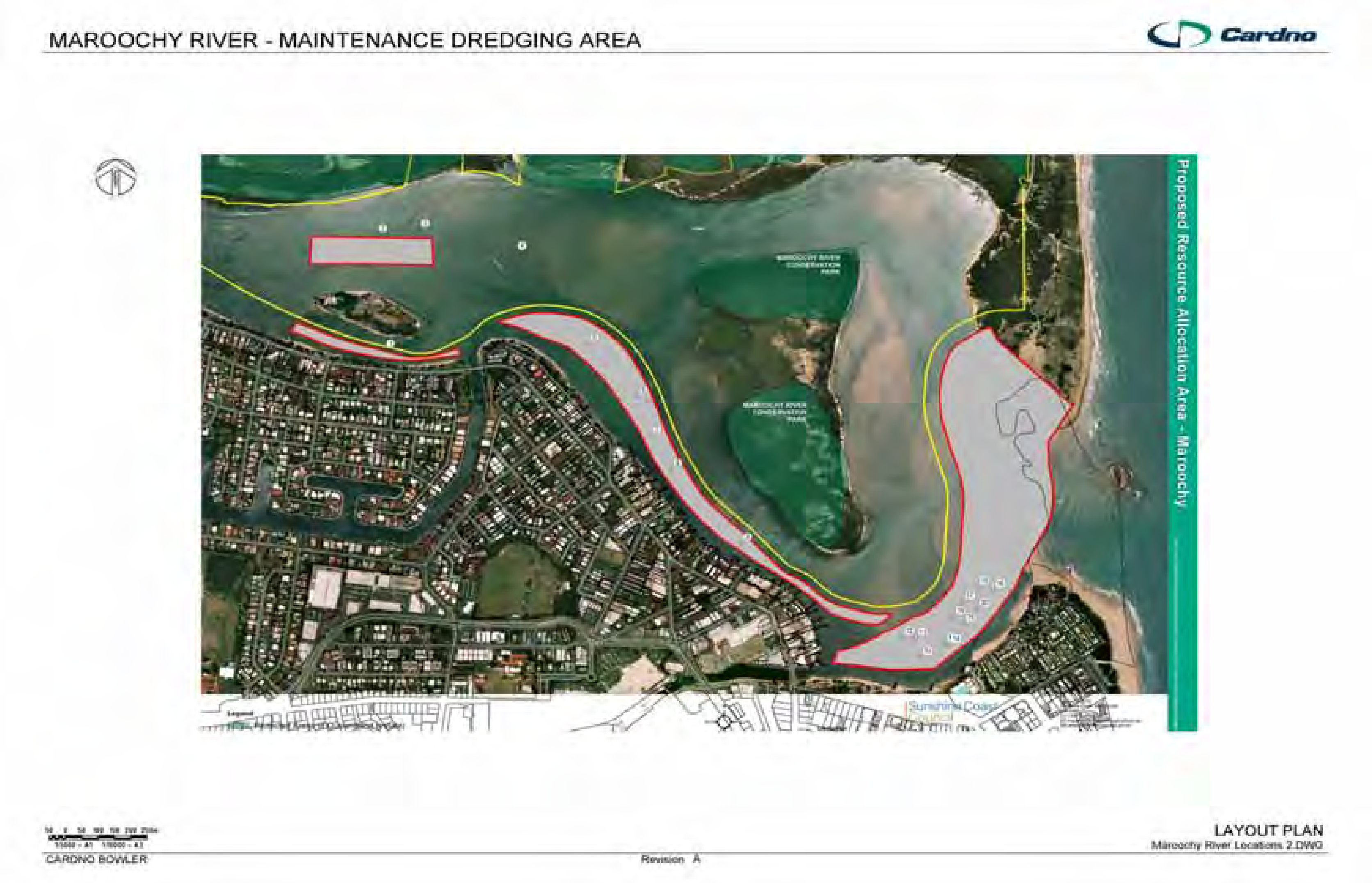

Figure 3-2 Maroochy River Sediment Sample Locations (from Cardno Bowler, 2011)

3.2.1 Material Available for Beach Nourishment

The material available from within the Maroochy River mouth suitable for nourishment of the shoreline between Alex Heads and Maroochydore Surf Clubs has been estimated based on the following:

- Findings of the sediment investigation reported in Section 3.2 including the recommendation that the western portion of Area 4 be the primary source of material for beach nourishment purposes.
- Assumed dredging operational difficulties in locations exposed to wave energy and other shallow areas.
- A dredge depth that does not exceed 3m below the existing sediment surface level.
- The requirement to not disturb declared Fish Habitat Areas or other sensitive marine habitats.

Based on the above a notional dredge area has been defined and is shown in Figure 3-3. The proposed dredge area has a total surface area of approximately 64,000m^2. Table 3-1 provides estimates of the material available based on the proposed dredge area defined in Figure 3-3 and various dredge depths.

Table 3-1 Dredge Depth and Estimated Volume of Material Available

Dredge Depth (m)	Volume of Material Available (m^3)
1	64000
1.5	96000
2	128000
2.5	160000
3	192000

Considering the available sand resources within the Maroochy River mouth, and the beach nourishment volume requirements reported in Section 2.3.1, the shoreline between Alex Heads and Maroochydore Surf Clubs could be feasibly widened by constructing a 20m berm at an elevation of 2mAHD and with a profile slope of 1 in 20. This would require approximately 125,000m^3 of nourishment material and therefore dredge depth of approximately 2m within the notional dredge area defined in Figure 3-3. It is noted that the proposed dredge depth is well within the river mouth deepening known to occur during major flood events within the Maroochy River (refer Section 6.2). While greater volumes are likely to be available via dredging beyond 2m depth, it is recommended that the initial sand extraction operation does not over exploit the available sand reserves thereby minimising the impact to the estuary system.

It is anticipated that extraction of up to 125,000m^3 could be repeated once the proposed dredge area is refilled with sand via natural sedimentation processes. The need for and frequency of renourishment would be determined through a detailed monitoring program. This is discussed further in Section 4.

As part of a separate project, it is also proposed that a small amount of material (<10,000m^3) from Area 4 and potentially the entrance to Cornmeal Creek (subject to further investigation) is placed along the Cotton Tree foreshore to complement shoreline revetment upgrade works.

LEGEND

- 🟥 Proposed Sand Extraction Area, approx. 64,000m²
- 🟨 Fish Habitat Area (DEEDI)
- ▨ Government Land

Title:

Proposed Maroochy River Sand Extraction Area

Figure: 3-3

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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Approx. Scale

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4 BENEFIT AND LONGEVITY OF PROPOSED WORKS

4.1 Benefit of Proposed Works

Maroochydore Beach displays periods of beach erosion followed by natural recovery, particularly in response to storms and high energy wave events. Historical aerial photography and beach profile measurements suggest the shoreline is dynamically stable however these datasets are too limited to delineate any long term trends (BMT WBM, 2011a). It is noted that the presence of exposed coffee rock is understood to be anecdotal evidence of a receding shoreline in a geological timescale (e.g. Jones, 1992 and Willmott, 2007). Presently, this section of coastline lacks the beach and dune system required to buffer significant erosion events. Furthermore, the erosion pressure will be amplified if sea level rise projections adopted as part of the Queensland Coastal Plan (2012) are realised.

Sand transport along Maroochydore Beach has a low residual to the north however this would be very seasonal and may reverse from year to year. The presence of the geotextile groyne (constructed 2001-2003 with localised beach nourishment using material from the lower Maroochy River) at the northern end of this beach unit provides some stability to the beach. The benefit of the groyne field in terms of beach widening extends south approximately to the Maroochydore Surf Club.

Sand removed from the Maroochy River mouth and placed along the Maroochydore Beach would be available for immediate distribution and transport by the natural coastal processes. This would directly benefit the beach in its present, eroded state and enhance the shoreline’s ability to withstand future erosion events. Over time and depending on the prevailing conditions, the material placed on the beach will be dispersed offshore across a wide nearshore area (the intertidal and surf zones). At times, cross shore transport processes that dominate during high energy conditions will also transport the material offshore. The beach will slowly recover during long periods of low energy conditions, typically over the winter months, when the material gradually moves back onshore. While the material moves on and offshore, possibly many times over many years, it will also slowly migrate towards the north due to the net northerly longshore transport along Maroochydore Beach. Eventually the material will be lost from the Maroochydore Beach system and will either be transported into the Maroochy River mouth and deposit within the estuary or bypass the mouth and continue north towards North Shore Beach.

The longevity of the proposed nourishment works is primarily determined by the rate at which the placed sand is transported out of the system. Considering the relatively low longshore sediment transport rates and differentials at Maroochydore Beach the apparent longevity of the works will be relative to the frequency of storms and associated short term erosion that occurs following placement of the nourishment material. During storms wave-driven longshore and cross shore transport will cause a lateral and offshore spreading of the material throughout the nearshore zone. The spreading is likely to be most dramatic following the initial high-energy wave event. It is important that this is not perceived as a project failure for the following reasons:

- Most of the material will not be lost from the beach system and will be available to return onshore during periods of low-energy wave conditions; and

- Any material that is lost from the beach system will be transported to adjacent beaches or be transported back into the lower Maroochy River.

It is anticipated that periodic renourishment of Maroochydore Beach using material from the Maroochy River may be viable in the medium-term, thereby creating a system of local sand recycling. This is discussed further in Section 4.2.

4.1.1 Longevity of Proposed Works

The Coastal Engineering Manual (USACE, 2002) provides an analytical method to estimate the longevity of a beach nourishment project. The method assumes an idealised beach and combines the equation for longshore sediment transport with the continuity equation to develop one-line shoreline change theory. This analytical approach can be used at the preliminary design phase to investigate the influence of the incident wave climate and the alongshore length of nourishment.

Average annual wave climates for various Sunshine Coast locations were developed as part of the coastal processes studies undertaken for the Sunshine Coast SEMP (BMT WBM, 2011b). The wave height and direction frequency recurrence table for Maroochydore Beach is provided in Appendix F together with a summary of the method used to estimate the 'half-life' of the proposed initial nourishment project. The 'half-life' refers to the time taken for 50% of the nourishment material to move out of the beach system and is estimated following

$$t_{50\%} = \frac{a^2 \pi}{4\varepsilon}$$

Equation 1

Where *a* is half the length of the project shoreline (total length is 1.7km) and *ε* is the 'shoreline diffusivity' or the rate at which material leaves the project area due to lateral spreading. Details regarding the calculation of the shoreline diffusivity are provided in Appendix F and results of the assessment are summarised below in Table 4-1. Note that the half-times presented in Table 4-1 have been factored (multiplied) by the percentage recurrence of each wave height condition. The total 'half-life' in Table 4-1 is the sum of the 'factored half-life' for each wave conditions and is therefore representative of the annual average wave climate.

Table 4-1 Estimated Longevity of Initial Nourishment Based on the Annual Average Incident Wave Climate (refer Appendix F)

Wave Height (m)	Wave Height % of year	ε (m^2/s)	*Factored* $t_{50\%}$ (sec)
0.1 - 0.3	0.1%	0.0004	1288036
0.3 - 0.5	19.6%	0.0025	44628174
0.5 - 0.7	39.0%	0.0069	32224746
0.7 - 0.9	21.5%	0.0141	8653993
0.9 - 1.1	11.6%	0.0246	2672766
1.1 - 1.3	5.9%	0.0388	861791
1.3 - 1.5	1.6%	0.0571	158966
1.5 - 1.7	0.4%	0.0797	28462
1.7 - 1.9	0.1%	0.1071	5301
1.9 - 2.1	0.1%	0.1393	4073
>2.1	0.1%	0.1768	3210
		Total (sec)	90529516
		Total (years)	2.9

The longevity assessment for the initial nourishment works estimates a half-life of 2.9 years after which time only 50% of the placed material will remain in within the Maroochydore Beach system. It is noted that this estimate is based on the long term annual average wave climate and that annual losses are likely to vary from year to year because of the dependency on storm activity.

Groynes are sometimes used in conjunction with large-scale beach nourishment to maximise the cost-benefit of the nourishment works. The groynes act to block littoral processes and restrict longshore sand losses. Additional groynes for Maroochydore Beach have not been considered in this project given the relatively small-scale nourishment works being proposed. The feasibility of a single groyne (or groyne field) would need to be determined via a detailed modelling investigation so that any undesirable effects (such as down drift erosion) could be understood and appropriately managed.

4.2 Predicted Renourishment Interval

Maroochydore Beach is presently in a severely eroded state and design storm erosion calculations summarised in Section 2.2 suggest an erosion buffer width of up to 62m is required to protect the adjacent assets. To achieve the necessary storm erosion buffer along this shoreline hundreds of thousands cubic metres of nourishment material would be required. This exceeds the amount of material considered to be feasibly available for an initial sand extraction program (refer Section 3) however a smaller amount will still provide benefit the shoreline. It is anticipated that the required volume could be realised through multiple sand extraction and renourishment exercises conducted over a number of years. The need, feasibility and frequency of additional works would be determined through a proposed detailed monitoring program. Figure 4-1 represents the simplified decision-making process based on physical factors to be considered prior to re-nourishing the Maroochydore Beach using material from the Maroochy River. It includes consideration of access to alternative sources of material should they become available. In the event that there is insufficient material for the required beach nourishment then an alternative shoreline protection solution should be considered.

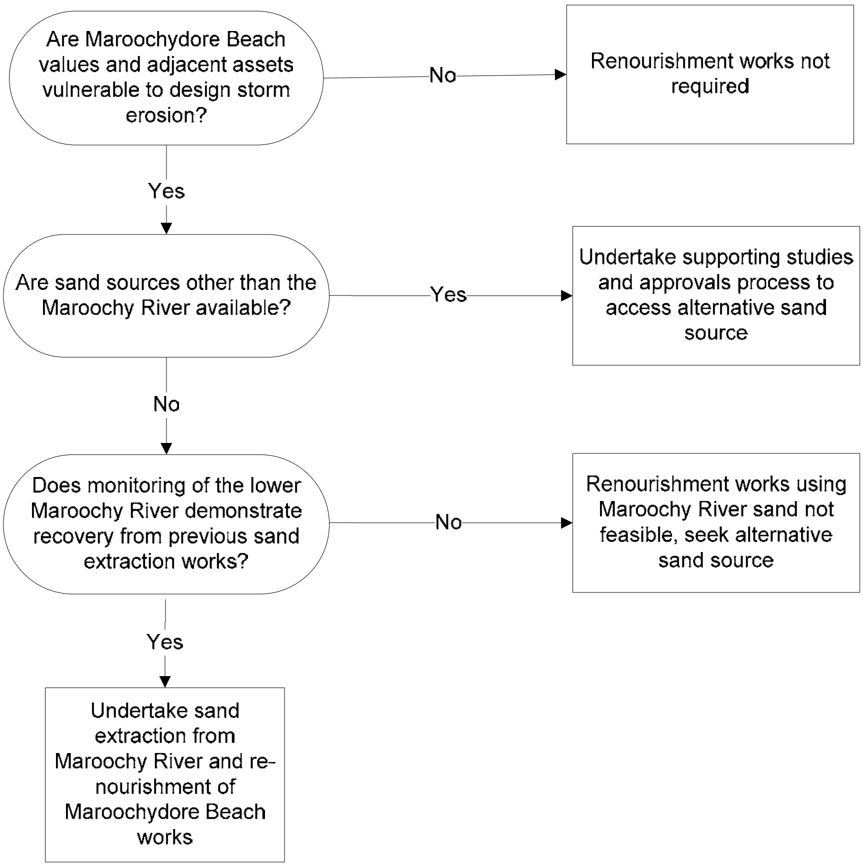

Figure 4-1 Decision Tree for Determining the Need and Feasibility of Future Re-Nourishment Works

The initial proposed sand extraction and nourishment seeks to access 125,000m^3 of sand from the lower Maroochy River. Ideally a similar volume could be accessed in the following year, subject to the outcomes of environmental and shoreline monitoring programs. Progressively smaller volumes may be accessed over the enduring years if it can be demonstrated through monitoring that sand can be sustainably relocated from the lower Maroochy River to Maroochydore Beach on an annual basis.

An idealised, hypothetical renourishment program is outlined in Table 4-2 and seeks to relocate 350,000m^3 over a four year period. The four year nourishment volume exceeds the erosion volumes associated with design storm conditions considered in Section 2.2 and is therefore expected to provide protection to adjacent assets. This preliminary four year estimate should be reviewed annually since sand transport into or out of the beach system will vary from year to year, primarily due to the dependency on storm activity. Success of the proposed project may lead Council to consider a permanent sand recycling system, such as the Submarine Sandshifter used at Noosa Beach. A recycling system would aim to intercept the sand from the littoral drift before it enters the Maroochy River mouth, possibly sourcing material from just south of the existing geotextile groyne field.

Table 4-2 Idealised Maroochydore Beach Renourishment Program

Year	Volume of Material (m3)
1	125,000
2	100,000
3	75,000
4	50,000
5	Consider Feasibility of Permanent Sand Recycling System

It is emphasised that periodic renourishment requirements can vary significantly from year to year and will be influenced by the occurrence of major storms. The volumes in Table 4-2 are estimates only and the actual renourishment interval and frequency will depend on the climatic conditions that occur. To this end, monitoring data is essential and particularly valuable in understanding the performance of the project and for optimising future renourishment programs.

4.3 Shoreline and Bathymetry Monitoring

Physical data collection and monitoring of the project area through beach profile surveys, hydrographic surveys, sediment sampling and aerial photography are required to:

1. Quantify the benefit to Maroochydore Beach in terms of shoreline protection and assess overall project performance;
2. Identify any adverse morphological responses within the lower Maroochy River or northern beaches; and
3. Determine the feasibility of undertaking additional renourishment works using material extracted from the lower Maroochy River.

The proposed physical data collection program designed to achieve these objectives is described below and locations for monitoring/survey works indicated in Figure 4-2. It is anticipated that monitoring would be undertaken throughout the lifetime of the project. An indicative physical data collection schedule is provided in Table 4-4 and is included in the proposed operations schedule in Section 5.5. Additional environmental monitoring programs are described in the supporting Maroochydore Beach Nourishment Approval Application report.

4.3.1 Maroochydore Beach Monitoring

Periodic survey of beach profile lines over the lifetime of the project will enable calculation of:

- The required nourishment volume;
- The volume of nourishment material that remains within the Maroochydore Beach system;
- Determine the amount of material that has remained on the beach; and
- Compare present beach condition to the target storm erosion buffer.

The Maroochydore Beach profile cross-sectional surveys obtained in December 2010 (used for nourishment volume and storm erosion calculations presented in this report) should be repeated prior to undertaking and following the completion of any nourishment works. In the year following the initial placement of nourishment material, additional profiles at 2-3 monthly intervals are also recommended. Analysis of the survey data will allow Council to quantify the benefit and longevity of the proposed nourishment works. Through continual, repeat surveying over the course of many years and potential renourishment programs a better understanding of Maroochydore Beach fluctuations will be developed. This knowledge will also help Council to respond in a considered way to possible future severe erosion events.

4.3.2 Lower Maroochy River Monitoring

A hydrographic survey in the vicinity of the dredge footprint should be undertaken before and after any sand extraction works. This information will provide the basis to determine the recovery (sedimentation rate) within the dredged area and the feasibility of future sand extraction programs. Repeat bed level and sediment characteristics surveys would also be needed prior to each sand extraction program to confirm the volume and quality of material available for future re-nourishment programs. Table 4-3 summarises the lower Maroochy River survey requirements.

Table 4-3 Lower Maroochy River Bathymetry and Sediment Sample Scheme (modified from: USACE, 2002)

Timing	Survey and Sample Description
Pre-works	Sediment cores to characterise target material and access suitability for beach nourishment. Hydrographic survey covering expected dredge area and lower Maroochy River.
Post-works	Sediment cores to characterise post dredged area sediment distribution. Hyrdographic survey of dredged area surface to assess volume removed.
Pre-renourishment works (i.e. prior to an additional nourishment program)	Sediment cores to characterise infilling sediment. Hydrographic survey to determine infilling volume to assess feasibility of renourishment works.

Note: An additional hydrographic survey would be required following a major flood event in the lower Maroochy River.

In addition to surveying below the water level, upper beach profile survey locations along the Cotton Tree shoreline (southern shore of the lower Maroochy River) should also be established and repeated to verify that there are no adverse shoreline responses to the sand extraction works. The Cotton Tree upper beach surveys should be undertaken in conjunction with the lower Maroochy River hydrographic survey works.

4.3.3 Northern Beaches Monitoring

At least one beach profile cross-sectional survey location along North Shore Beach (southern shore of the lower Maroochy River) should be established and repeated to verify that the northern supply of sand is not reduced by the proposed works. The North Shore Beach surveys should include the upper beach profile, extend approximately 800m offshore and be undertaken in conjunction with the Maroochydore Beach surveys.

4.3.4 Physical Data Collection Schedule

A proposed physical monitoring plan is provided in Table 4-4. Throughout the initial year of monitoring the physical response of the placed material would be analysed. Sediment sampling and surveys 10 months after completion of the initial works would characterise the infilling sediment allowing a decision to be made regarding the feasibility of renourishment works.

Table 4-4 Physical Data Collection/Monitoring Plan

Monitoring Component	Initial Works		Month Following Initial Placement				
	Pre-works	Post-works	2	4	6	8	10
Beach profiles	x	x	x	x	x	x	x
Sediment sampling	x	x					x
Dredge area survey	x	x					x

It is understood Council have an agreement with NearMap Pty Ltd who regularly undertake aerial photo mapping of the local government area. This service is likely to provide suitable images to help assess and document the performance of the project. Additional, targeted aerial photography of the shoreline may be considered necessary depending on the timing and frequency of the NearMap surveys.

Beach camera systems, such as CoastalCOMS (Coastal Observation and Monitoring Solutions), may be considered as an additional monitoring option. Such systems can provide valuable physical information including the shoreline position, the beach width and wave statistics.

Title:

Proposed Shoreline and Bathymetry Monitoring

Figure: 4-2

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5 PROPOSED SAND EXTRACTION AND NOURISHMENT OPERATIONS

5.1 Extent of Proposed Sand Extraction

The proposed dredge area is approximately 62,000m^2 and is located in the south channel of the lower Maroochy River. This area is indicated in Figure 3-3 and Figure 5-2.

5.2 Sand Extraction Operations and Footprint

The type of dredging operation that would need to be employed to remove material from the lower Maroochy River will be dependent on the depth at the time of dredging, the physical characteristics of the sediments to be dredged and the location proposed for placement of dredged material within each dredge event. It is understood that previous dredging activity nearby at the Mooloolah River has been undertaken by a variety of dredging methods including by a cutter/suction dredge (CSD), a trailer suction hopper dredge (TSHD) or a clam bucket with hopper dredge (CBHD). It is anticipated that a CSD dredge would be most appropriate for the scale of dredging proposed for this project, this dredge type is discussed below.

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 beach. The maximum distance of pumping depends on the dredge capacity. For the type of dredger that would have sufficient manoeuvrability to operate effectively in the lower Maroochy River a maximum pumping distance of 1.2km may apply. Delivery of sand beyond this distance would be achieved using booster pumps along the pipeline route. A CSD uses a combination of anchors and spuds to pull the dredge along so the footprint of the dredge is higher than for a TSHD. The submerged pipeline crossing from the dredge to the Cotton Tree shoreline may also hinder other vessel access during dredging. A pipeline would need to be permanently in place over the dredging period, as it cannot be easily dismantled and installed each day. A CSD may have a risk of pipeline breaking in heavy seas (although this is unlikely in the lower Maroochy River during the recommended dredge window). In general, a small CSD such as that shown in Figure 5-1 can only work in a swell of up to 0.6m.

Figure 5-1 400mm Cutter Suction Dredge (Photo Courtesy of Hall Contracting Pty Ltd)

5.3 Sand Delivery Pipeline

The proposed tidal works infrastructure consists of a permanent 400mm OD PN8 poly pipeline approximately 2,200m long running from Cotton Tree along the Maroochydore beach to a location just north of the Alexandra Headlands skate park. The general alignment of this pipeline is shown in Figure 5-2. The pipeline will be set back one metre from the edge of the dune line. If subsequent re-nourishment programs are considered viable then the pipeline may become semi-permanent infrastructure and be concealed within the dune system. Outlets (Y-junctions) will be constructed at 500m spacing along the pipeline route. During operations an extension pipeline (approximately 250m long) will connect to one of the outlets, extending from the main pipeline to below the low water mark to allow material to be placed across the full width of the exposed beach profile. These outlets will allow for sand pumped through the pipeline to enter the active beach system and contribute to the building and protection of the beach front.

Where the pipeline crosses beach access points it will be buried or fed through a purpose design conduit. Minor excavation will be required under each access location. It may also be necessary to excavate part of the dune system along the proposed alignment for the pipeline. This work will also require clearing of dune vegetation in an approximate half-metre wide path along the line of the dune. Excavation and clearing work will seek to avoid major trees or shrubs but will requiring clearing of smaller plants, such as dune grasses and juvenile casuarinas. A vegetation expert will be commissioned to assist in identifying the most appropriate pipeline route, avoiding vegetation loss wherever possible. Following the laying of the pipeline, excavated areas of dunes will be rehabilitated and replanted with native vegetation, including dune grasses and casuarinas.

LEGEND

- ▨ Proposed Sand Extraction Area, approx. 64,000m²
- 🟩 Indicative Pipeline Route
- ☐ Fish Habitat Area (DEEDI)
- ▨ Government Land

Title:

Indicative Sand Delivery Pipeline Route

Figure: 5-2

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 250 500m

Approx. Scale

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Filepath : I:\B18779_I_mpb Maroochy_Nourishment\DRG\COA_004_120118_Pipeline.wor

5.4 Beach Profiling

Conventional earth moving machinery (excavator) will be used to distribute the sand delivered to the beach and construct the berm profile. During operating hours (7am to 5pm, Monday to Saturday) beach access will be restricted in the immediate area where sand is being placed and the excavator is working. Temporary fencing to the beach on three sides, enclosing a 50m x 20m working area, will be erected. Considering the net northerly sediment transport along Maroochydore Beach it is anticipated that sand delivery and beach profiling works will commence at the southern extent of the study area (close to Alex Heads Surf Club) and progress north during the operating period.

5.5 Proposed Schedule

The selected dredge contractor will develop a conceptual cut plan/program for the dredging of the sand from the lower Maroochy River. The 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 in the first session to Maroochydore Beach to minimise further impacts from the shoreline erosion.

An indicative project schedule is provided in Table 5-1 which has been developed through consideration of various seasonal and operational factors, including:

- A preference to undertake works during the winter months outside of the shorebird season (refer Section 6.5.2) and when low energy wave conditions are typically observed. This period is 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 16 weeks (proposed period June to September). This operating window conservatively allows for standby days due to poor working conditions or other operational constraints.

Minimum surveying and monitoring requirements are also included Table 5-1. Shoreline profiles, bathymetric surveys and sediment sampling/analysis both before and after the works are considered necessary to enable:

- The volume of material required for beach nourishment;
- Accurate estimates of the volume of material available for extraction;
- Suitability of the material for beach nourishment purposes;
- Benefit and longevity of the works; and
- Feasibility of future sand extraction and re-nourishment works.

It is noted that potential additional sand extraction and beach nourishment works would follow the same schedule with the exception of the pipeline installation (task 6) which is proposed to remain in place following the initial program and re-established for subsequent works. Following the initial sand placement beach profile surveys at two-monthly intervals are recommended (task 9). It may be appropriate to reduce the frequency of periodic beach profile surveys following future renourishment works.

Table 5-1 does not include the nourishment works included as part of the Cotton Tree Foreshore restoration project. To minimise disturbance and project costs, it is anticipated these minor works would be undertaken within the June to September period of the given year (task 7).

Table 5-1 Indicative Project Schedule

Task	Proposed Date/Timing	Responsibility
Pre-operations survey period		
1. Maroochydore Beach survey	Prior to operations	Survey Contractor
2. Maroochy River bathymetric survey	Prior to operations	Survey Contractor
3. Maroochy River south shore survey	Prior to operations	Survey Contractor
4. Sediment Sampling and Analysis	Prior to operations	Geotechnical Consultant
5. Confirm material availability and nourishment requirements	Prior to operations	Dredge Consultant
Operations period		
6. Pipeline installation	Commence April/May	Dredge Contractor
7. Sand extraction and delivery	June to September	Dredge Contractor
8. Environmental monitoring	Continuously during operations period	Council and/or Environmental Consultant
Post-operations survey period		
9. Maroochydore Beach survey	At two monthly intervals following initial operations	Survey Contractor
10. Maroochy River bathymetric survey	Post operations and again at 10 months	Survey Contractor
11. Maroochy River south shore survey	Post operations and again at 10 months	Survey Contractor
12. Pre/post nourishment beach profile analysis	Ongoing throughout project lifetime	Dredge Consultant

6 ENVIRONMENTAL ASSESSMENTS

This section identifies the potential impacts of the proposed project and summarises the recommended mitigation measures. Further detail on the potential impacts and mitigation measures for the proposed project will be discussed in the supporting material to be submitted with the applications for relevant approvals.

6.1 Flooding and Estuarine Hydrodynamics

The Maroochy River entrance is a well flushed and dynamic estuarine system. Due to the relatively minor volume of initial sand extraction being proposed (approximately 125,000m^3) no measurable impacts to flooding or the wider estuarine hydrodynamics are expected. It is noted that detailed modelling considering significantly greater volumes of sediment removal at a number of hypothetical river mouth locations undertaken as part of Maroochy River Entrance Relocation Study (WBM Oceanics, 1997) concluded that estuary flooding was unlikely to be adversely affected. This finding suggests that the wider estuary flood hydrodynamics are relatively insensitive to minor morphological changes at the mouth and is therefore considered relevant to this study. It is acknowledged that the Maroochy River mouth morphology, and most likely the estuary tidal prism, has changed since the previous modelling exercise.

6.2 Estuarine Sediment Transport

The lower estuary of the Maroochy River is a complex system of channels, intertidal shoals, islands and coastal bars. The entrance is dominated by a large spit which extends southwards from the north shore. Within the estuary Goat and Channel Islands (presently connected) divide the river into two main channels.

The river entrance is an important controlling factor on the tidal regime in the estuary. The shoals and sand bars at the entrance generally restrict the propagation of the tide from the ocean into the estuary with corresponding reduction in the tidal range when the entrance area is relatively small. Natural river entrances on sandy coastlines have been shown to exhibit a dynamic equilibrium wherein there is a relation between the tidal prism and the cross-sectional area of the entrance. The present river entrance is considered to be in such dynamic equilibrium.

At the Maroochy River entrance there is a strong relationship between coastal and estuarine processes. Coastal sediment transport plays a significant role in the development of coastal spits and the migration of the entrance channels. It is also an important factor in the overall dynamic behaviour of the lower river by suppling sand which is transported into the estuary under the influence of the prevailing tide and wave conditions.

As part of the process of the Maroochy River entrance relocating to the south of Pincushion Island in 1999, a large quantity of sand, which was the beach and dune system connecting to Pincushion Island, moved into the entrance. This caused substantial shoaling in the lower part of the estuary. This sand has largely remained within the estuary and is reworked by the prevailing coastal and estuarine processes. Under major riverine flood conditions much of this material would be scoured and naturally distributed back to the sea with the flood flow discharge. Such river conditions have not been experienced in the lower Maroochy River since 1992, an event that caused the river mouth bed level to scour and deepen by up to 4m (BMT WBM, 2008).

Following a major flood event, areas where sandy material has been removed via natural processes are expected to gradually infill with sediment from neighbouring and offshore areas as the estuary morphology finds a new dynamic equilibrium. Similar sedimentation processes will occur following the removal of sand via anthropogenic methods however the scale of impact is typically smaller and therefore the system returns to dynamic equilibrium more rapidly.

In the case of the dredging proposed for this project, the removal of sediment may lead to minor changes of the tidal hydrodynamics. Small changes to the magnitude of flood and ebb tide currents in the vicinity of the dredge footprint are expected however this will not constitute a significant impact to the overall existing tidal regime. Minor modification to the tidal currents will lead to corresponding changes to the sediment transport potential. These changes are expected to drive sedimentation within the dredged area and may lead to modification to the adjacent intertidal shoals and the Cotton Tree Caravan Park shoreline. It is noted that this impact is expected to be minor and well within natural fluctuations, therefore having little influence on long term sedimentation rates or shoreline position. A monitoring program designed to detect any adverse morphological responses following the proposed works is described in Section 4.2.

6.3 Coastal Sediment Transport

Sand relocated from the Maroochy River mouth and placed along Maroochydore Beach will be available for immediate distribution and transport by the natural coastal processes. This would be an advantage for the beach in its present eroded state. Over time the placed sand is expected to be dispersed laterally and offshore and eventually transported toward the north, either moving back into the lower estuary or bypassing the river mouth and benefiting the beaches to the north. While the project will modify the coastal sediment transport rates along Maroochydore Beach by supplying the system with more material, no adverse impacts to coastal sediment transport are expected.

6.4 Water Quality

6.4.1 Environmental Values and Water Quality Objectives

Environmental values (EVs) for water and water quality objectives (WQOs) for the site area, under the *Environmental Protection (Water) Policy 2009* (EPP (Water)), are set by the EPP (Water) *Maroochy River Environmental Values and Water Quality Objectives*.

EVs are identified for both open coastal and enclosed coastal/lower estuary waters, covering both the Maroochydore coastline and the extraction sites within the Maroochy River. These EVs consist of both aquatic ecosystem EVs (related to the protection of aquatic ecosystems, including seagrass) and human use EVs (related to recreational, consumption and cultural values). EVs identified for the entire site area are:

- Aquatic ecosystems;
- Human consumer;
- Primary recreation;

- Secondary recreation;
- Visual recreation; and
- Cultural and spiritual values.

In addition, seagrass has been identified as an EV for open coastal waters.

WQOs are prescribed for the protection of the EVs. These are listed in Table 6-1 below.

Table 6-1 Maroochy River Water Quality Objectives

EV	WQO to protect EV
Protection of aquatic ecosystems (open coastal waters)	• turbidity: <1 NTU • suspended solids: <10 mg/L • chlorophyll a: <1 µg/L • total nitrogen: <150 µg/L • oxidised N: <3 µg/L • ammonia N: <5 µg/L • organic N: < 140 µg/L • total phosphorus: <16 µg/L • filterable reactive phosphorus (FRP): <5 µg/L • dissolved oxygen: 95 – 105% saturation • pH: 8.2 – 8.4 • secchi depth: >5.0m
Protection of aquatic ecosystems (enclosed coastal/lower estuary waters)	• turbidity: <6 NTU • suspended solids: <15 mg/L • chlorophyll a: <2 µg/L • total nitrogen: <200 µg/L • oxidised N: <3 µg/L • ammonia N: <8 µg/L • organic N: < 180 µg/L • total phosphorus: <20 µg/L • filterable reactive phosphorus (FRP): <6 µg/L • dissolved oxygen: 90 – 105% saturation • pH: 8.0 – 8.4 • secchi depth: >1.5m (note: minimum secchi depth needed to restore seagrass to areas where it has been lost is 1.7m)
Protection of seagrass (marine/estuarine waters)	The minimum WQOs needed to restore seagrass to areas where it has been lost are: • median total suspended solids: <10 mg/L • median secchi depth: 1.7 m • light attenuation coefficient: >0.9 However, in areas where seagrass is intact, it is more important to maintain existing water quality. Therefore the WQOs are: • local total suspended solids, turbidity, secchi and light attenuation is maintained • local seagrass distribution and composition is maintained, as measured by:

EV	WQO to protect EV
	- extent of seagrass - species diversity - seagrass depth limit
Protection of aquatic ecosystems (riparian areas)	Protect or restore riparian areas
Suitability for visual recreation	Recreational water bodes should be aesthetically acceptable to recreational users. The water should be free from visible materials that may settle to form objectionable deposits; floating debris, oil, scum and other matter; substances producing objectionable colour, odour, taste or turbidity; and substances and conditions that produce undesirable aquatic life
Protection of cultural and spiritual values	Protect or restore indigenous and non-indigenous cultural heritage consistent with relevant policies and plans

6.4.2 Impact and Mitigation

The proposed works involve dredging in the Maroochy River. This has the potential to cause impacts to water quality in relation to turbidity and release of waste chemicals and litter. It is noted that the material proposed to be dredged is dominated by marine sands that do not generate significant turbidity plumes (both in intensity and extent).

Mitigation measures proposed in the Site Based Management Plan include:

- Operation of the dredge in a manner that minimises turbidity during operations;
- Visual monitoring of the plume by the dredging contractor;
- Water quality testing by the dredging contractor, assessed against DERM standards; and
- Visual monitoring for oil, grease, floating scum and litter.

Where any impact to water quality is observed, operations will be amended to ensure the management of this impact.

6.5 Aquatic and Terrestrial Ecology

The ecology of the Maroochydore Beach and Maroochy River consists of both aquatic and terrestrial fauna and flora species. Within these groupings there are a number of species and communities which are significant at a State and National level.

6.5.1 Regional Ecosystems

Regional ecosystems of the study area consist of strand and fore dune complex, occurring in a narrow strip with width increasing towards the north of Maroochydore Beach and along island within the Maroochy River. This community is sparsely structured and consists of spinifex grassland and casuarina woodlands. The ecosystem is presently listed as a least concern regional ecosystem (RE) (12.12.14) under the *Vegetation Management Act 1999* (VM Act).

Vegetation continues northward along the line of the dune from the north-east corner of the Alexandra Headlands skate park, developing from sparse dune vegetation to open woodland, almost unbroken to the mouth of the Maroochy River. Breaks in cover do occur at the Maroochy Surf Lifesaving Club and along a number of beach access routes. Vegetation immediately adjacent to the Maroochy River is mostly non-remnant and cleared.

Prominent species include:

- *Spinifex sericeus*
- *Casuarina equisetifolia spp*
- *Acacia leiocalyx*
- *A. disparrima*
- *Banksia integrifolia*
- *Pandanus tectorius*
- *Corymbia tessellaris*
- *Cupaniopsis anacardioides*
- *Acronychia imperforata*

6.5.2 Listed Species

There are a number of threatened and migratory species listed at both State and national levels that are known or likely to use the existing vegetation at the site as habitat for foraging, nesting and/or roosting purposes.

6.5.2.1 Threatened Species

Threatened species include five species listed under the *Nature Conservation Act 1994* (NC Act) and 50 species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act). While not all these species are likely to occur on site, a number are confirmed to occur on site. These include:

- Sooty oystercatcher
- Little tern
- Eastern curlew
- Koala
- Australasian bittern
- Grey-headed flying-fox
- Water mouse
- Loggerhead turtle
- Green turtle
- *Prasophyllum exilis*

Other important species are also likely to occur on site.

6.5.2.2 Migratory Species

Migratory species are protected under the EPBC Act as a Matter of National Environmental Significance. This includes terrestrial migratory species, marine migratory species, and shorebirds.

Shorebirds – Maroochydore Beach and the lower Maroochy River are common nesting and roosting site for a number of migratory shorebirds. Under the *Maroochy Plan 2000* the dunes of Alexandra Headland and Cotton Tree Planning Areas (encompassing the entire site) are identified as significant habitat for these birds. Similarly, mapping of significant coastal biodiversity under the State coastal plans has identified these coastal dunes as important habitat for shorebirds.

Five separate shorebird roosting areas have been identified by local surveys:

- Area A – Maroochy River north shore;
- Area B - Maroochy River sand bar;
- Area C – Goat Island (eastern);
- Area D – Goat Island (western); and
- Area E – Maroochy River Nojoor Road Sandbanks.

These surveys have recorded significant populations of migratory terns and other shorebird species. Area A is the only site providing sanctuary for birds during the highest tides. Area E and the northern section of Area D represent the single most important site in the estuary for feeding and roosting.

Shorebirds occupy these Areas during the months between September and March/April.

Migratory terrestrial species – terrestrial migratory species are exclusively birds including the rainbow bee-eater, rufous fantail and regent honeyeater. These species are not common in the Maroochydore area and usually occur in low density.

Migratory marine species – migratory marine species include cetaceans (i.e. humpback whale) and sea turtles (i.e. green turtle, loggerhead turtle).

These species are not expected to be found within the lower Maroochy River however may be observed offshore from coastal areas. Migrating cetaceans tend to swim to the east of Moreton Island, coming closer to shore further north at Hervey Bay and Fraser Island. Sea turtles are known to forage in benthic vegetation offshore and to nest in the Sunshine Coast area on very limited occasions (tens of females), usually further south towards Caloundra. These activities, however, are not known to occur within the direct vicinity of the site and thus it is extremely unlikely that any migratory marine species will be present on site.

6.5.3 Fish Habitat Areas

Maroochy River is a fish habitat area (FHA), declared by Fisheries Queensland, under the Department of Employment, Economic Development and Innovation (DEEDI), to protect important fisheries resources. Important species in this FHA include:

- Australian bass
- Bream
- Estuary cod
- Blue salmon
- Flathead
- Garfish
- Jewfish
- Luderick
- Mangrove jack
- Sea mullet
- Tailor
- Whiting
- Banana prawns
- Mud crabs
- School prawns
- Greasyback prawns
- Eastern king prawns
- Bay prawns

Marine vegetation on shores adjoining the FHA include *Rhizophora*, *Bruguiera* and *Avicennia* mangroves together with saltmarsh along the northern shore, *Achrostichum speciosum* (mangrove fern) along the southern shore, and sparsely-vegetated sandbanks. Vegetation communities on the in-stream islands are RE 12.12.14, including casuarinas, an important marine plant. Seagrass beds also occur within the Maroochy River.

There are no mangroves in close proximity to proposed dredging areas.

6.5.4 Impact and Mitigation

Impacts on aquatic and terrestrial ecology include the physical removal of important species as well as disruption or loss to roosting, nesting, foraging and breeding habitat, and the disruption of species movement. Dredging activities may also lead to the pollution of receiving waters (see Section 6.4 above). Where excavated areas are left open within proximity to species habitat, there is also risk that species will fall into holes and become injured or trapped.

These impacts are to be mitigated in the following way:

- Exclusion of mapped seagrass beds larger than 25m^2 from dredging areas;
- Exclusion of dredging in shorebird Areas A, D and E and keeping all machinery and equipment far from these areas;
- Development of emergency, contingency and spill response procedures by dredging contractor;
- Disposal of waste at onshore facilities;
- Visual monitoring of water (for pollution and waste spills);
- Restricted and stage clearing and excavating, followed immediately by revegetation;
- Use of spotter-catcher to remove fauna species before clearing; and
- Fencing of excavation areas.

6.6 Visual and Recreational Amenity

Dredging and placement of the dredged material will result in the formation of visual plumes during operations that are noticeable (particularly from the air or at elevated locations near the Maroochy River mouth, such high rise apartments) and can affect the visual amenity of the lower Maroochy River and nearshore marine area. These plumes are largely unavoidable in the context of existing technology but are not likely to have long term adverse ecological effects. Given that the dredging will not be continuous (only undertaken between 7am and 5pm) and that the material being targeted is predominantly marine sand likely to quickly settle out of suspension, the effects of turbidity plumes from operation of the dredger on visual amenity is not seen as a significant issue.

6.7 Ambient Noise on Site

Adjacent to the southern part of the development area is Alexandra Parade, a State controlled road and one of the major arterials for the Sunshine Coast Region. On the opposite side of Alexandra Parade are a series of shops and residential accommodation facilities, mainly catering towards tourism traffic in the area. On the coastward side of the road is vegetated dunes and beach. Noise associated with the development area, therefore, varies. Overall ambient noise sources include:

- Road traffic;

- Resort and hotel (facilities, bar, residents etc.);
- Residential homes;
- Caravan parks (Cotton Tree and Maroochydore Sea Breeze);
- Beachfront apartments;
- Pedestrians and beachgoers;
- Surf clubs (Alexandra Heads and Maroochy);
- Offshore boating; and
- Natural sources such as waves and wind.

Local ambient noise is therefore higher during daytime hours than night with most noise lessening at night due to compulsion (i.e. caravan parks and resorts) or by practicality (pedestrians and road traffic). The biological environment that currently exists is adapted to this level and pattern of ambient noise.

No ambient noise measurements have been undertaken as part of this study.

6.7.1 Impact and Mitigation

Dredging, clearing and tidal works will lead to an increase in ambient noise from the machinery and tools used. This is unlikely to impact the surrounding environment in daylight hours, due to high ambient noise already existing, but would impact the ambient noise at night. Impacts include:

- Disturbance of local residents and shops;
- Loss of tourism revenue from hotels and caravan park;
- Disturbance of diurnal species; and
- Disruption of nocturnal species.

As dredging may need to be undertaken in conjunction with tides, work may be necessitated outside normal working hours.

Measures aimed at mitigating impact to noise include:

- Contractor to take all reasonable precautions to minimise noise, such as the use of mufflers;
- Contractor to undertake aural inspection daily to identify excessive noise;
- Where complaints are received, the contractor or a relevant agent must undertake noise monitoring to ensure compliance with permit conditions; and
- Where monitoring reveals non-compliant noise levels, remedial action is to be taken immediately.

The contractor will also ensure the taking of all reasonable precautions

6.8 Access and Navigation

Navigational safety within the lower Maroochy River will be maintained during throughout the dredge campaign through the following actions:

- Advise the Regional Harbour Master with details to issue a Notice to Mariners prior to the commencement of dredging operations; and
- Meet with and consult with the Regional Harbour Master prior to commencement of dredging activities and during the dredging campaign as needed.

The outcome will be that no marine accidents associated with the dredge operations occur.

Access to Maroochydore Beach will be restricted within a small area where earth moving machinery is used to profile the nourishment material throughout the duration of the project. This location will vary depending on the stage of the works. Temporary fencing enclosing a 50m x 20m area will be used to restrict access and ensure no public accidents associated with the profiling works are caused.

6.9 Native Title

When undertaking dredging and placement of dredged material, all reasonable and practicable measures must be undertaken to ensure activities do not harm Aboriginal cultural heritage, pursuant to the *Aboriginal Cultural Heritage Act 2003*. Measures that may be taken to ensure compliance with this Act include:

- Following the statutory ‘duty of care’ guidelines, which may require consultation with the relevant Aboriginal party; or
- Development and approval of a Cultural Heritage Management Plan.

Compliance with the *Aboriginal Cultural Heritage Act 2003* will need to be determined prior to the commencement of any dredging and disposal works.

Native title legislation in Australia provides for the recognition and protection of native title. The Commonwealth *Native Title Act 1993* and *Native Title (Queensland) Act 1993* should be considered prior to the commencement of works.

Cognisant of the requirements under the *Native Title Act*, native title parties would be given notification and an opportunity to comment on proposed activities that could affect native title rights prior to the commencement of future dredging operations.

6.10 Environmental Management Plan

A proposed Site Based Management Plan has been developed for the project and is included in the supporting Maroochydore Beach and Cotton Tree Foreshore Nourishment Approval Application report. The management measures proposed address the requirements of State authorities in relation to the approvals required for the proposed works.

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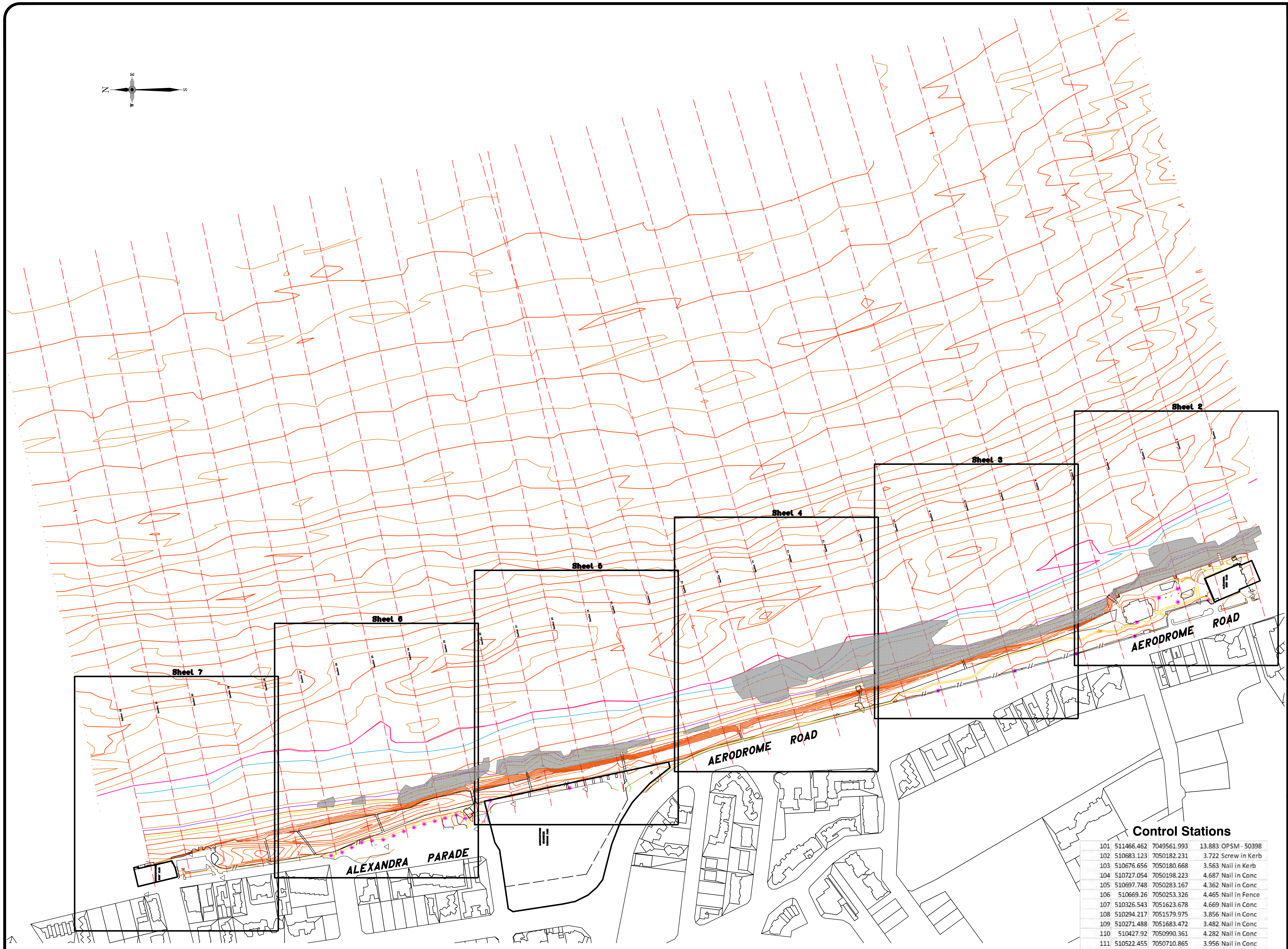
APPENDIX A: UPPER BEACH AND NEARSHORE SURVEY



Control Stations

101	511466.462	7049561.993	13.883	OPSM - 50398
102	510683.123	7050182.231	3.722	Screw in Kerb
103	510676.656	7050180.668	3.563	Nail in Kerb
104	510727.054	7050198.223	4.687	Nail in Conc
105	510697.748	7050283.167	4.362	Nail in Conc
106	510669.26	7050253.326	4.465	Nail in Fence
107	510326.543	7051623.678	4.669	Nail in Conc
108	510294.217	7051579.975	3.856	Nail in Conc
109	510271.488	7051683.472	3.482	Nail in Conc
110	510427.92	7050990.361	4.282	Nail in Conc
111	510522.455	7050710.865	3.956	Nail in Conc
112	510414.787	7051086.877	4.576	Nail in Kerb
113	510394.647	7051185.054	4.088	Nail in Kerb
114	510360.568	7051235.234	3.89	Nail in Kerb
115	510336.461	7051357.039	3.532	Dumpy Peg
116	510310.477	7051331.288	3.192	OPSM - 137818
117	510309.599	7051455.558	3.498	OPSM - 19398
118	510481.411	7050699.496	3.585	OPSM - 90529

Defined Contours (AHD)

−0.99m	LAT (Lowest Astronomical Tide)
−0.73m	MLWS (Mean Low Spring Tide)
+0.67m	MHWS (Mean High Spring Tide)
+1.18m	HAT (Highest Astronomical Tide)

Scale 1:2500 – Lengths are in Metres.

20 0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360

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LEGEND

COMMUNICATIONS

▭ COMMUNICATIONS PIT

ELECTRICITY

● POWER POLE

✱ LIGHT POLE

▭ ELECTRICAL PILLAR

ELECTRICITY O/H

ROAD

⊖ STREET SIGN

EDGE OF BITUMEN

FENCE

SEWERAGE

Ⓢ SEWER MANHOLE

STORMWATER

○ STORMWATER M/H

▭ GULLY TRAP

SURVEY

△ SURVEY STATION

◎ PSM

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SHEET 1 OF 7

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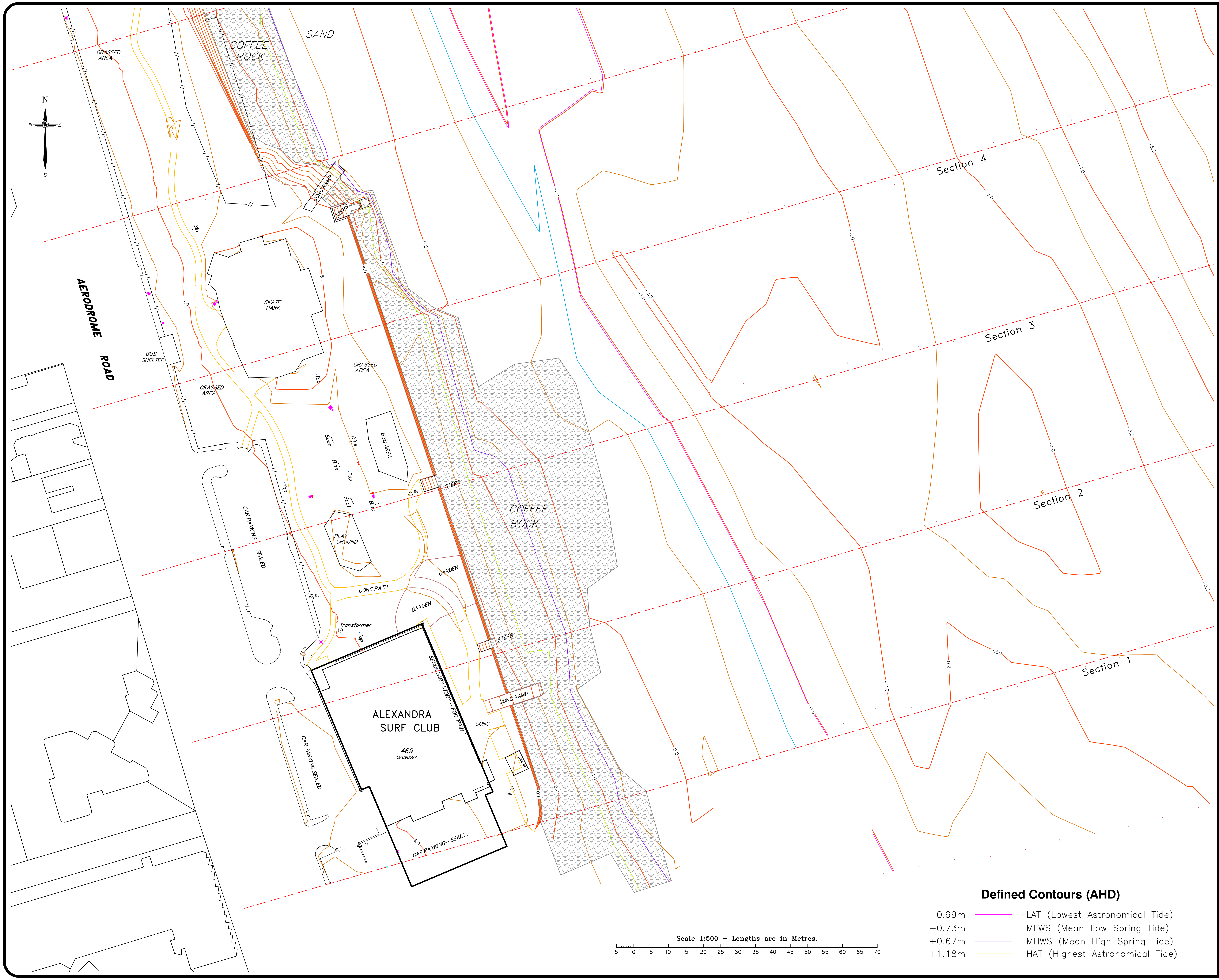

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- E ELECTRICAL PILLAR
- ELECTRICITY O/H

ROAD
- STREET SIGN
- EDGE OF BITUMEN
- FENCE

SEWERAGE
- S SEWER MANHOLE

STORMWATER
- SW STORMWATER M/H
- GULLY TRAP

SURVEY
- △ SURVEY STATION
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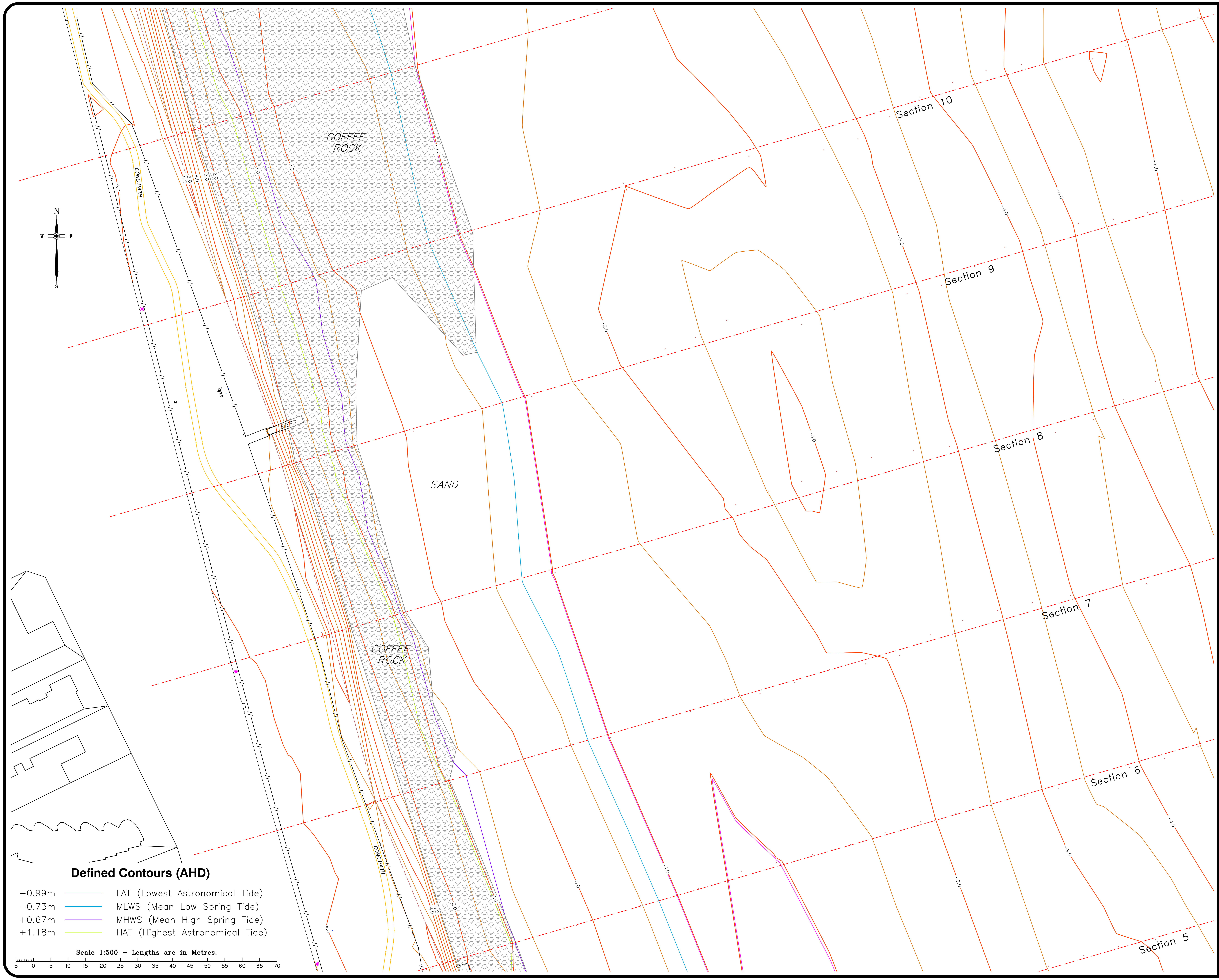

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ELECTRICITY

● POWER POLE

✷ LIGHT POLE

E ELECTRICAL PILLAR

—⌇— ELECTRICITY O/H

ROAD

⊖ STREET SIGN

– – – – EDGE OF BITUMEN

—//— FENCE

SEWERAGE

Ⓢ SEWER MANHOLE

STORMWATER

SW STORMWATER M/H

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SHEET 3 OF 7

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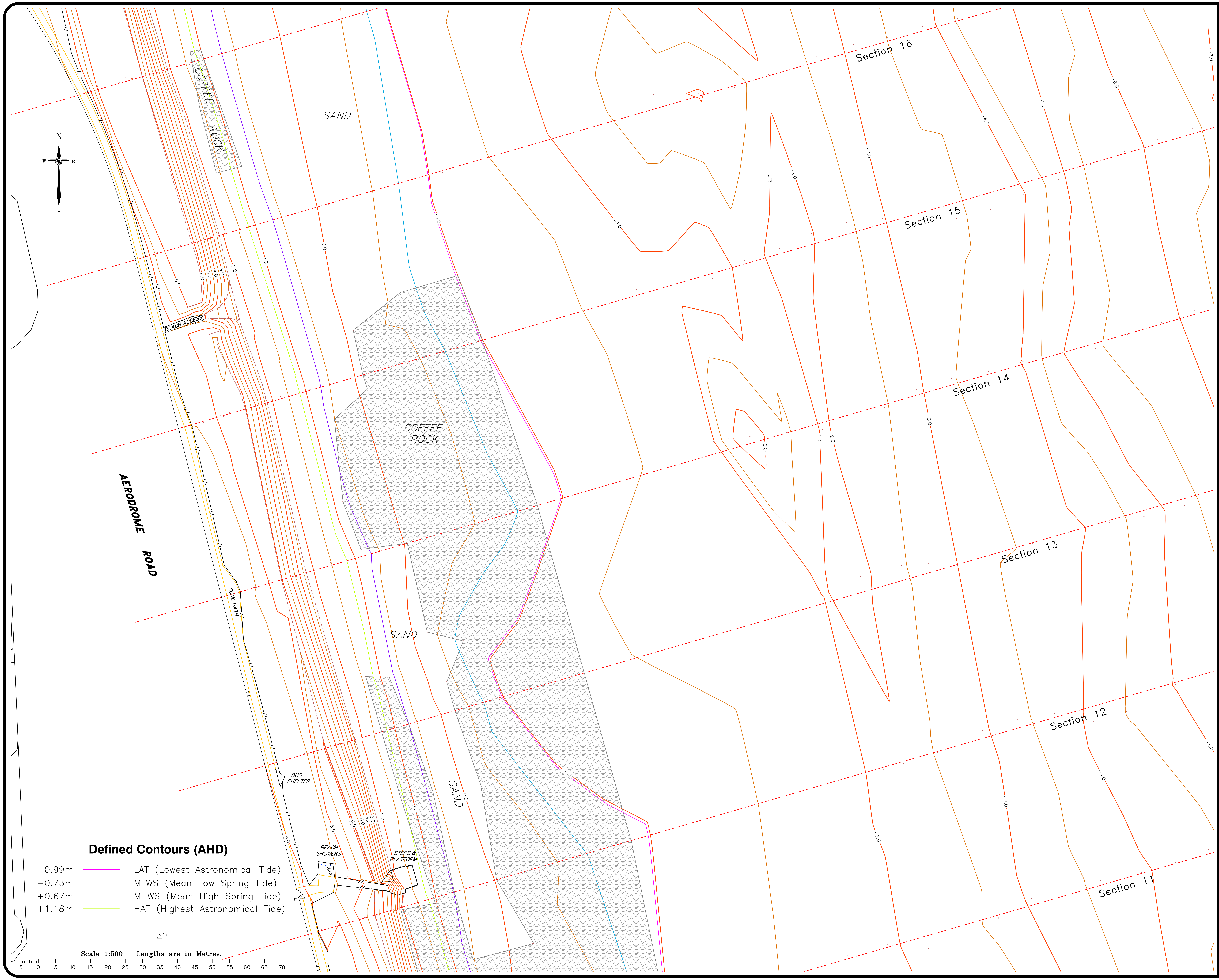

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5 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70

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FENCE

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SHEET 4 OF 7
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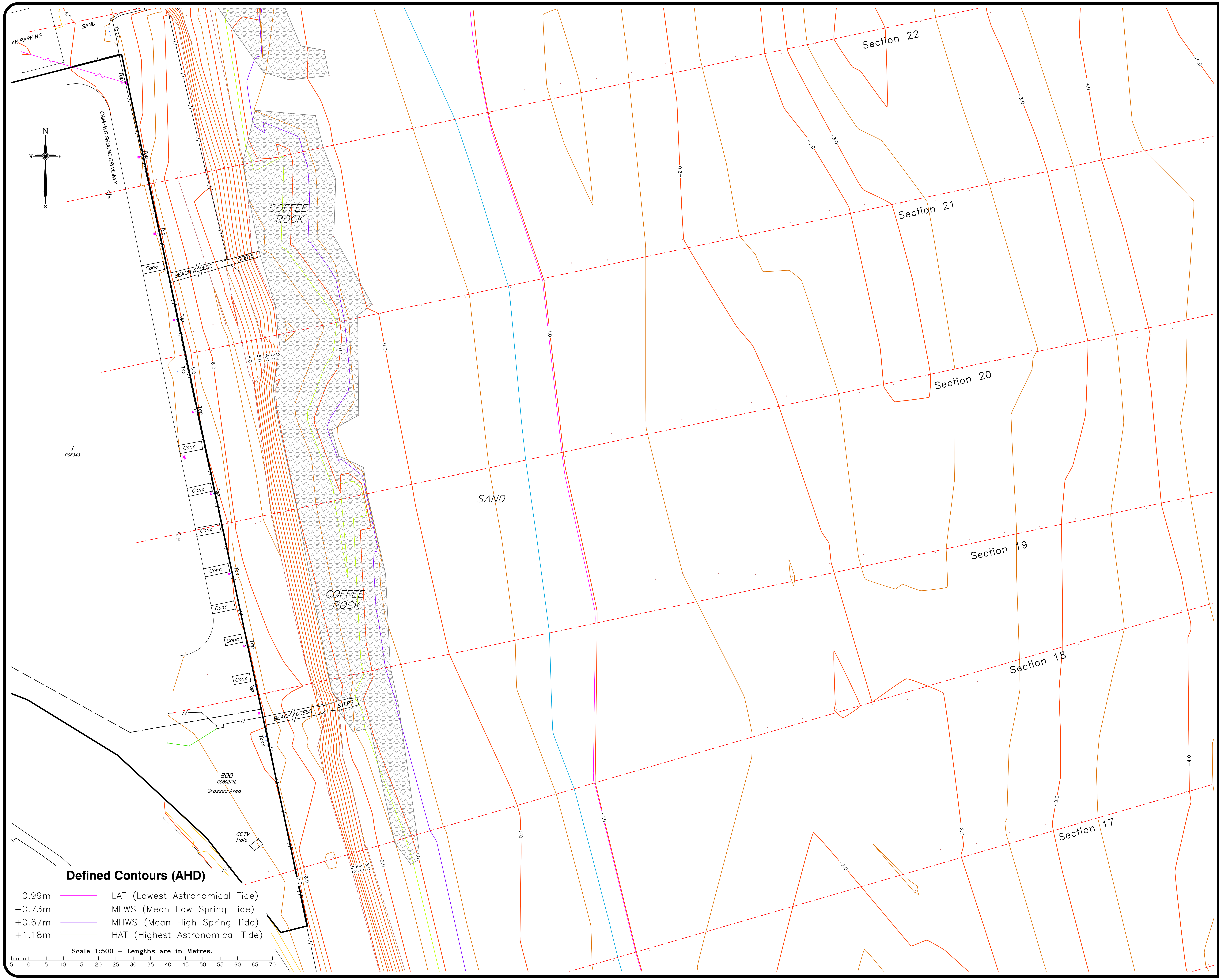

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- E ELECTRICAL PILLAR
- ELECTRICITY O/H

ROAD
- STREET SIGN
- EDGE OF BITUMEN
- FENCE

SEWERAGE
- Ⓢ SEWER MANHOLE

STORMWATER
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SHEET 5 OF 7
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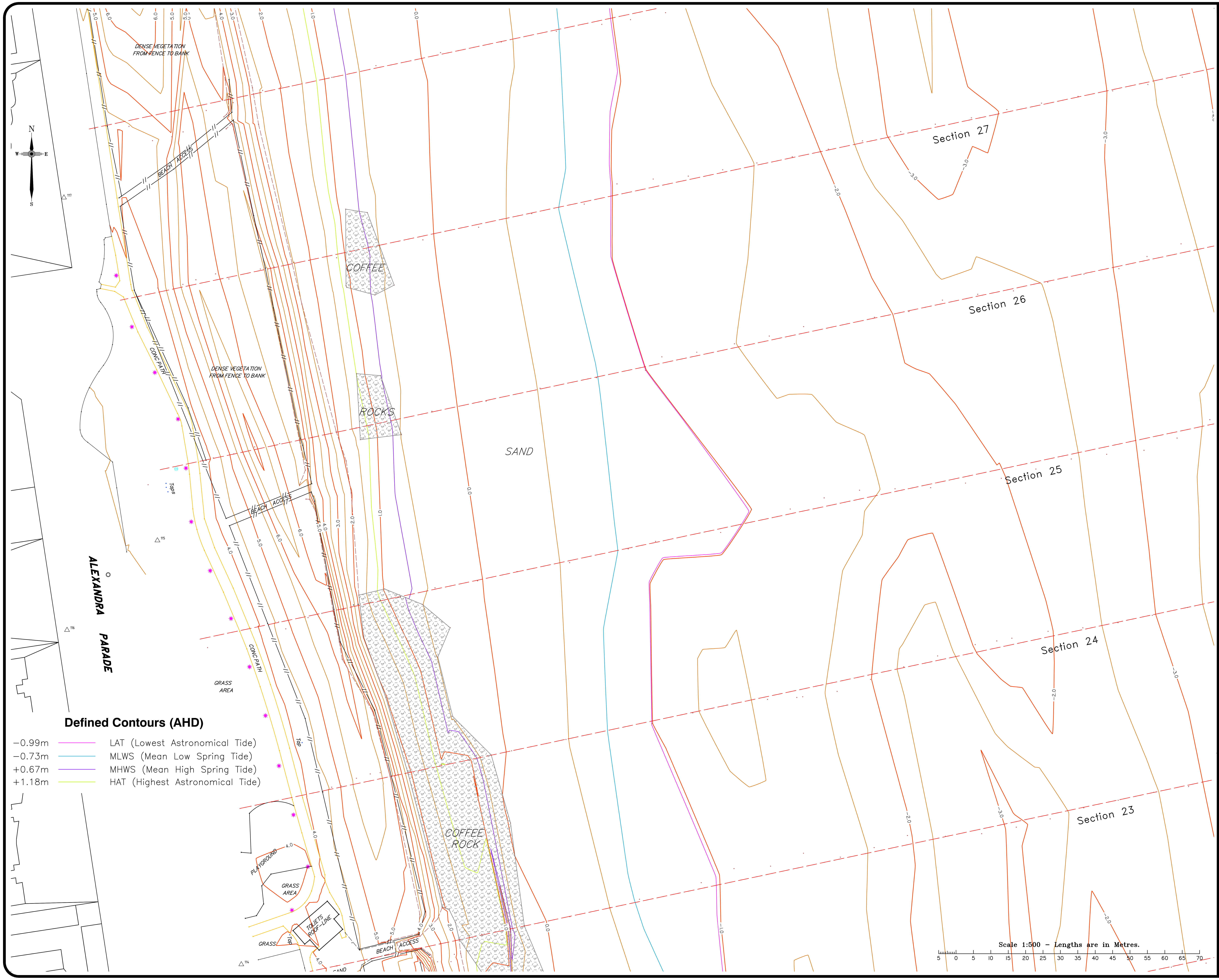

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―//― FENCE

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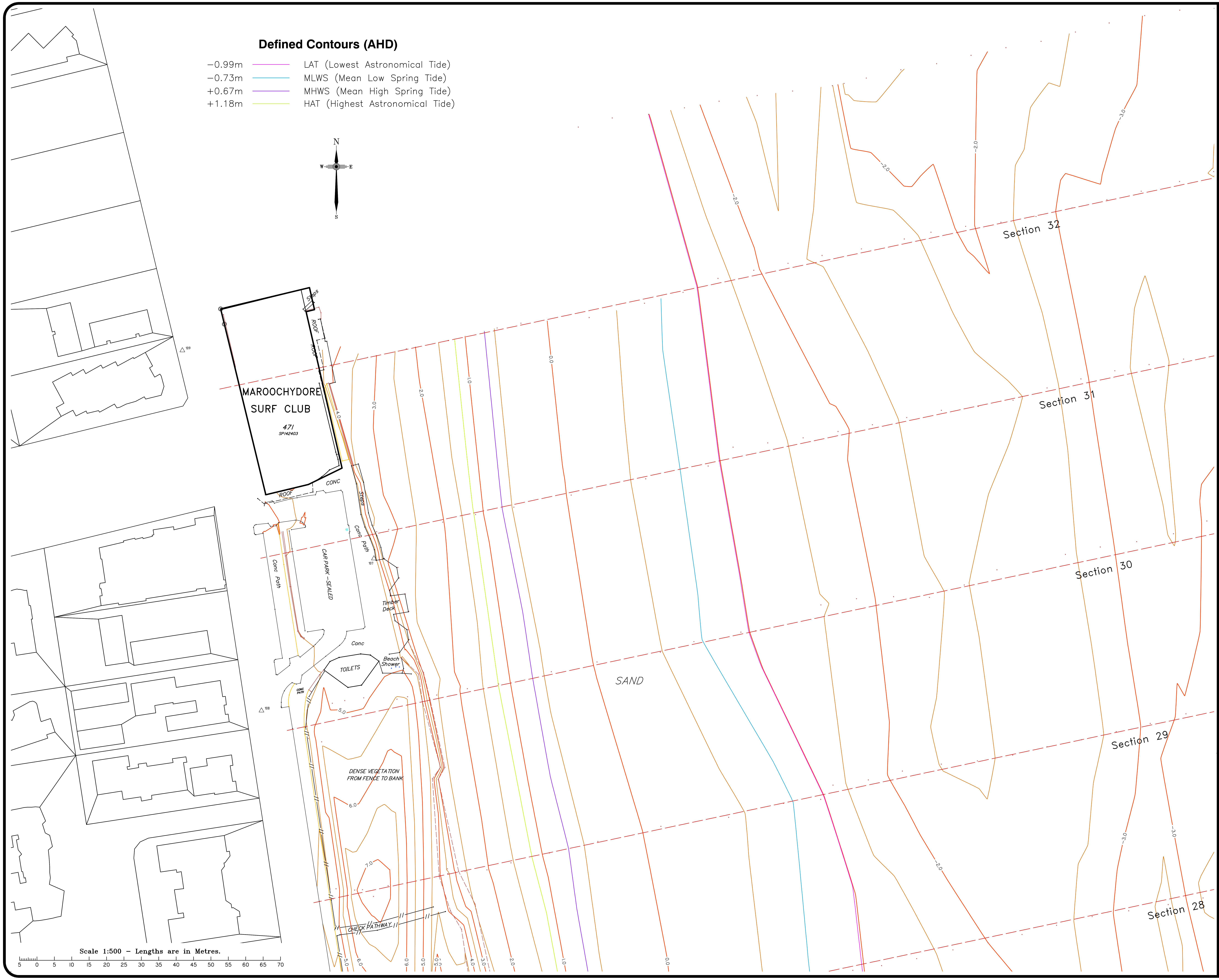

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APPENDIX B: STORM EROSION PROFILES

SHORT TERM STORM EROSION

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

The potential for short term storm erosion due to severe wave and elevated sea water levels (surge conditions) has been predicted using the simple cross-shore equilibrium profile model of Vellinga (1983). This storm erosion model requires the following inputs:

- An initial beach profile and sediment characteristics;
- Design wave conditions (50yr ARI adopted); and
- Design storm surge conditions (100yr ARI adopted).

Storm erosion assessment was performed at 16 locations where recent cross-sectional beach profile measurements were obtained (odd numbered cross-sections indicated in Figure 2-1). For all storm erosion assessments median sand grain size of 0.2mm was applied. The Queensland Coastal Plan (DERM, 2012) recommends the 50yr ARI offshore wave height and the 100yr ARI storm tide levels are used for the short term erosion assessment. The design wave condition was obtained from the wave assessment undertaken as part of the Sunshine Coast SEMP coastal processes investigation (BMT WBM, 2011). The design storm tide level, excluding wave setup, was obtained from the Maroochy Shire Storm Tide Study (Connell Wagner, 2005). The contribution of wave setup to the design water level was assumed to be 12.5% of the design wave height. The adopted design wave and water level conditions were:

- 50yr ARI Wave Height = 6.0m; and
- 100yr ARI Water Level = 2.4m.

Table B- 1 lists the predicted storm erosion for the 16 locations. The storm erosion distance is measured landward from the position where the design water level intersects the beach profile. The resulting erosion profile is presented with the initial beach profile for each location.

Table B- 1 Summary of Design Storm Erosion Widths between Alex Heads and Maroochydore Surf Clubs

Section (refer Figure 2-1)	Design Storm Erosion Width (m)
1	44
3	62
5	59
7	58
9	61
11	58
13	58
15	56
17	40
19	38
21	37
23	36
25	25
27	28
29	26
31	36
Average Storm Erosion Width	**45**

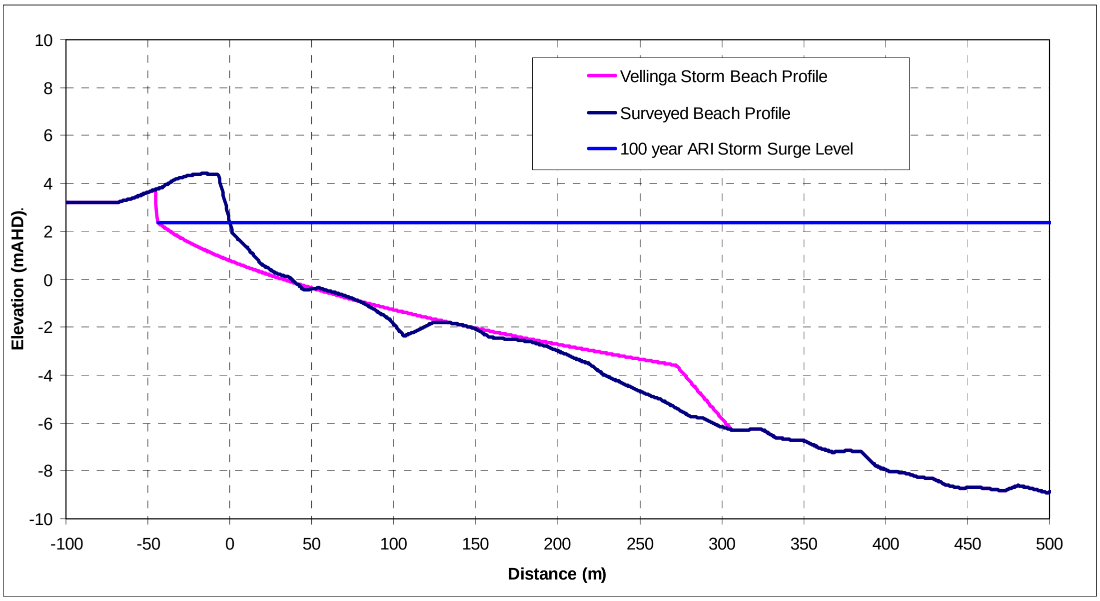


Figure B- 1 Beach Profile 1 and Predicted Storm Profile

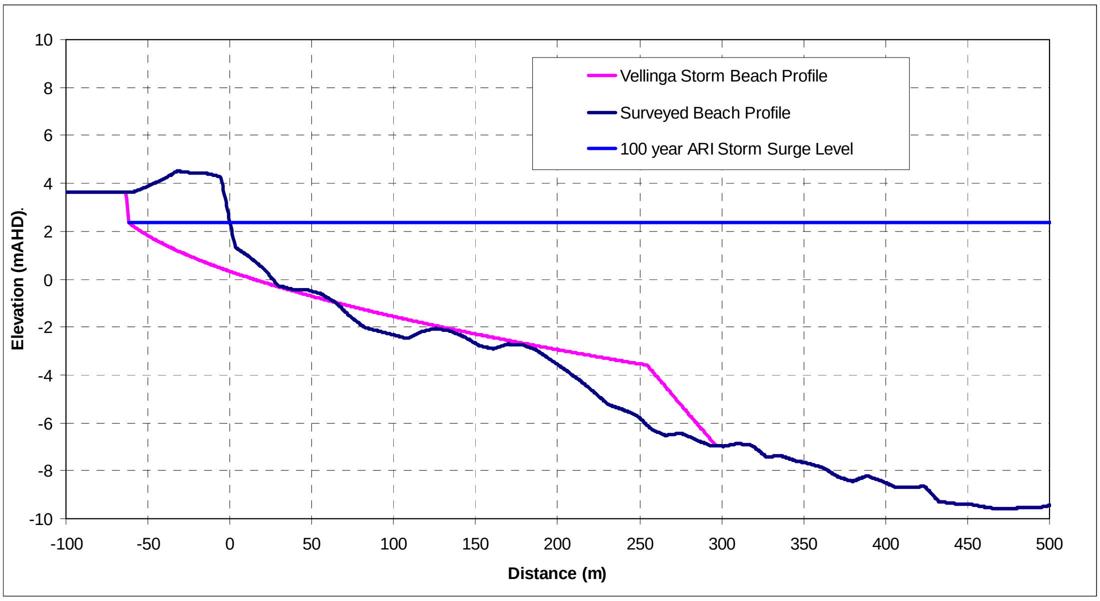


Figure B- 2 Beach Profile 3 and Predicted Storm Profile

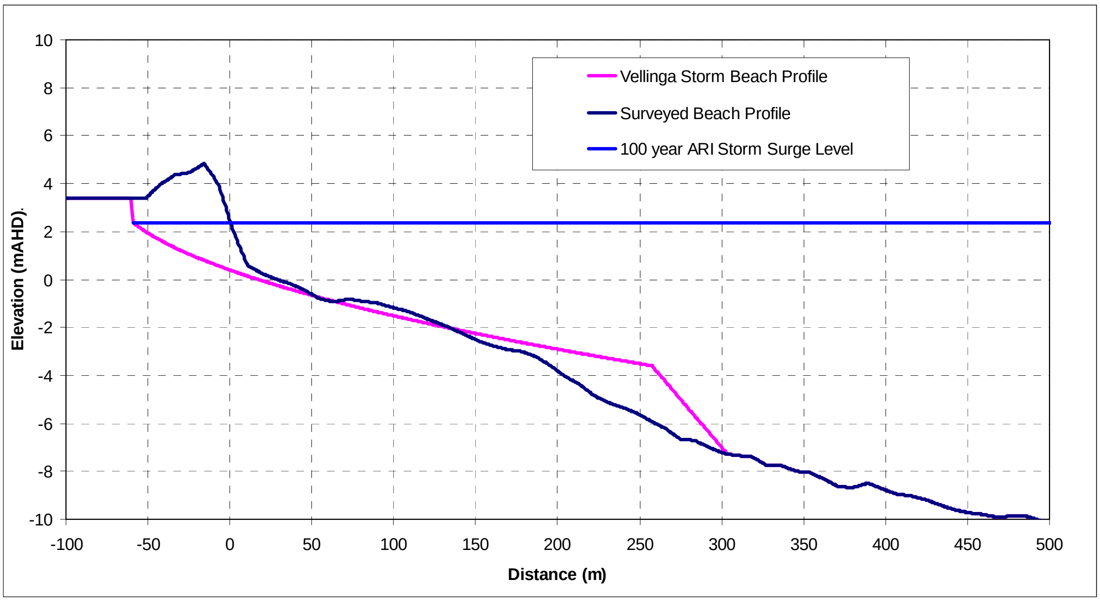
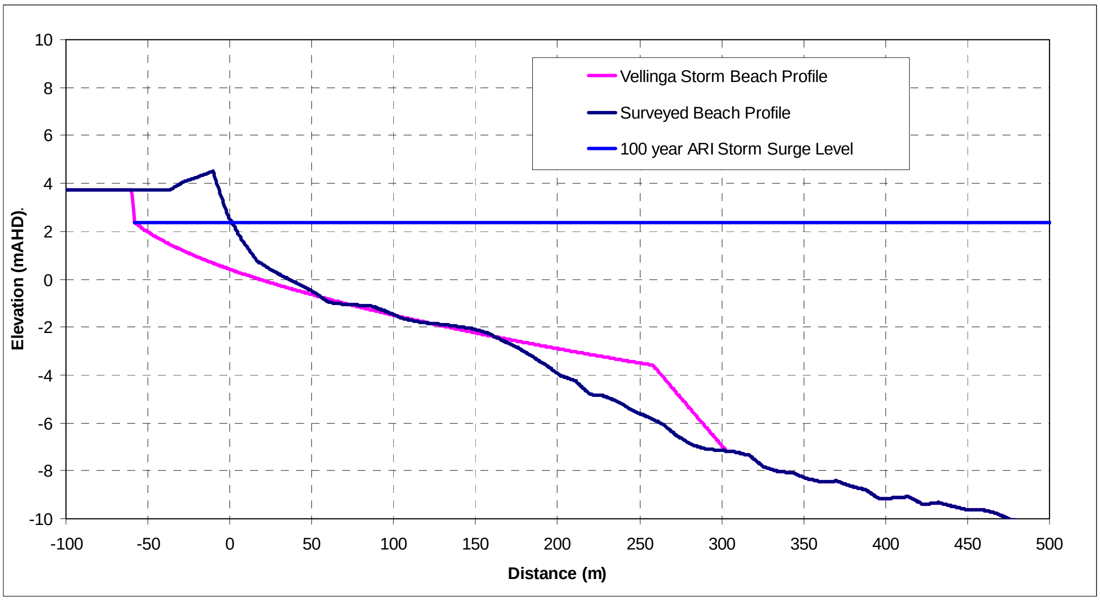


Figure B- 3 Beach Profile 5 and Predicted Storm Profile



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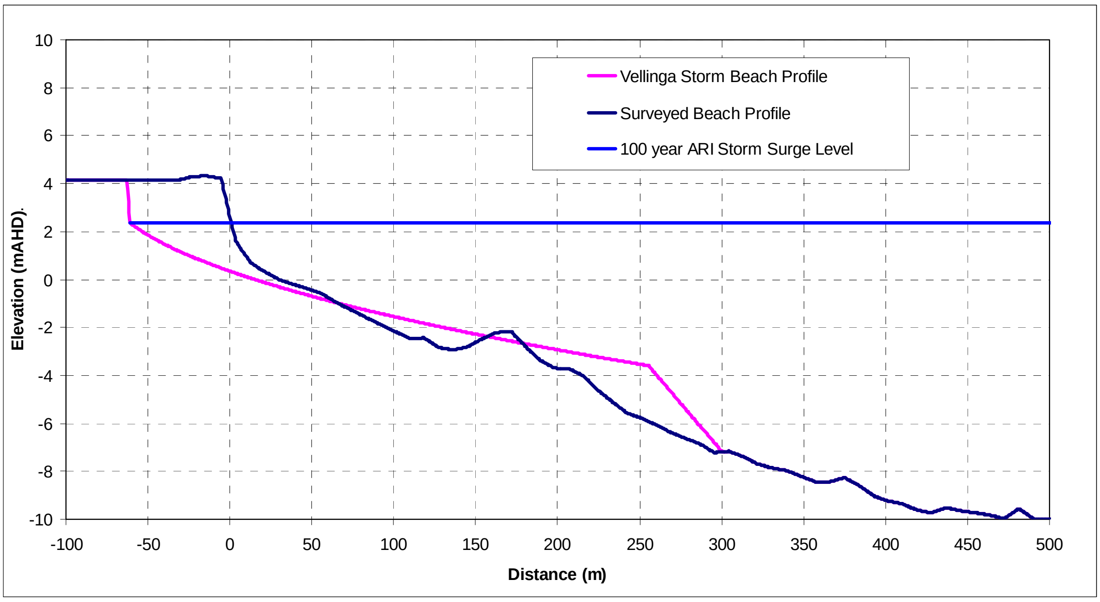


Figure B- 5 Beach Profile 9 and Predicted Storm Profile

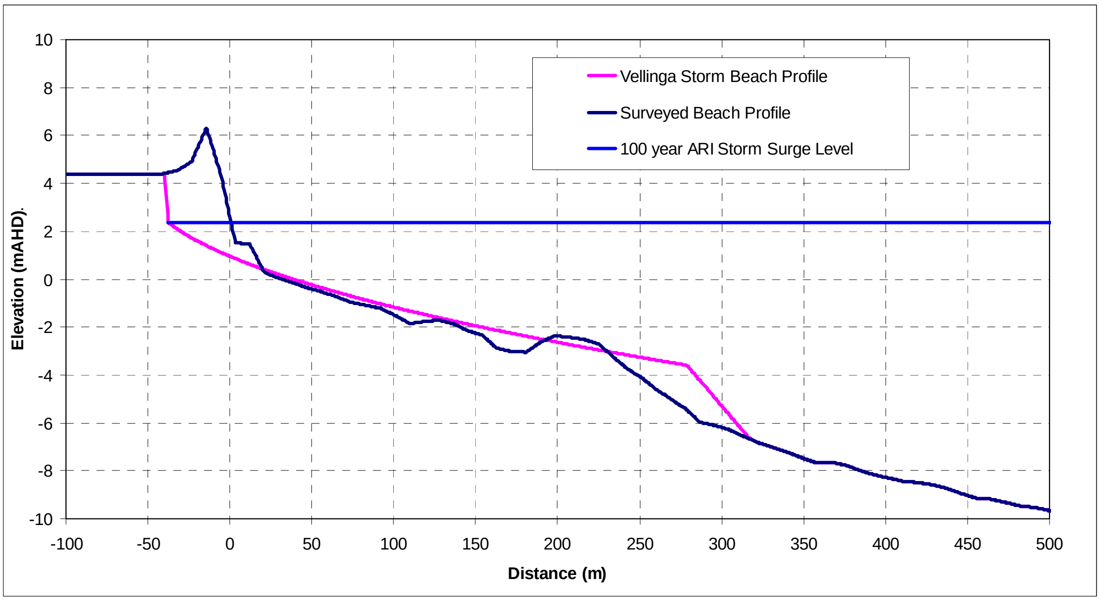


Figure B- 6 Beach Profile 11 and Predicted Storm Profile

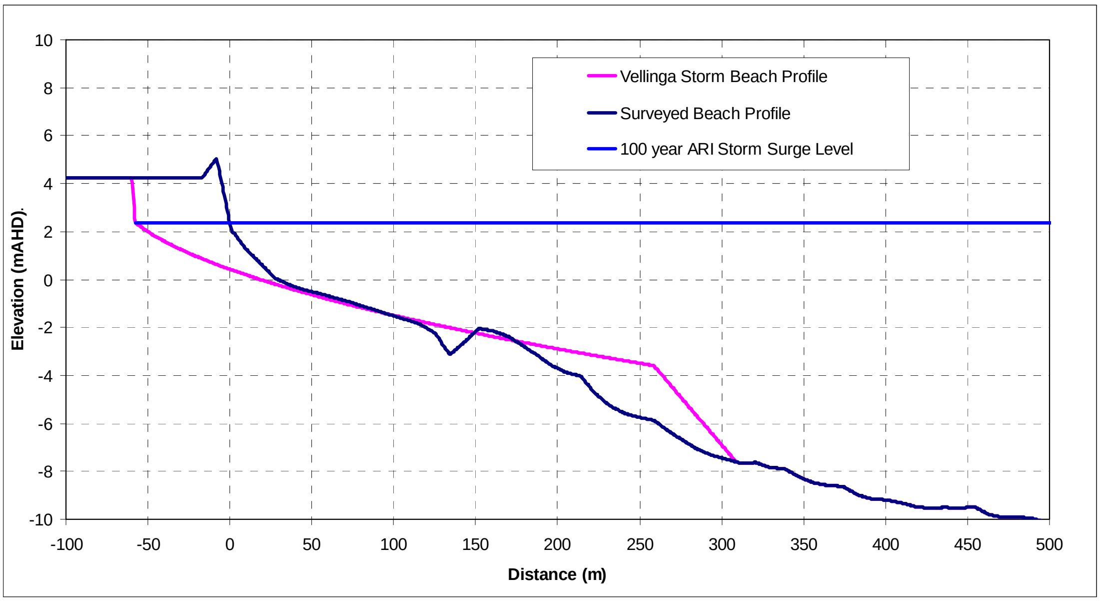


Figure B- 7 Beach Profile 13 and Predicted Storm Profile

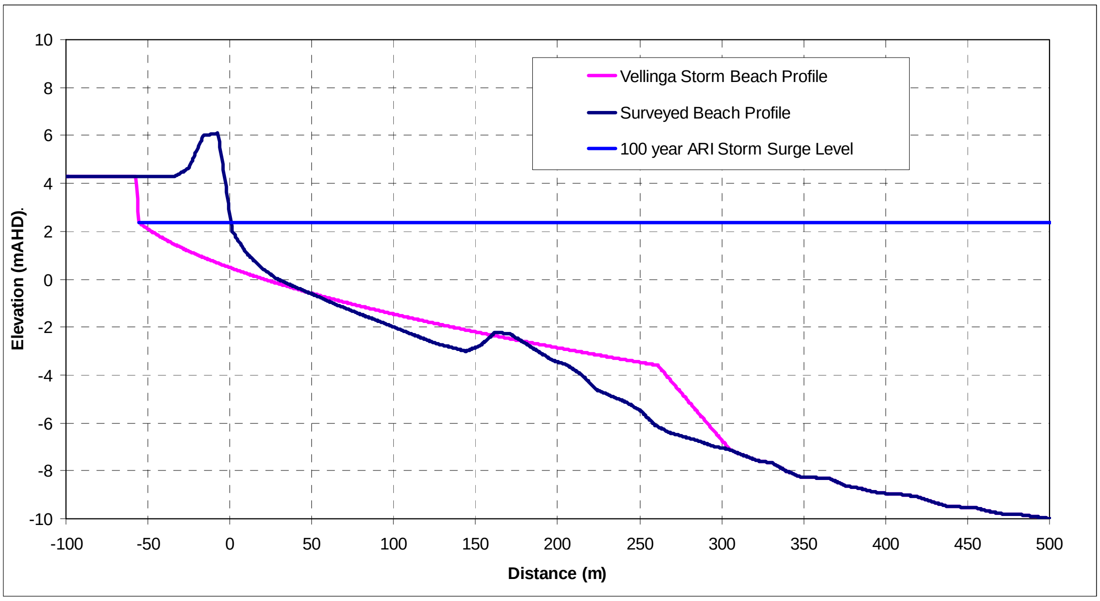


Figure B- 8 Beach Profile 15 and Predicted Storm Profile

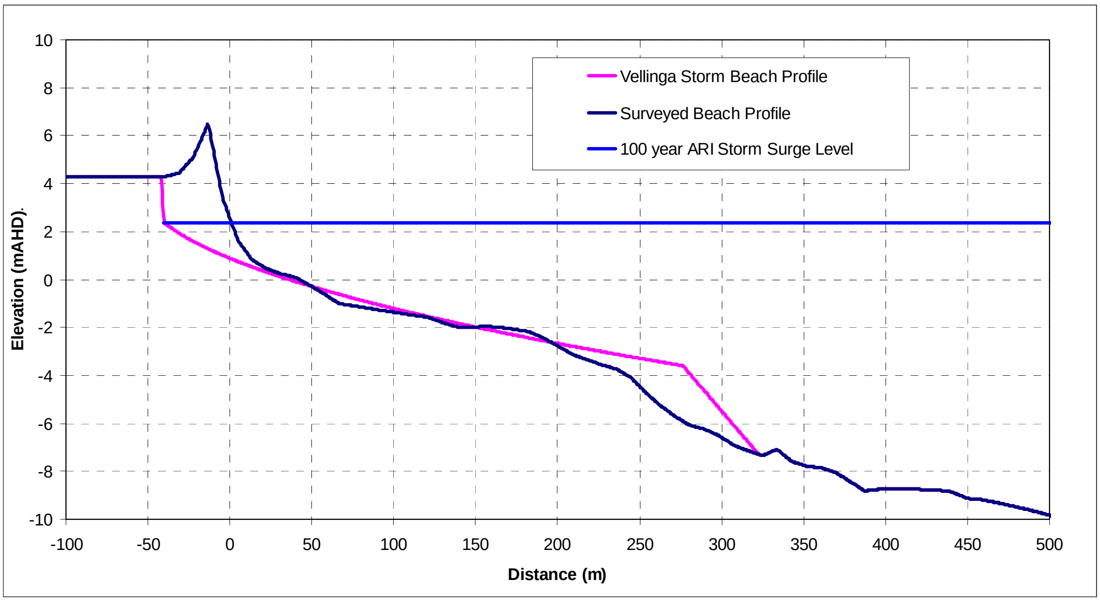


Figure B- 9 Beach Profile 17 and Predicted Storm Profile

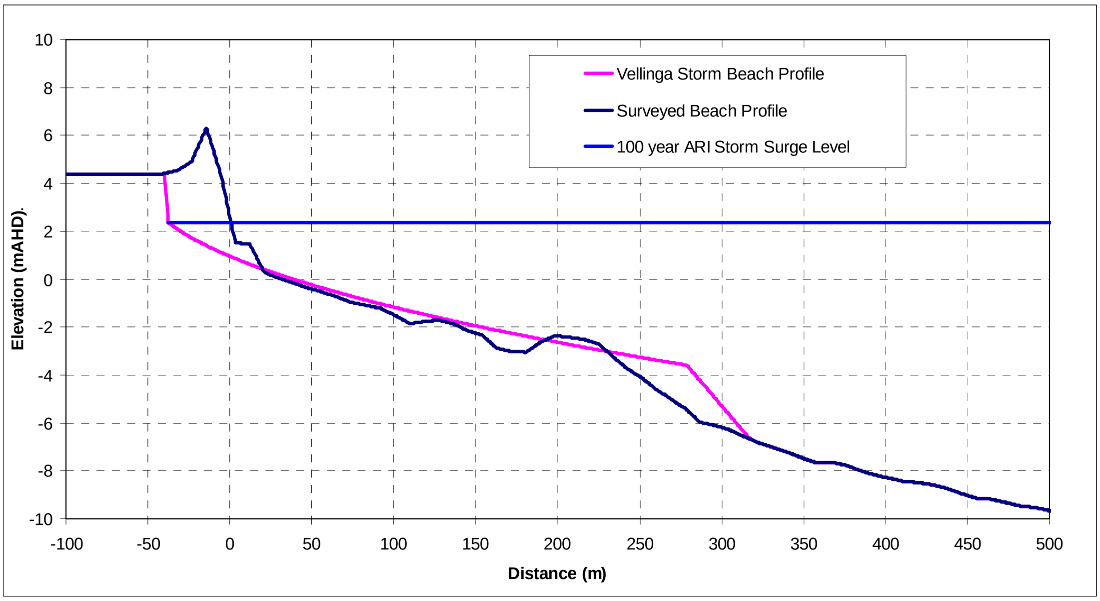


Figure B- 10 Beach Profile 19 and Predicted Storm Profile

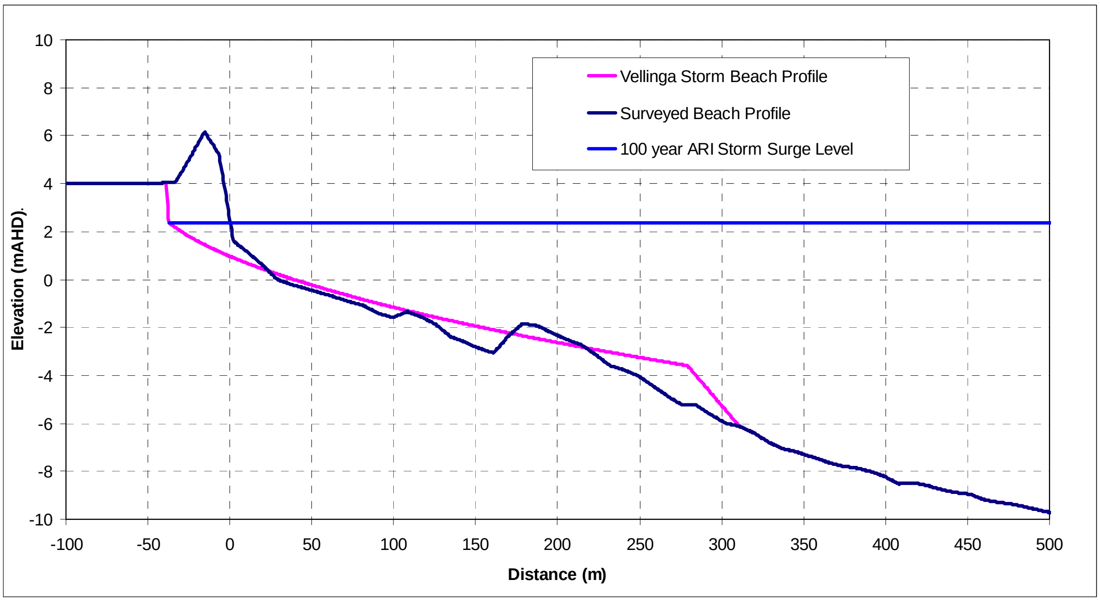


Figure B- 11 Beach Profile 21 and Predicted Storm Profile

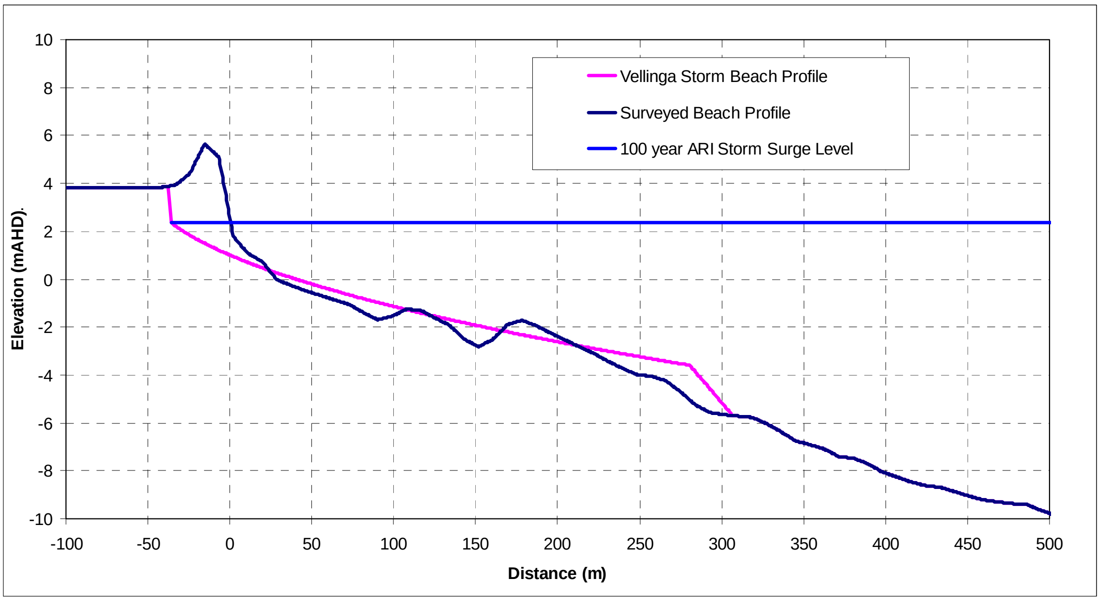


Figure B- 12 Beach Profile 23 and Predicted Storm Profile

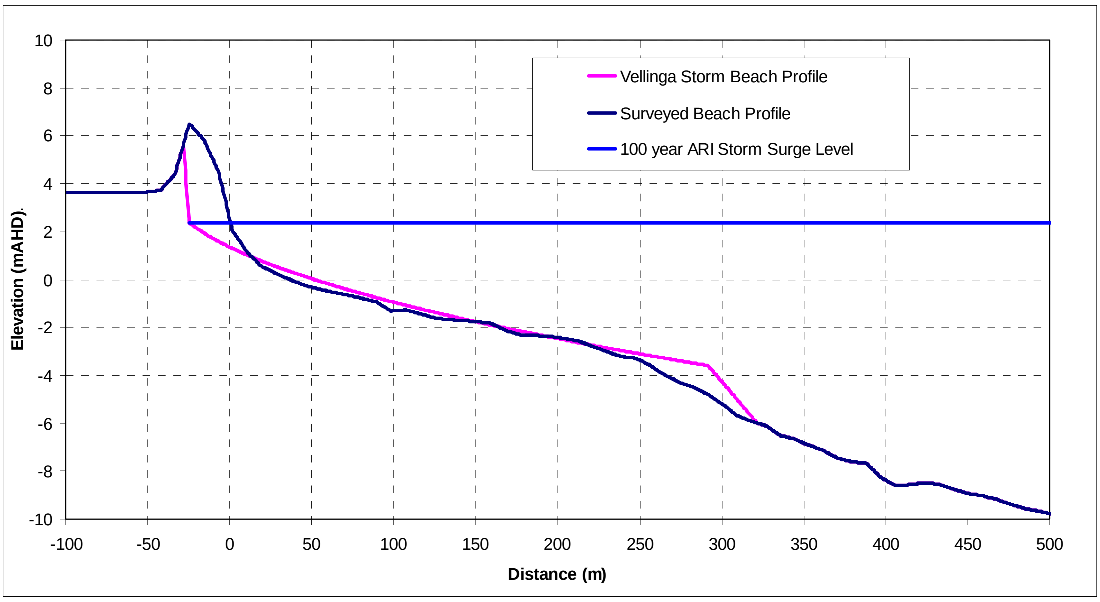


Figure B- 13 Beach Profile 25 and Predicted Storm Profile

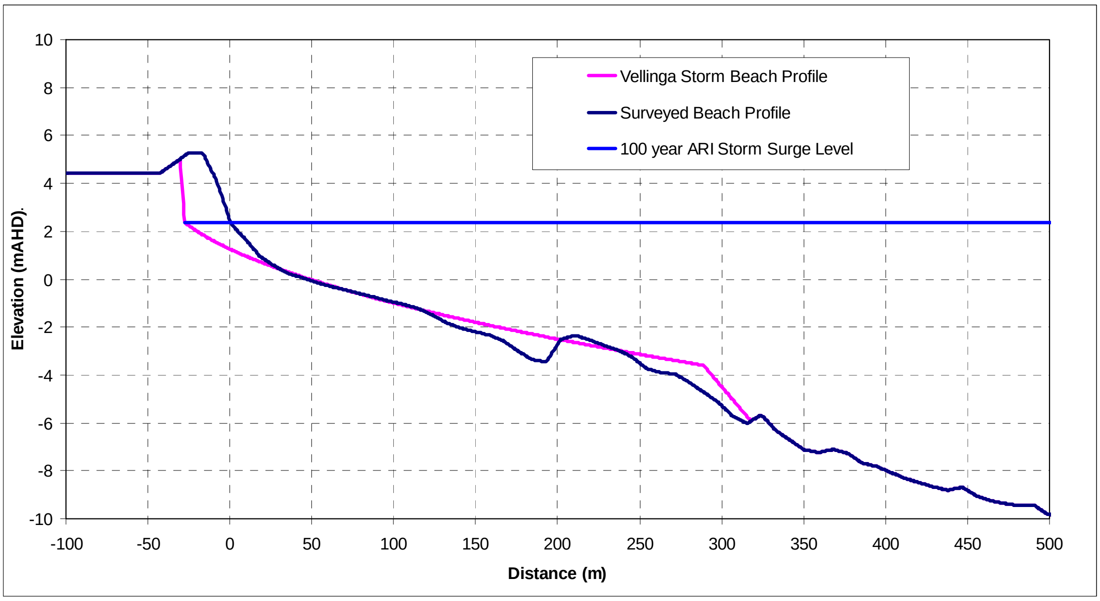


Figure B- 14 Beach Profile 27 and Predicted Storm Profile

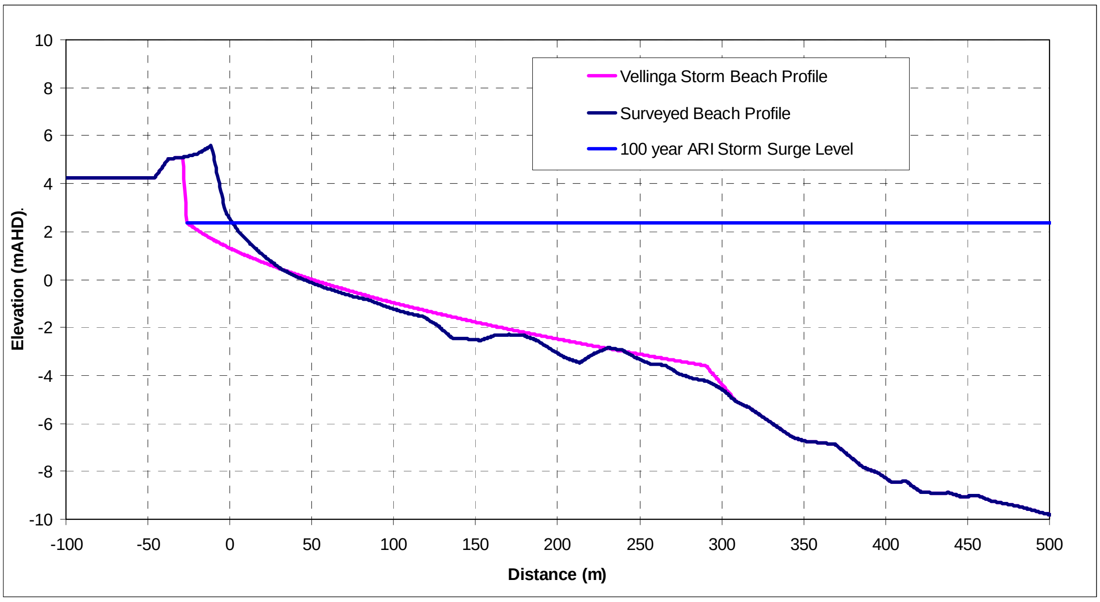


Figure B- 15 Beach Profile 29 and Predicted Storm Profile

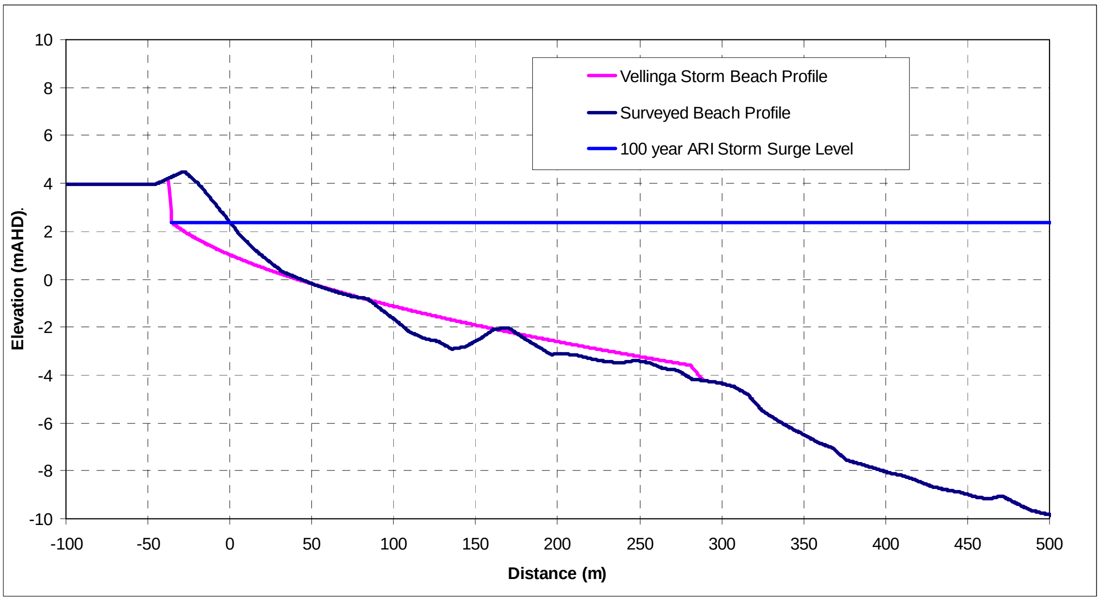
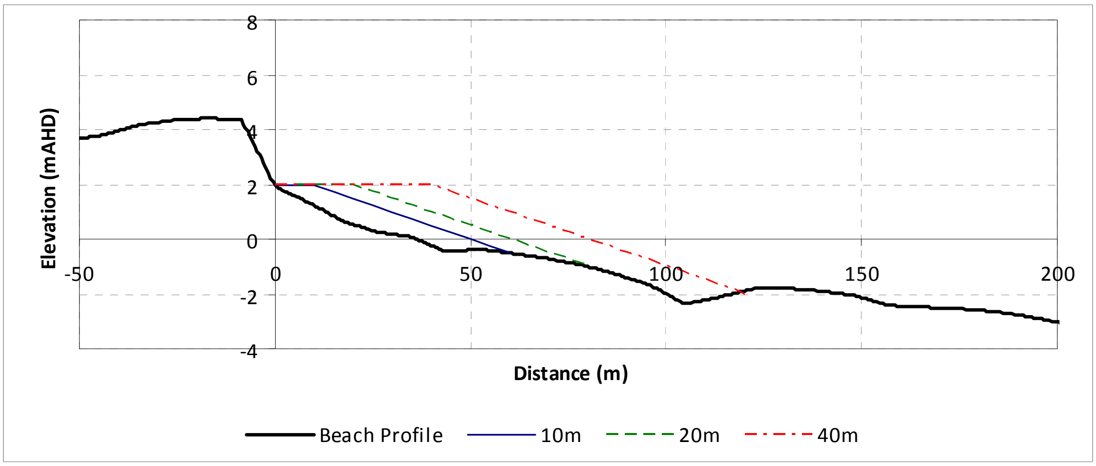


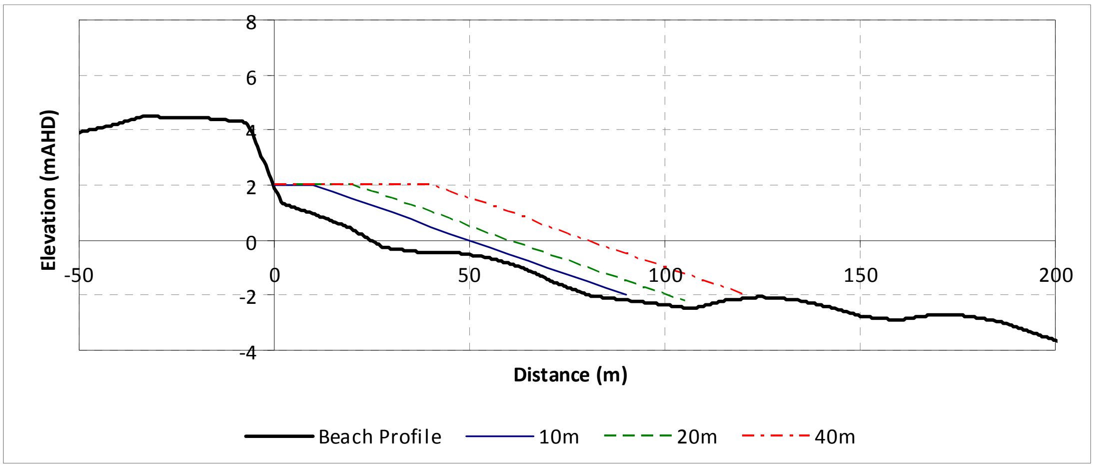
Figure B- 16 Beach Profile 31 and Predicted Storm Profile

APPENDIX C: BEACH NOURISHMENT VOLUME ESTIMATES



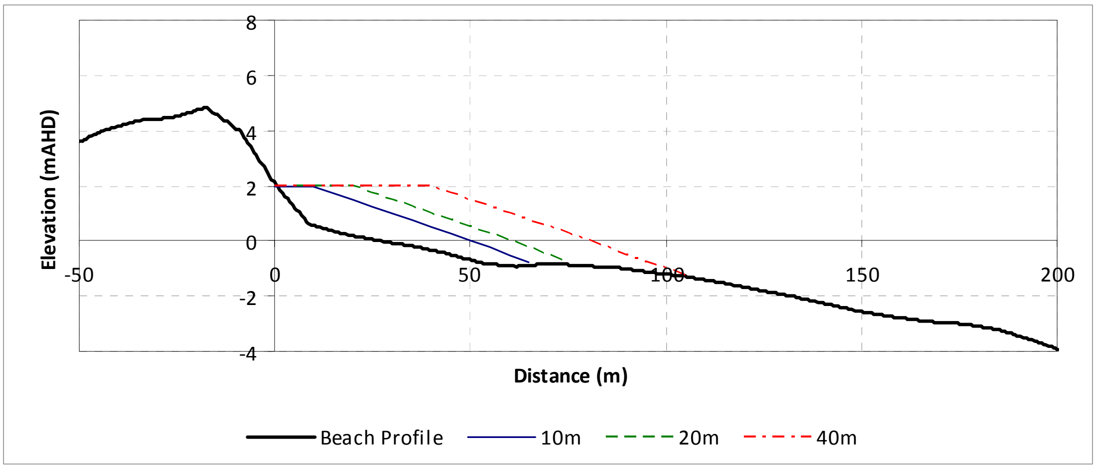
Design Area (m^2)			Design volume per unit length (m^3)		
10m berm	**20m berm**	**40m berm**	**10m berm**	**20m berm**	**40m berm**
38	65	143	3800	6500	14300

Figure C- 1 Beach Profile 1 and Design Berm Profiles



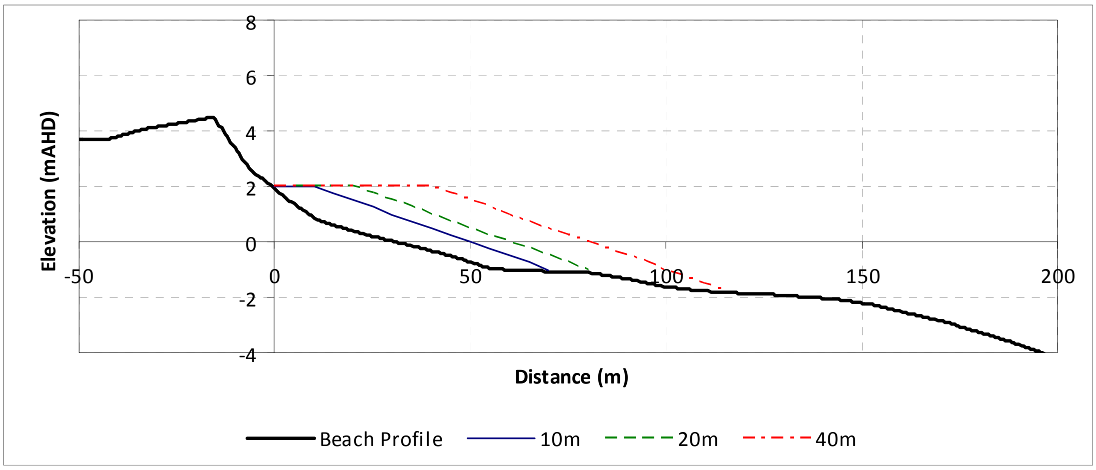
Design Area (m^2)			Design volume per unit length (m^3)		
10m berm	**20m berm**	**40m berm**	**10m berm**	**20m berm**	**40m berm**
65	109	185	6500	10900	18500

Figure C- 2 Beach Profile 3 and Design Berm Profiles



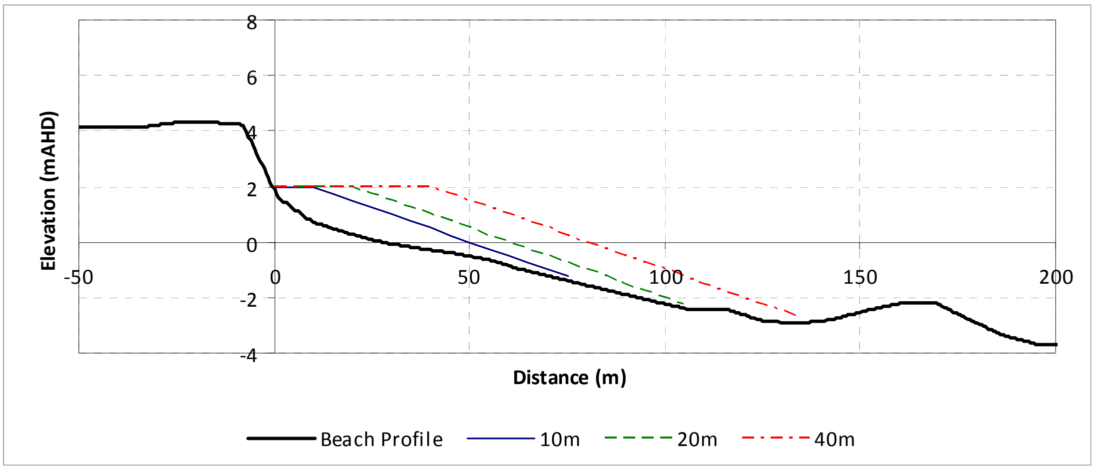
Design Area (m²)			Design volume per unit length (m³)		
10m berm	20m berm	40m berm	10m berm	20m berm	40m berm
57	84	148	5700	8400	14800

Figure C- 3 Beach Profile 5 and Design Berm Profiles



Design Area (m²)			Design volume per unit length (m³)		
10m berm	20m berm	40m berm	10m berm	20m berm	40m berm
55	85	149	5500	8500	14900

Figure C- 4 Beach Profile 7 and Design Berm Profiles



Design Area (m^2)			Design volume per unit length (m^3)		
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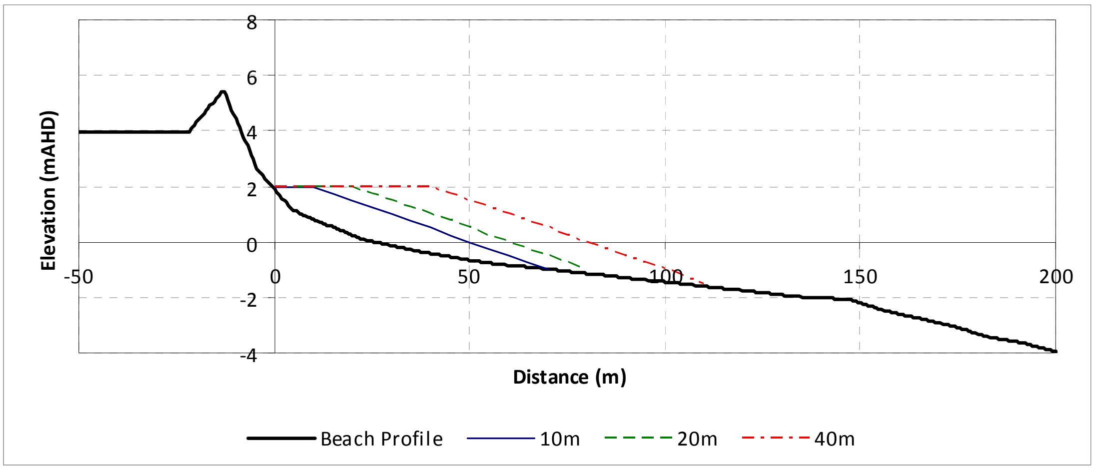
55	97	190	5500	9700	19000

Figure C- 5 Beach Profile 9 and Design Berm Profiles



Design Area (m^2)			Design volume per unit length (m^3)		
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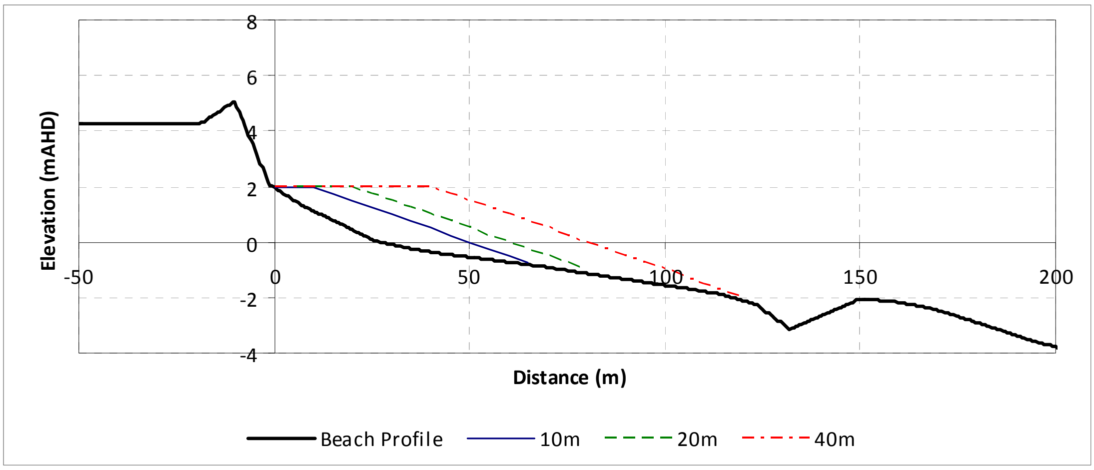
57	87	156	5700	8700	15600

Figure C- 6 Beach Profile 11 and Design Berm Profiles



Design Area (m^2)			Design volume per unit length (m^3)		
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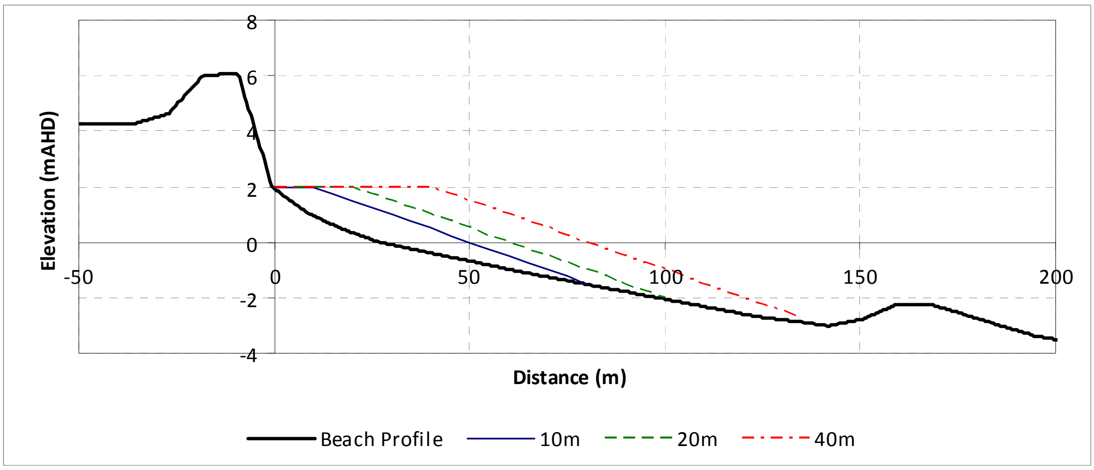
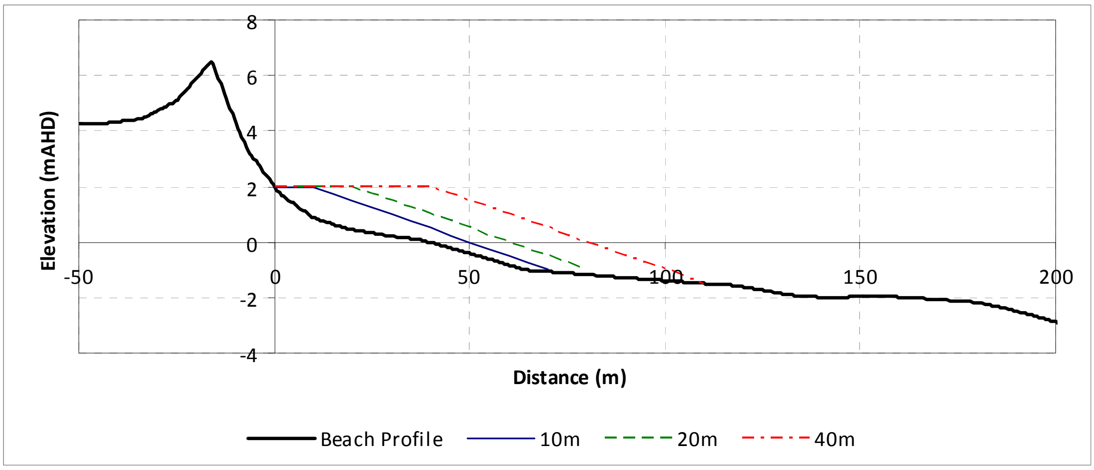
47	77	150	4700	7700	15000

Figure C- 7 Beach Profile 13 and Design Berm Profiles



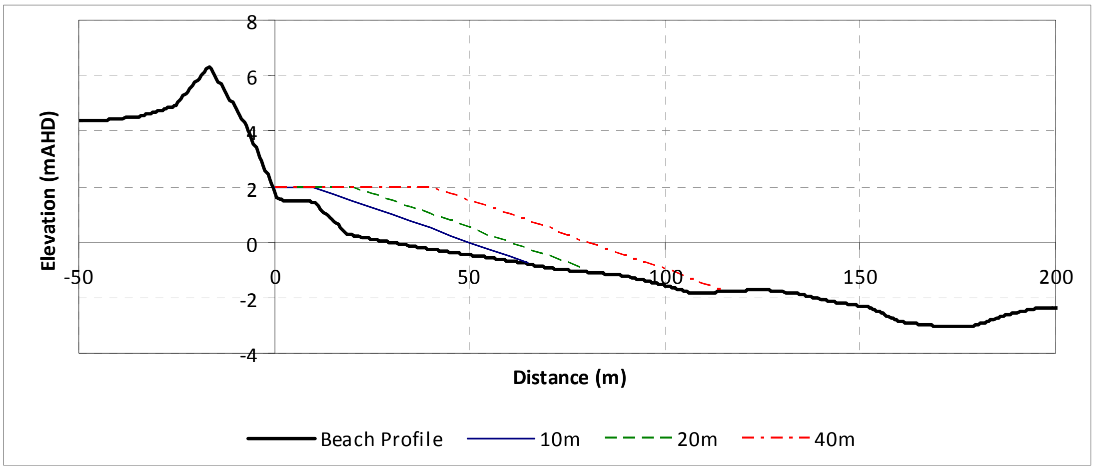
Design Area (m^2)			Design volume per unit length (m^3)		
10m berm	20m berm	40m berm	10m berm	20m berm	40m berm
57	95	187	5700	9500	18700

Figure C- 8 Beach Profile 15 and Design Berm Profiles



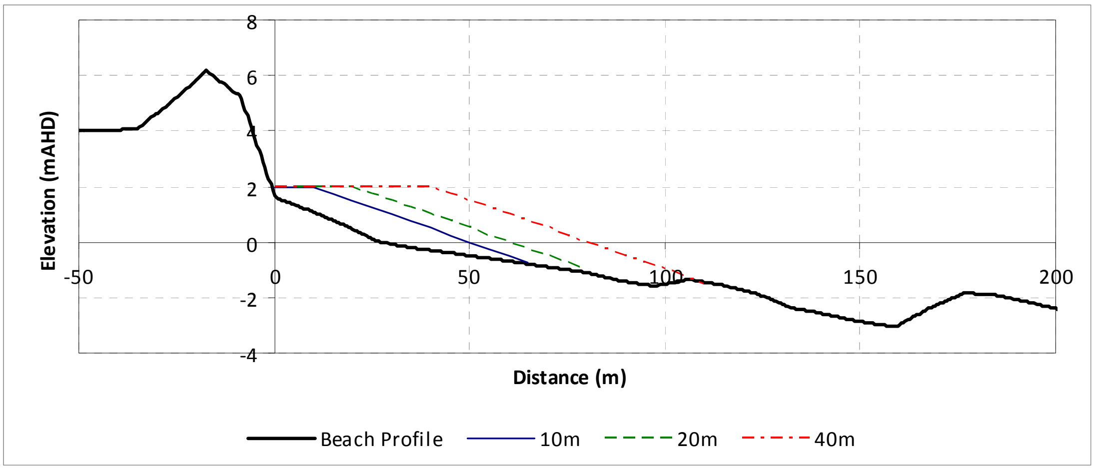
Design Area (m^2)			Design volume per unit length (m^3)		
10m berm	20m berm	40m berm	10m berm	20m berm	40m berm
44	74	143	4400	7400	14300

Figure C- 9 Beach Profile 17 and Design Berm Profiles



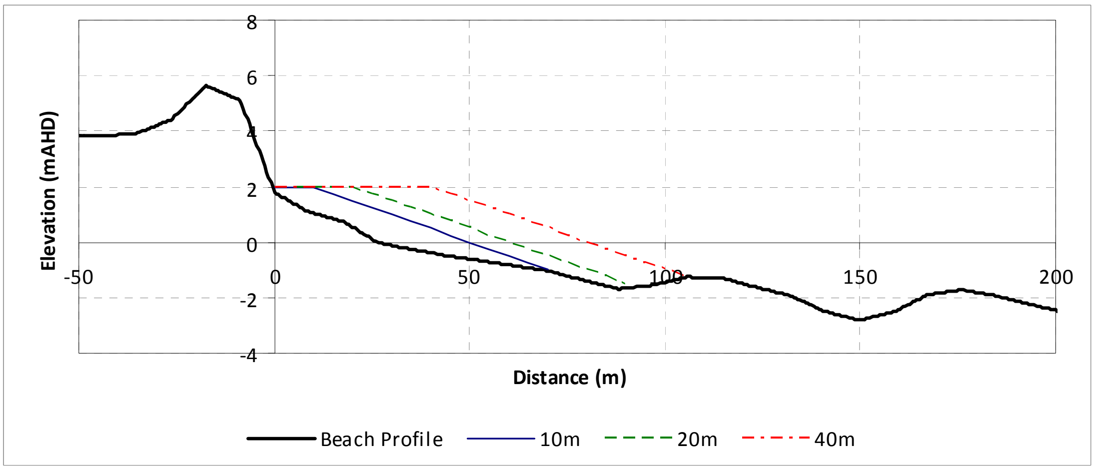
Design Area (m^2)			Design volume per unit length (m^3)		
10m berm	20m berm	40m berm	10m berm	20m berm	40m berm
45	75	146	4500	7500	14600

Figure C- 10 Beach Profile 19 and Design Berm Profiles



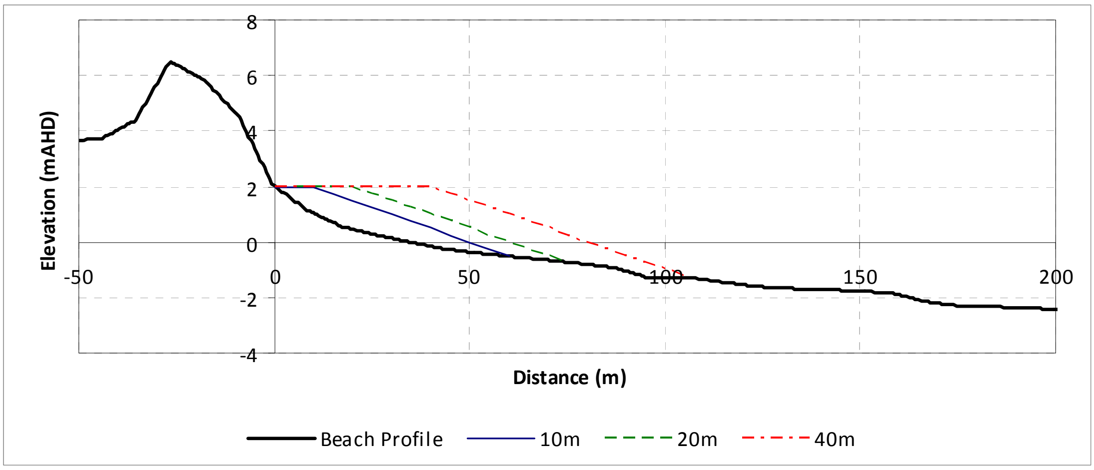
Design Area (m^2)			Design volume per unit length (m^3)		
10m berm	20m berm	40m berm	10m berm	20m berm	40m berm
47	77	147	4700	7700	14700

Figure C- 11 Beach Profile 21 and Design Berm Profiles



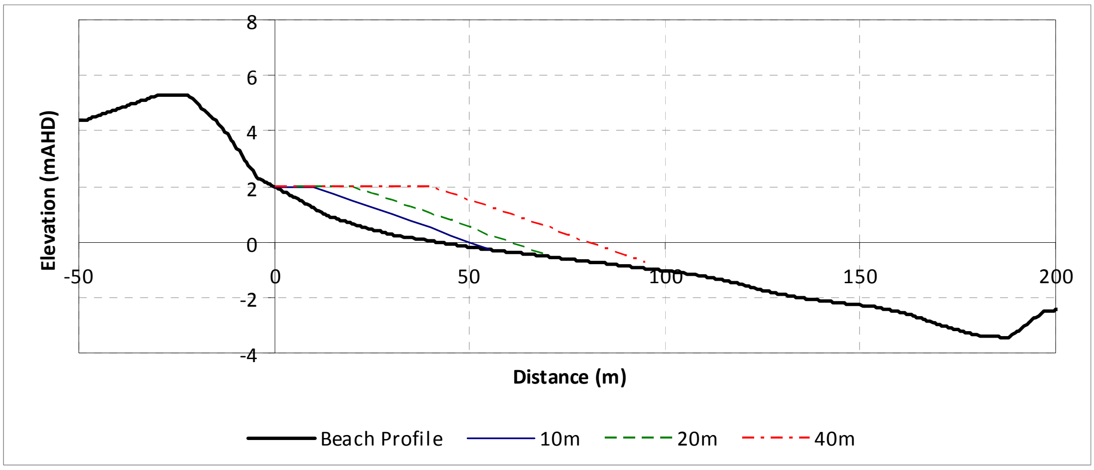
Design Area (m^2)			Design volume per unit length (m^3)		
10m berm	20m berm	40m berm	10m berm	20m berm	40m berm
50	85	148	5000	8500	14800

Figure C- 12 Beach Profile 23 and Design Berm Profiles



Design Area (m²)			Design volume per unit length (m³)		
10m berm	20m berm	40m berm	10m berm	20m berm	40m berm
39	66	127	3900	6600	12700

Figure C- 13 Beach Profile 25 and Design Berm Profiles



Design Area (m²)			Design volume per unit length (m³)		
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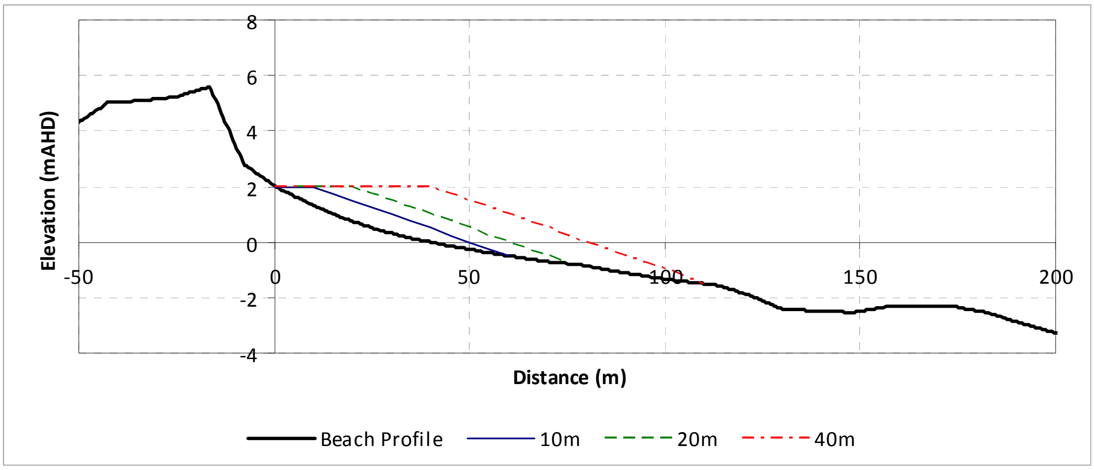
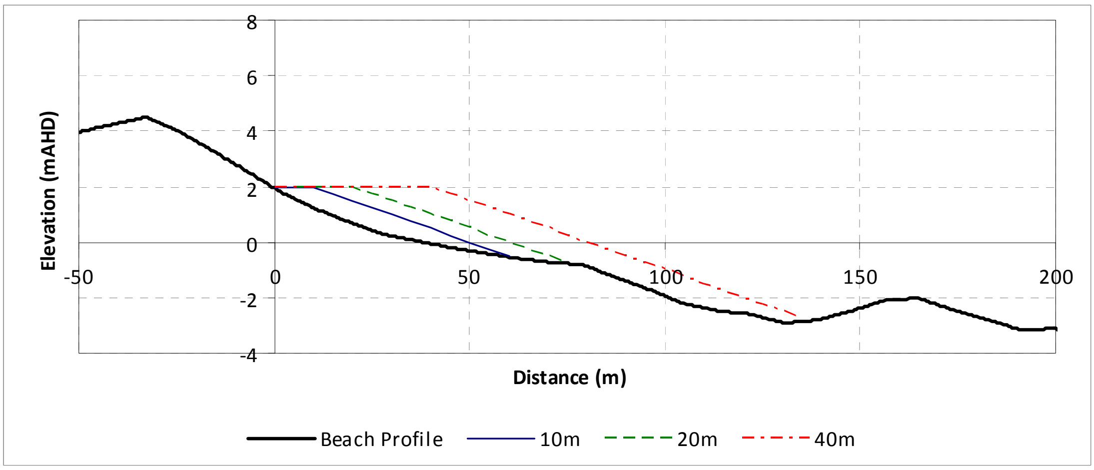
30	54	109	3000	5400	10900

Figure C- 14 Beach Profile 27 and Design Berm Profiles



Design Area (m^2)			Design volume per unit length (m^3)		
10m berm	20m berm	40m berm	10m berm	20m berm	40m berm
29	56	119	2900	5600	11900

Figure C- 15 Beach Profile 29 and Design Berm Profiles



Design Area (m^2)			Design volume per unit length (m^3)		
10m berm	20m berm	40m berm	10m berm	20m berm	40m berm
33	60	149	3300	6000	14900

Figure C- 16 Beach Profile 31 and Design Berm Profiles

APPENDIX D: MAROOCHY RIVER MOUTH HISTORICAL PHOTOGRAPHS

Figure D- 1 Maroochy River Mouth Aerial Photography (1958 – 1967)

Figure D- 2 Maroochy River Mouth Aerial Photography (1974 – 1979)

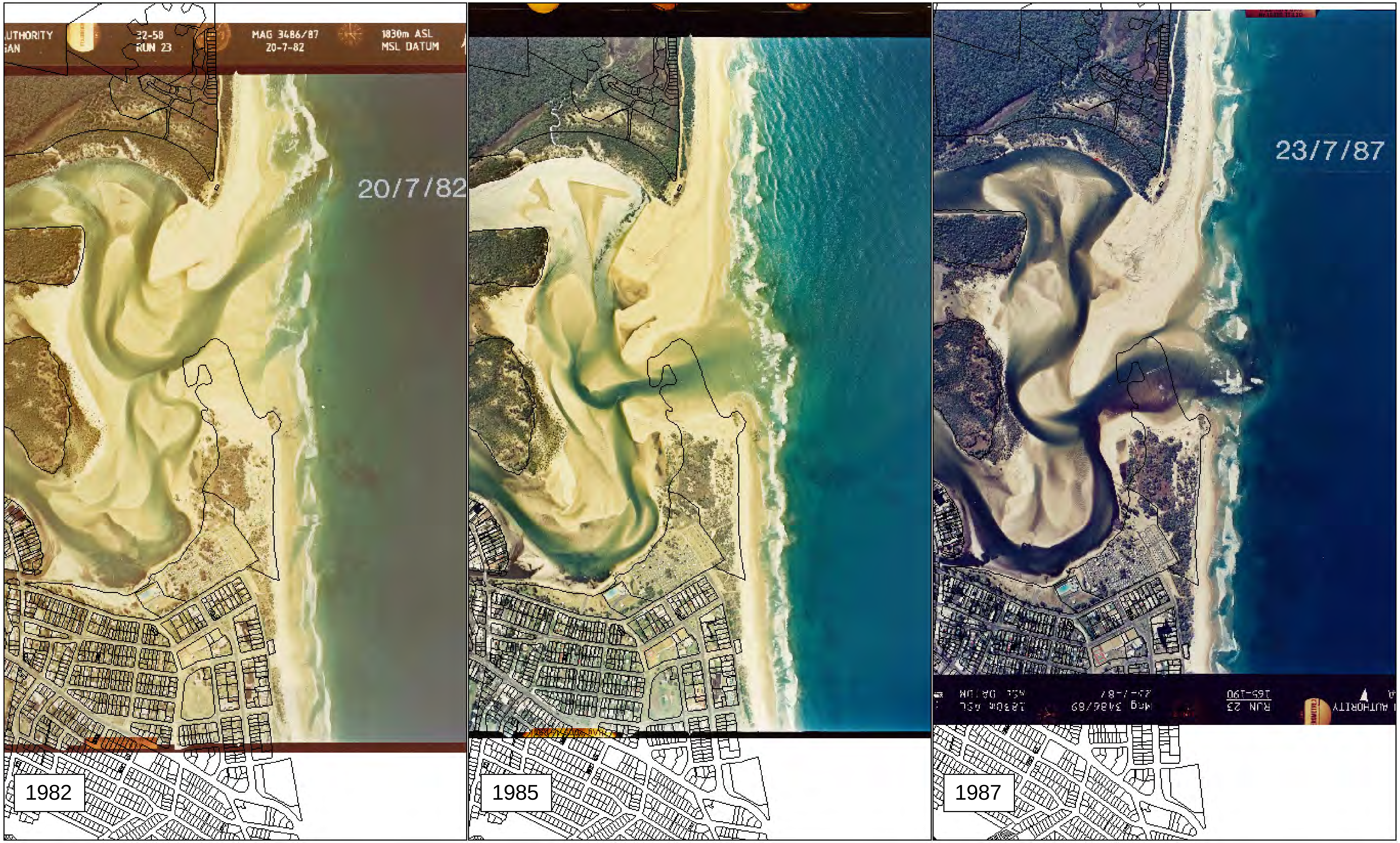


Figure D- 3 Maroochy River Mouth Aerial Photography (1982 – 1987)

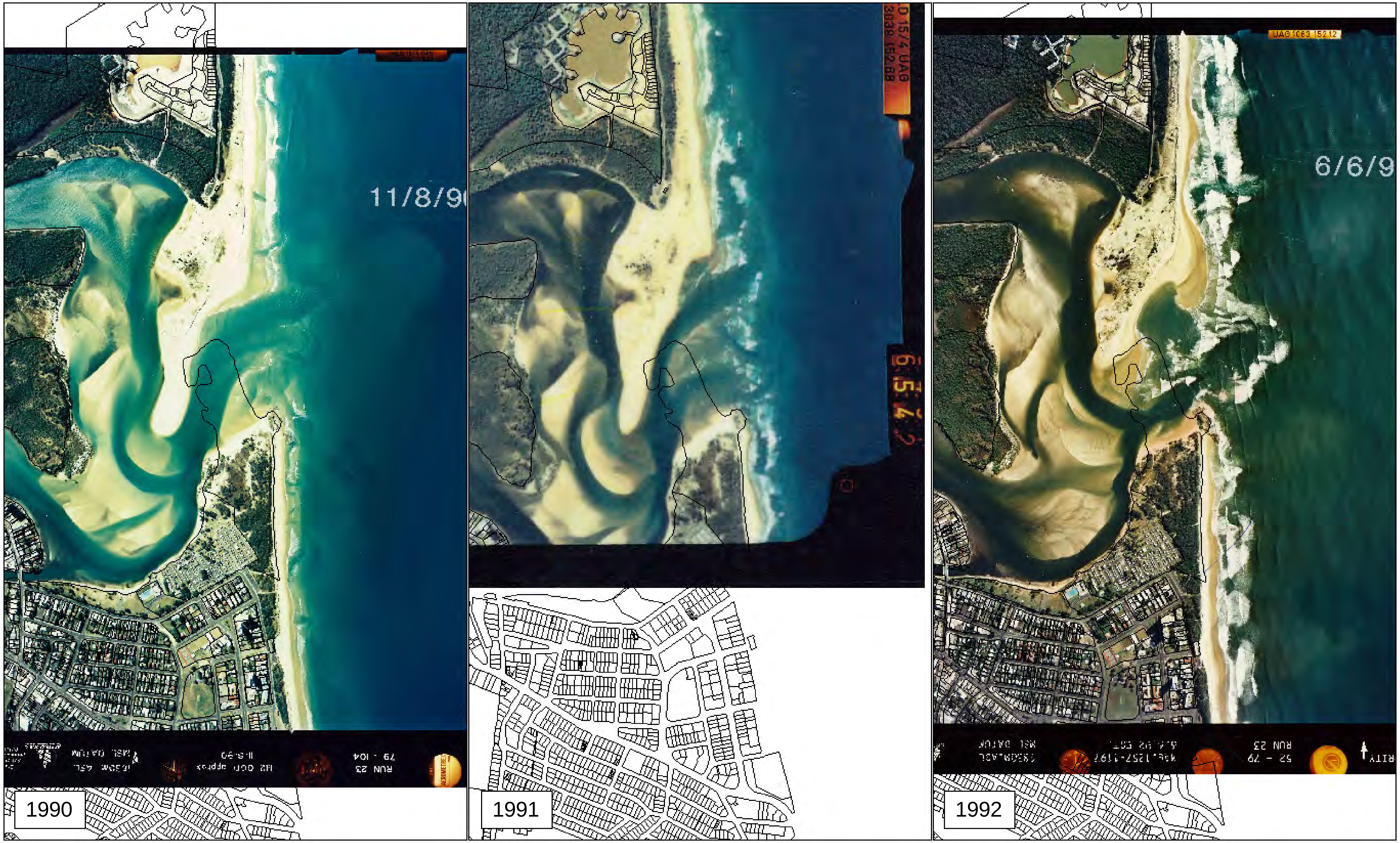


Figure D- 4 Maroochy River Mouth Aerial Photography (1990 – 1992)

Figure D- 5 Maroochy River Mouth Aerial Photography (1994 – 1999)

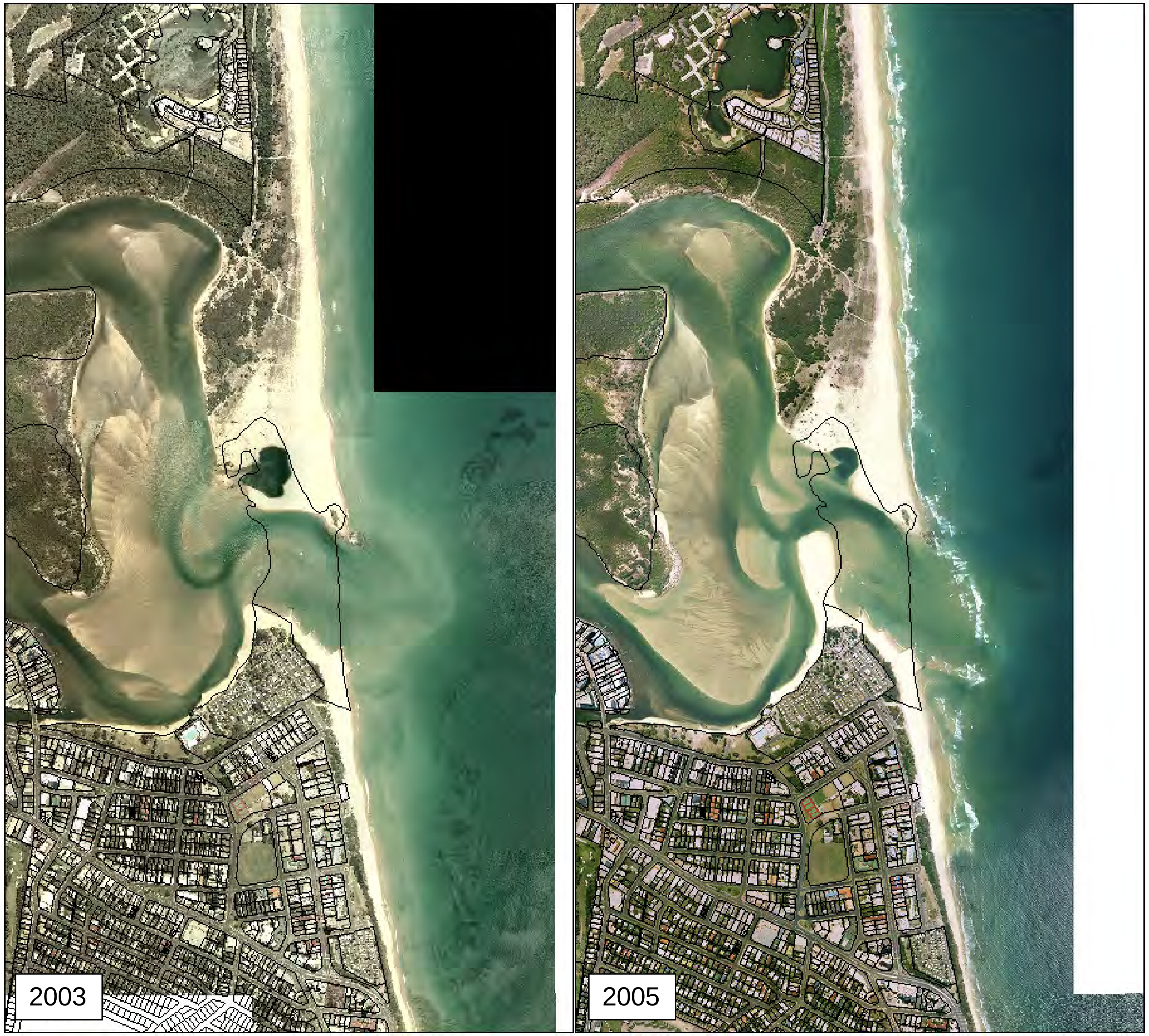


Figure D- 6 Maroochy River Mouth Aerial Photography (2003 – 2005)

APPENDIX E: MAROOCHY RIVER SEDIMENT INVESTIGATION REPORT

Maroochy River Sediment Investigation Report

Job Number: 3747/P/137

Prepared for Sunshine Coast Council

Date: 19 December 2011

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Document Control

Version	Date	Author		Reviewer	
1.0	19 December 2011	Paul Mayes		Matt Courtney	

Executive Summary

Cardno Bowler Pty Ltd was engaged by Sunshine Coast Regional Council to perform an investigation of the sediment in sections of the lower reaches of the Maroochy River for the purposes of supporting an application to dredge these areas for the purposes of beach nourishment both to the south of the Maroochy River mouth and within the lower reaches Maroochy River itself.

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 areas and to assess the extent and severity of the Acid Sulfate Soils at these sites. These data could then be used to target dredging operations to areas likely to produce the best resource for the beach nourishment program. Supplementary to these sediment characterisations a survey of the seagrass present within the area was also carried out to determine if existing marine plant distribution would impact 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 Acid Sulfate Soils. Subsurface strata at the site were dominated by fine to medium grained sand with varying, but generally very low, levels of silt. The results of the analytical Acid Sulfate Solis laboratory testing on the samples collected support the presence of Acid Sulfate Soils within the material tested. However, 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 0.139%S were always exceeded by acid neutralising capacity to give net acidity values for all samples tested of nil. Hence, no liming rates are defined within this report.

Paul Mayes (PhD.)
Principal Environmental Scientist

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Annex A - Site Plan

Annex B – Borehole locations

Annex C – Borehole Logs

Annex D – Particle Size Distribution results

Annex E – Acid Sulfate Soil results

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.

$\mathrm{pH_F}$: The pH of the soil in soil/distilled water paste.

$\mathrm{pH_{FOX}}$: 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 lower reaches of the Maroochy River 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 river mouth for the purposes of beach nourishment in the local area. Four specific areas within the river mouth were identified by council as potential dredging zones and this investigation concentrates on these areas and the assessment of the insitu sediments with respect to their potential use in beach nourishment programs. The scope of work covered in this investigation included the following:

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

The nature of the sediments present within the four selected areas 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.

The aim of this sediment investigation was to make an assessment of the quality of the sediments present within each of the four proposed target areas 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.

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 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 four target zones were located within the lower reaches of the Maroochy River downstream of the Sunshine Motorway bridge, the locations are shown in Annex A and will be referred to throughout this report as Area 1 through 4 as shown on this plan. See Figure 1 below for a locality plan of the subject site.

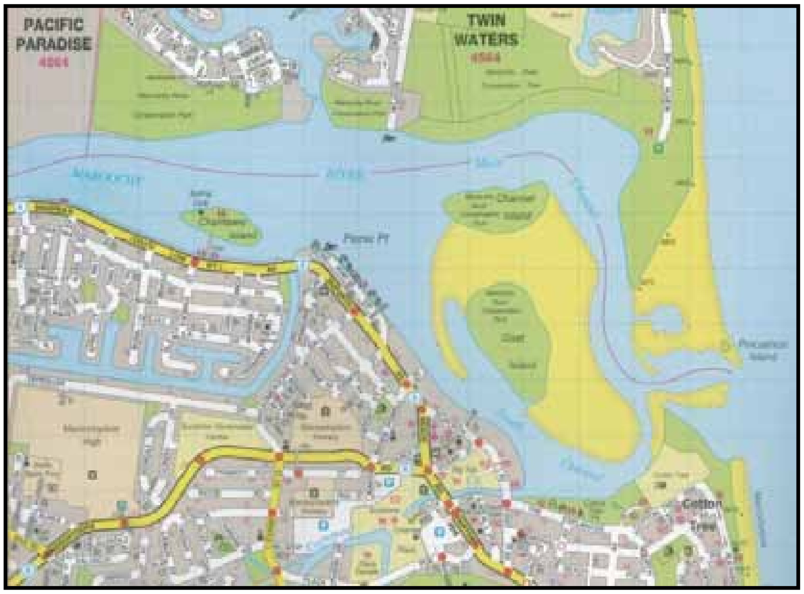


Figure 1: Locality Plan

The subject site was contained within the lower reaches of the Maroochy River and is heavily influenced by tidal flows. Water depths at the four areas were significantly influenced by tidal movements, with some areas completely exposed at low tide and maximum water depths in excess of 3.0m at high tide in other areas. This area of the river 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.

Fieldwork

A total of 20 boreholes (BH1 to BH20) were advanced across the site. The boreholes were divided across the four areas on the basis of the size of the individual areas and expected sand resource distribution as follows: Area 1: Borehole 1, Areas 2: Borehole 2-4, Area 3: Boreholes 5-9, Area 4: Borehole 10-20, see Annex B for a plan showing the borehole locations. It is noted that the identified location of area 2 was indicative only, and open to relocation on the basis existing site conditions, as such the three locations assigned to area 2 were outside the actual area identified. With respect to area 4, the logistics of sample collection and actual dredging was also considered when selecting sampling locations. The high wave action zone at the river bar was considered incompatible with either the collection of samples for testing during this investigation or actual dredging process and as such this area was not sampled during this investigation. Furthermore, the extremely shallow nature of some sections of area 4 (less than 0.5m of water cover at high tide) meant it was not possible to collect samples from these sections. It should also be noted that the sampling locations were marked with recreational quality GPS equipment with an average accuracy of approximately 5m.

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 are the Maroochy River. The vibracore rig collects a continuous core of the soft strata which is suitable for investigations of this nature. The target depth of the lake boreholes was 3.0 metres below the existing sediment surface level, however some boreholes were terminated prior to this target depth due to the 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.

Borehole locations were initially selected digitally, using the provided site plans with overlays of the four investigation areas 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 four areas 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 ground survey was then undertaken using a small dingy and snorkelling equipment.

Laboratory Testing

Particle Size Distribution

Representative samples covering a variety of depths were selected and dried at 105°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°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.

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 Maroochy River bed itself. However, this map does indicate that land on the northern bank of the river is likely to contain potential Acid Sulfate Soils within 0.5m of the surface. Furthermore, this map indicates that disturbed land on the southern bank of the river 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 graded 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 areas. The 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. 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 results of the analytical laboratory analysis (see Annex D) showed that none 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 is due to a combination of the presence of intrinsic acid neutralising capacity (ANC) and generally low levels of oxidisable sulfur within the samples tested. The maximum S_{Cr} level detected in the samples tested during this investigation was 0.139% oxidisable sulfur, however the majority of samples returned very low levels of S_{Cr}, at or around the 0.03% level (often below the detection limit of the test method). These results confirm the presence of Acid Sulfate Soils within the samples tested during this investigation, however in the vast majority of samples the levels of acidity are very low and in all cases the materials intrinsic acid neutralising capacity exceeds the potential of the material to generate acidity. As such no further treatment of the materials tested would be required.

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. These results suggest that there will be limited high quality harvestable sand resources at areas 1 through 3. Whilst the particle size distribution of the sediments tested from these areas 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 areas 1 through 3 are significantly more variable than at area 4.

The soil profiles at area 4 were generally more uniform and the material was generally paler in colour than that sampled from areas 1 though 3. The exceptions to this generalisation were boreholes 18 through 20 (located in the north-eastern section of area 4) which were slightly more variable and darker in colour than the rest of the boreholes within area 4 and were more similar to the boreholes within areas 1 through 3. These data suggest the sediments present within the western section of area 4 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 Maroochy River mouth are problematic there may be opportunity to recover some smaller quantities of suitable material from areas 1 through 3, however the data presented here suggest that these opportunities would not yield the same quantity or quality of resource for beach nourishment purposes.

Seagrass Survey

The seagrass survey of the proposed dredging areas revealed no significant (greater than 50m^2) patches of seagrass present within the areas recommended for dredging.

There are some very small patches of seagrass adjacent to area 3 which may need to be considered if dredging is to be undertaken in this area. However, the general higher quality and consistency of the material identified in area 4 means dredging from area 3 (or areas 1 and 2) should be considered as a secondary option to dredging within area 4. If the quantity of resource available in area 4 is insufficient for the requirements of the beach nourishment program/s or the logistics of transporting the material from area 4 to its destinations are difficult, further consideration of the use of sediments from area 3 (or areas 1 and 2) will be required.

If dredging is isolated to area 4, there will be no need to consider the location of seagrass beds when selecting material for the beach nourishment programs.

Summary

The following points summarise the findings of the Sediment Investigation of the Maroochy River.

- Sediments tested at the selected sampling locations were dominated by sands with generally low levels of silt.
- Areas 1 through 3 showed more variable soil profiles with darker materials closer to the surface than those identified at area 4.
- Soil profiles at area 4 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 samples tested.
- It is recommended that area 4 be used as the primary source of material for the beach nourishment program/s.

Annex A - Site Plan

Resource Investigation Area - Maroochy

Coordinates of resource investigation area points

Location	Longitude	Latitude
1	153.078375	-26.640441
2	153.078326	-26.641273
3	153.082078	-26.640504
4	153.082127	-26.641314
5	153.077927	-26.643047
6	153.077750	-26.643313
7	153.080231	-26.643846
8	153.080232	-26.644099
9	153.082872	-26.643832
10	153.082951	-26.644036
11	153.084134	-26.643031
12	153.086848	-26.642976
13	153.086278	-26.643786
14	153.090117	-26.647805
15	153.089755	-26.648346
16	153.093089	-26.650654
17	153.094438	-26.653341
18	153.097585	-26.653500
19	153.098104	-26.650998
20	153.101138	-26.648987
21	153.097723	-26.645427
22	153.099275	-26.643173

Legend

- 🟩 Protected Areas of Queensland (estate)
- ▬ Coastal Structures
- ▭ FishHabitatAreas
- - - - Fish Habitat 100m Buffer
- ▨ Resource Investigation Area
- ━ Proposed Beach Nourishment

**Please Note: Area 1 is indicative only.
Refer to navigation channel markers
for exact location**

N
W E
S

1:8,444

0 70 140 280 420 Meters

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

Disclaimer

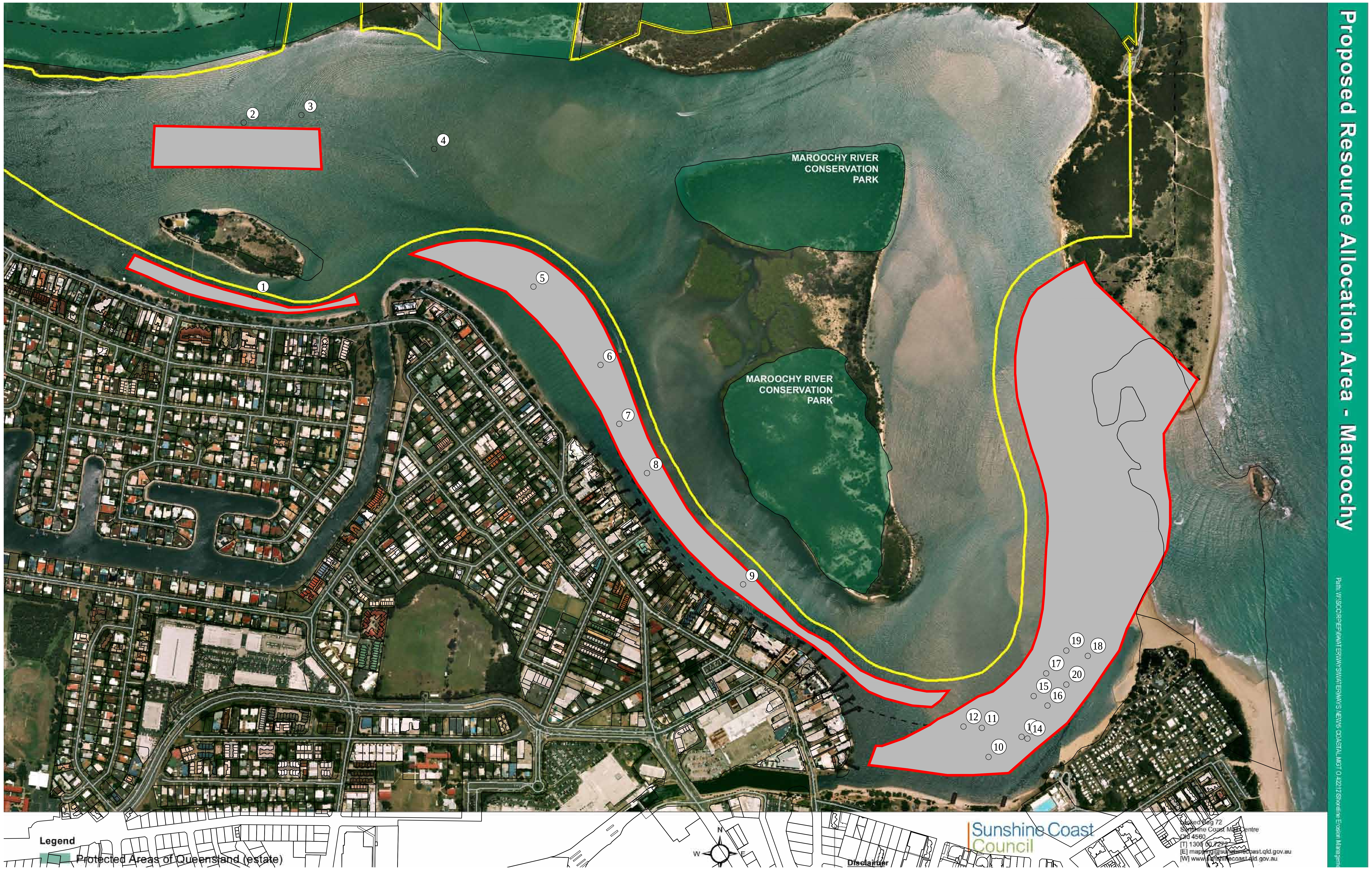
Some datasets represented are obtained from various Queensland State Departments.
While every care is taken to ensure the accuracy of this product, neither the Sunshine Coast Council nor the State of Queensland makes any representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs that may occur as a result of the product being inaccurate or incomplete in any way or for any reason.

Prepared by: TJM *At Paper Size A3* *Last Printed on December 20, 2011*

Path: W:\SCC\RP\EP\6WATERWAYS\WATERWAYS NEW5 COASTAL MGT O.4221 2\Shoreline Erosion Management Plans\Sand sourcing study

Annex B – Sampling Locations

MAROOCHY RIVER - MAINTENANCE DREDGING AREA



50 0 50 100 150 200 250m

1:5000 - A1 1:10000 - A3

LAYOUT PLAN

Maroochy River Locations 2.DWG

CARDNO BOWLER

Revision A

Annex C – Borehole Logs

Maroochy Beach Att 2 Feasibility Report

BOREHOLE LOG SHEET

32 Hi-Tech Drive
Kunda Park/QLD/4556
Telephone: +61 7 54501544
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BOREHOLE No: 3747-P137-BH01

SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**

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

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 508024 7053007

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

NOTES Water depth 0.7m

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-brown, trace silt, shell fragments present, ALLUVIAL		
			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, very dark brown, with silt, ALLUVIAL		
			2.5 3.0		SP	**SAND**, fine to medium grained, grey-brown, with silt, ALLUVIAL		
			3.5			Borehole 3747-P137-BH01 terminated at 3m		

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BOREHOLE LOG SHEET

BOREHOLE No: 3747-P137-BH02

SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**

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

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 508000 7053393

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		SP	**SAND**, fine to medium grained, grey-brown, trace silt, shell fragments present, ALLUVIAL		
			2.0		SP	**SAND**, fine to medium grained, dark brown, with silt, ALLUVIAL		
			2.5 3.0 3.5			Borehole 3747-P137-BH02 terminated at 2.4m		Borehole terminated due to vibracore refusal.

Maroochy Beach Att 2 Feasibility Report

BOREHOLE LOG SHEET

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BOREHOLE No: 3747-P137-BH03
SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 508129 7053410
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, grey-brown, with silt, ALLUVIAL		
			1.5		SP	**SAND**, fine to medium grained, grey, with silt, ALLUVIAL		
			2.0 2.5		SP	**SNAD**, fine grained, dark brown, with silt, ALLUVIAL		
			3.0 3.5			Borehole 3747-P137-BH03 terminated at 2.8m		Borehole terminated due to vibracore refusal.

Maroochy Beach Att 2 Feasibility Report

BOREHOLE LOG SHEET

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BOREHOLE No: 3747-P137-BH04
SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 508426 7053334
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water Depth 0.4m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5 1.0 1.5		SP	**SAND**, fine grained, pale grey, shell fragments present, ALLUVIAL		
			2.0 2.5 3.0		SP	**SAND**, fine to medium grained, grey to dark grey, with silt, shell fragments present, ALLUVIAL		
			3.5			Borehole 3747-P137-BH04 terminated at 3m		

Maroochy Beach Att 2 Feasibility Report

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BOREHOLE No: 3747-P137-BH05
SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 508648 7053026
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, brown, trace silt, ALLUVIAL		
			0.5		SP	**SAND**, fine to medium grained, grey, with silt, ALLUVIAL		
			1.0					
			1.5					
			2.0					
			2.5					
					SP	**SAND**, fine grained grained, very dark brown, with silt, ALLUVIAL		
			3.0			Borehole 3747-P137-BH05 terminated at 2.9m		Borehole terminated due to vibracore refusal.
			3.5					

BOREHOLE LOG SHEET

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BOREHOLE No: 3747-P137-BH06
SHEET: 1 of 1

DATE STARTED 9/11/11 **COMPLETED** 9/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 508798 7052851
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
					SP	**SAND**, fine grained, pale grey to grey, trace silt, shells fragments present, ALLUVIAL		
			0.5					
			1.0		SP	**SAND**, fine to medium grained, brown, trace silt, ALLUVIAL		
			1.5					
			2.0					
			2.5					
			3.0			Borehole 3747-P137-BH06 terminated at 3m		
			3.5					

Maroochy Beach Att 2 Feasibility Report

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BOREHOLE No: 3747-P137-BH07
SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 508840 7052719
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES Water Depth 1.2m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
			0.5		SP	**SAND**, fine to coarse grained, dark grey, trace silt, ALLUVIAL		
			1.0		SP	**SAND**, fine to medium grained, grey, trace silt, shell fragments present, ALLUVIAL		
			1.5 2.0 2.5 3.0		SP	**SAND**, fine to medium grained, pale grey to grey, trace silt, ALLUVIAL		
			3.5			Borehole 3747-P137-BH07 terminated at 3m		

Maroochy Beach Att 2 Feasibility Report

BOREHOLE LOG SHEET

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BOREHOLE No: 3747-P137-BH08

SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**

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

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 508902 7052609

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
				▨	SP	**SAND**, fine to medium grained, grey, trace silt, ALLUVIAL		
			0.5	▨				
			1.0	▨				
			1.5	▨				
			2.0	▨	SP	**SAND**, fine to medium grained, grey and dark grey, trace silt, trace low plasticity clay, ALLUVIAL		
				▨	SP	**SAND**, fine to medium grained, dark grey, trace silt, ALLUVIAL		
			2.5	▨				
			3.0			Borehole 3747-P137-BH08 terminated at 3m		
			3.5					

Maroochy Beach Att 2 Feasibility Report

BOREHOLE LOG SHEET

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BOREHOLE No: 3747-P137-BH09

SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**

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

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509117 7052360

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 1.5 2.0 2.5 3.0		SP	**SAND**, fine grained, grey, with silt, shell fragments present, ALLUVIAL		
			3.5			Borehole 3747-P137-BH09 terminated at 3m		

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BOREHOLE No: 3747-P137-BH10

SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**

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

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509666 7051974

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
					SP	**SAND**, fine to medium grained, brown to dark brown, ALLUVIAL		
			0.5		SP	**SAND**, fine to medium grained, grey, ALLUVIAL		
			1.0					
			1.5					
			2.0					
			2.5					
			3.0			Borehole 3747-P137-BH10 terminated at 3m		
			3.5					

Cardno Bowler

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BOREHOLE No: 3747-P137-BH11

SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**

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

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509890 7052260

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

NOTES Water Depth 1.2m

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine to coarse grained, pale brown to brown, trace silt, ALLUVIAL		
			0.5					
			1.0					
					SP	**SAND**, fine to coarse grained, grey, trace silt, ALLUVIAL		
			1.5					
			2.0					
			2.5					
						Borehole 3747-P137-BH11 terminated at 2.8m		Borehole terminated due to vibracore refusal.
			3.0					
			3.5					

Maroochy Beach Att 2 Feasibility Report

BOREHOLE LOG SHEET

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BOREHOLE No: 3747-P137-BH12

SHEET: 1 of 1

DATE STARTED 9/11/11 **COMPLETED** 9/11/11 **R.L. SURFACE** **DATUM**

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

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509610 7052042

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

NOTES

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, pale brown, trace silt, shell fragments present, ALLUVIAL		
			3.5			Borehole 3747-P137-BH12 terminated at 3m		

Maroochy Beach Att 2 Feasibility Report

BOREHOLE LOG SHEET

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Kunda Park/QLD/4556
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BOREHOLE No: 3747-P137-BH13
SHEET: 1 of 1

DATE STARTED 9/11/11 **COMPLETED** 9/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509740 7052019
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES

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, pale brown, trace silt, shell fragments present, ALLUVIAL		
			3.5			Borehole 3747-P137-BH13 terminated at 3m		

BOREHOLE LOG SHEET

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BOREHOLE No: 3747-P137-BH14

SHEET: 1 of 1

DATE STARTED 9/11/11 **COMPLETED** 9/11/11 **R.L. SURFACE** **DATUM**

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

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509753 7052015

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

NOTES

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 grained, pale brown, trace silt, shell fragments present, ALLUVIAL		
			3.5			Borehole 3747-P137-BH14 terminated at 3m		

Maroochy Beach Att 2 Feasibility Report

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BOREHOLE No: 3747-P137-BH15
SHEET: 1 of 1

DATE STARTED 9/11/11 **COMPLETED** 9/11/11 **R.L. SURFACE** **DATUM**
DRILLING CONTRACTOR Abyss Commercial Diving **SLOPE** 90° **BEARING** ---
EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509767 7052110
HOLE SIZE 50mm **LOGGED BY** PM **CHECKED BY** DC
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
					SP	**SAND**, fine grained, pale brown, trace silt, ALLUVIAL		
			0.5					
			1.0					
			1.5		SP	**SAND**, fine to medium grained, pale brown, trace silt, ALLUVIAL		
			2.0					
			2.5					
			3.0			Borehole 3747-P137-BH15 terminated at 3m		
			3.5					

Maroochy Beach Att 2 Feasibility Report

BOREHOLE LOG SHEET

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BOREHOLE No: 3747-P137-BH16

SHEET: 1 of 1

DATE STARTED 9/11/11 **COMPLETED** 9/11/11 **R.L. SURFACE** **DATUM**

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

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509798 7052089

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

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				▨	SP	**SAND**, fine grained, pale brown, trace silt, shell fragments present, ALLUVIAL		
			0.5	▨				
			1.0	▨				
			1.5	▨				
			2.0	▨				
			2.5	▨				
			3.0	▨				
						Borehole 3747-P137-BH16 terminated at 3m		
			3.5					

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BOREHOLE LOG SHEET

BOREHOLE No: 3747-P137-BH17

SHEET: 1 of 1

DATE STARTED 9/11/11 **COMPLETED** 9/11/11 **R.L. SURFACE** **DATUM**

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

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509795 7052161

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

NOTES

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					
			1.5					
			2.0					
			2.5					
					SM	**SILTY SAND**, fine grained, very dark brown, trace low plasticity clay, ALLUVIAL		
			3.0			Borehole 3747-P137-BH17 terminated at 3m		
			3.5					

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BOREHOLE No: 3747-P137-BH18
SHEET: 1 of 1

DATE STARTED 8/11/11
COMPLETED 8/11/11
R.L. SURFACE
DATUM
DRILLING CONTRACTOR Abyss Commercial Diving
SLOPE 90°
BEARING ---
EQUIPMENT Vibracore
HOLE LOCATION 56 J 509888 7052200
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		SP	**SAND**, fine to medium grained, brown, trace silt, ALLUVIAL		
			1.0 1.5 2.0 2.5		SP	**SAND**, fine to medium grained, grey, trace silt, ALLUVIAL		
			3.0 3.5			Borehole 3747-P137-BH18 terminated at 2.9m		Borehole terminated due to vibracore refusal.

BOREHOLE LOG SHEET

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BOREHOLE No: 3747-P137-BH19

SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** **DATUM**

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

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509840 7052212

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
					SP	**SAND**, fine to medium grained, brown, trace silt, ALLUVIAL		
			0.5 1.0 1.5		SP	**SAND**, fine to medium grained, pale grey to grey, ALLUVIAL		
			2.0 2.5		SP	**SAND**, fine to coarse grained, grey, trace silt, ALLUVIAL		
			3.0		SC	**CLAYEY SAND**, fine grained grained, dark grey, low plasticity clay, ALLUVIAL		
			3.5			Borehole 3747-P137-BH19 terminated at 3m		

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BOREHOLE No: 3747-P137-BH20

SHEET: 1 of 1

DATE STARTED 8/11/11 **COMPLETED** 8/11/11 **R.L. SURFACE** ____ **DATUM** ____

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

EQUIPMENT Vibracore **HOLE LOCATION** 56 J 509840 7052136

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

NOTES Water Depth 0.7m

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, ALLUVIAL		
			0.5 1.0	░	SP	**SAND**, fine to coarse grained, dark brown, trace silt, ALLUVIAL		
			1.5 2.0 2.5	░	SP	**SAND**, fine to medium grained, grey, trace silt, ALLUVIAL		
			3.0	▨	CH	**SILTY CLAY**, high plasticity, dark grey, ALLUVIAL		
			3.5			Borehole 3747-P137-BH20 terminated at 3m		

Annex D - Particle Size Distribution Test Results

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Particle Size Distribution

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

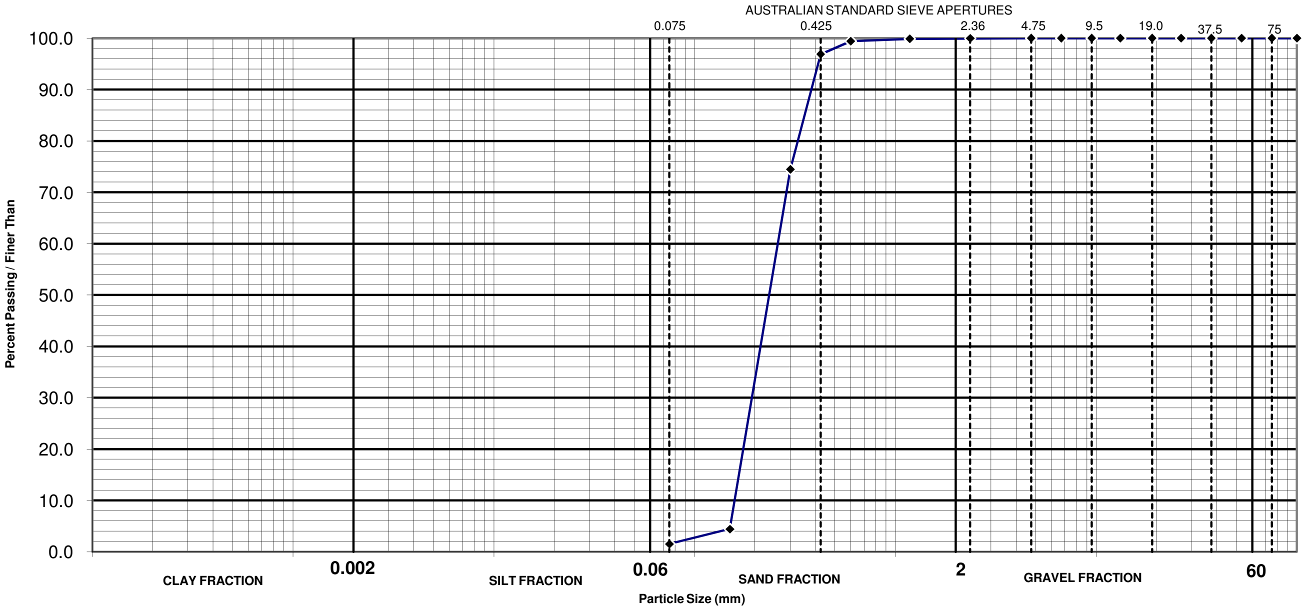
Sample Number: **3747/S/12753**
Sample Identification: **BH1: 0.0-0.5**
Date Sampled: **8/11/2011**

Report Number: **3747/S/12753Hyd**
Job Number: **3747/P/137**
Report Date: **14/12/2011**
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	97		
37.5		0.300	74		
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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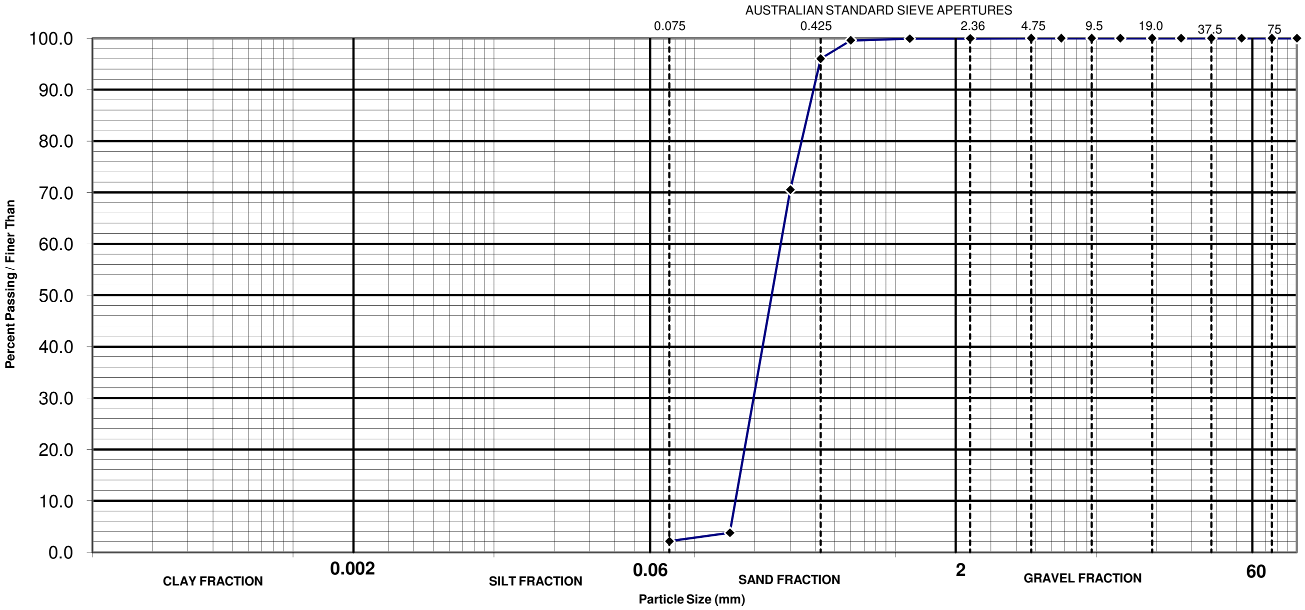
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12760Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12760**		
Sample Identification:	**BH2: 0.5-1.0**	Pre-treatment Loss:	**n/a**
Date Sampled:	**8/11/2011**	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	96		
37.5		0.300	71		
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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Particle Size Distribution

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

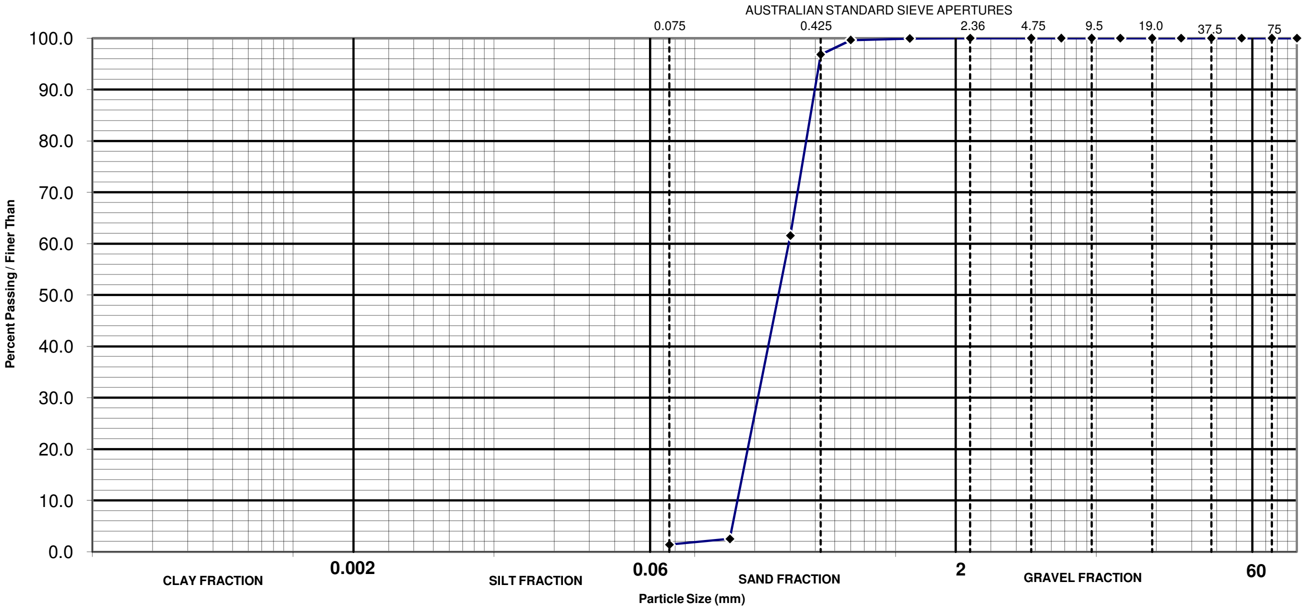
Sample Number: **3747/S/12765**
Sample Identification: **BH 3: 0.0-0.5**
Date Sampled: **8/11/2011**

Report Number: **3747/S/12765HYD**
Job Number: **3747/P/137**
Report Date: **14/12/2011**
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	97		
37.5		0.300	62		
26.5		0.150	3		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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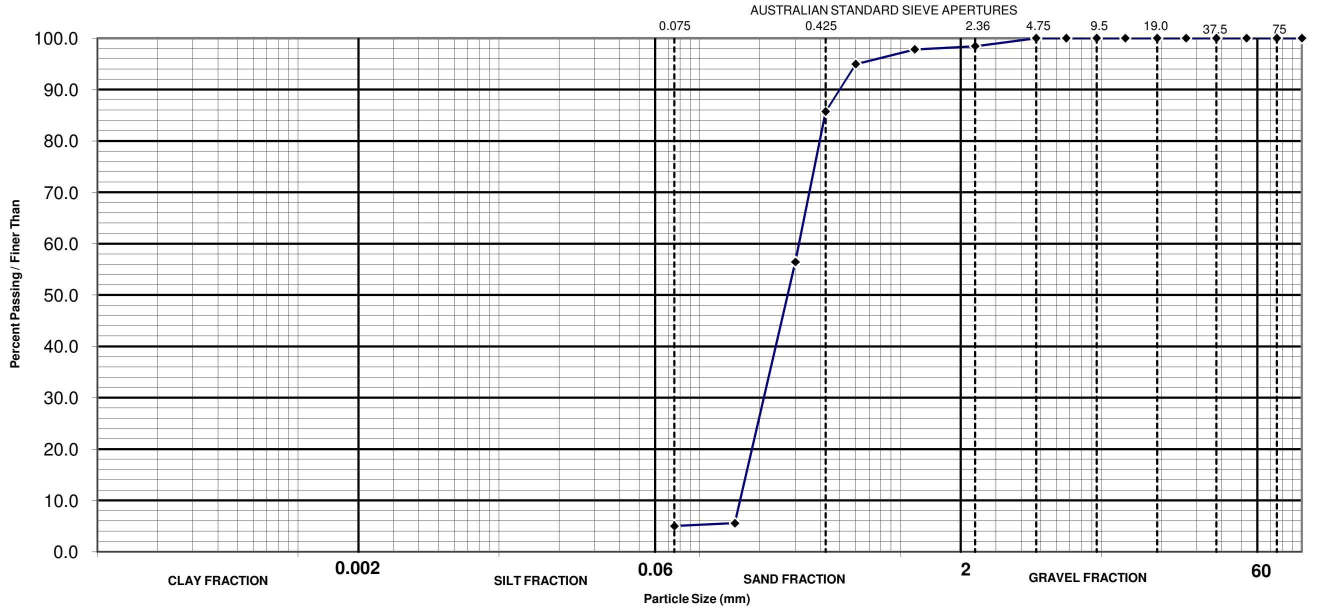
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12776Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12776**		
Sample Identification:	**BH4: 2.5-3.0**	Pre-treatment Loss:	**n/a**
Date Sampled:	**8/11/2011**	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	95		
53		0.425	86		
37.5		0.300	56		
26.5		0.150	6		
19.0		0.075	5		
13.2					
9.5					
6.7					
4.75	100				
2.36	98				

PARTICLE SIZE DISTRIBUTION



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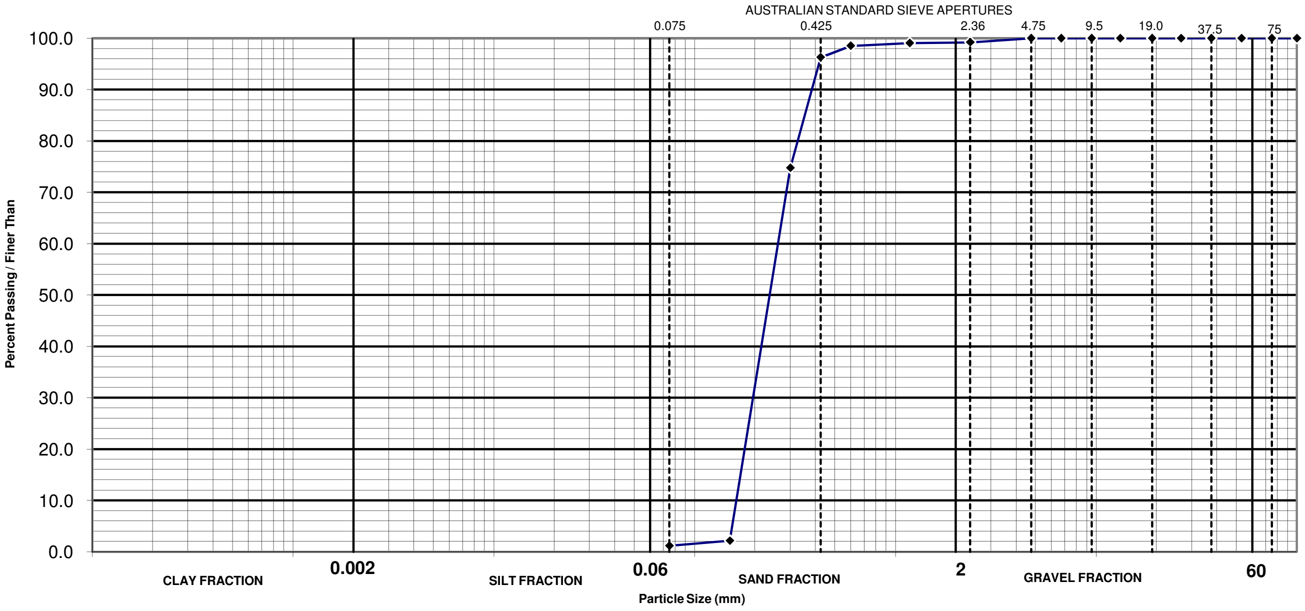
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12777Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12777**		
Sample Identification:	**BH5: 0.0-0.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**8/11/2011**	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	96
0.300	75
0.150	2
0.075	1

PARTICLE SIZE DISTRIBUTION



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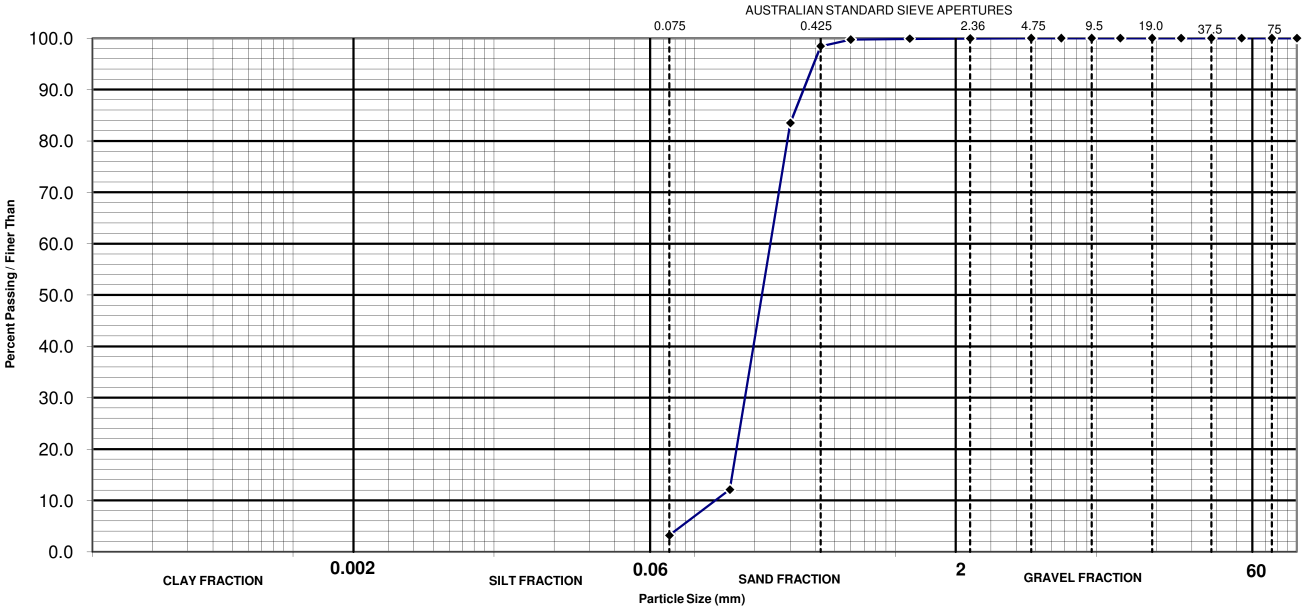
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12784Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12784**		
Sample Identification:	**BH6: 0.5-1.0**	Pre-treatment Loss:	**n/a**
Date Sampled:	**8/11/2011**	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	98		
37.5		0.300	83		
26.5		0.150	12		
19.0		0.075	3		
13.2					
9.5					
6.7					
4.75	100				
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: **Maroochy River Sediment Investigation**

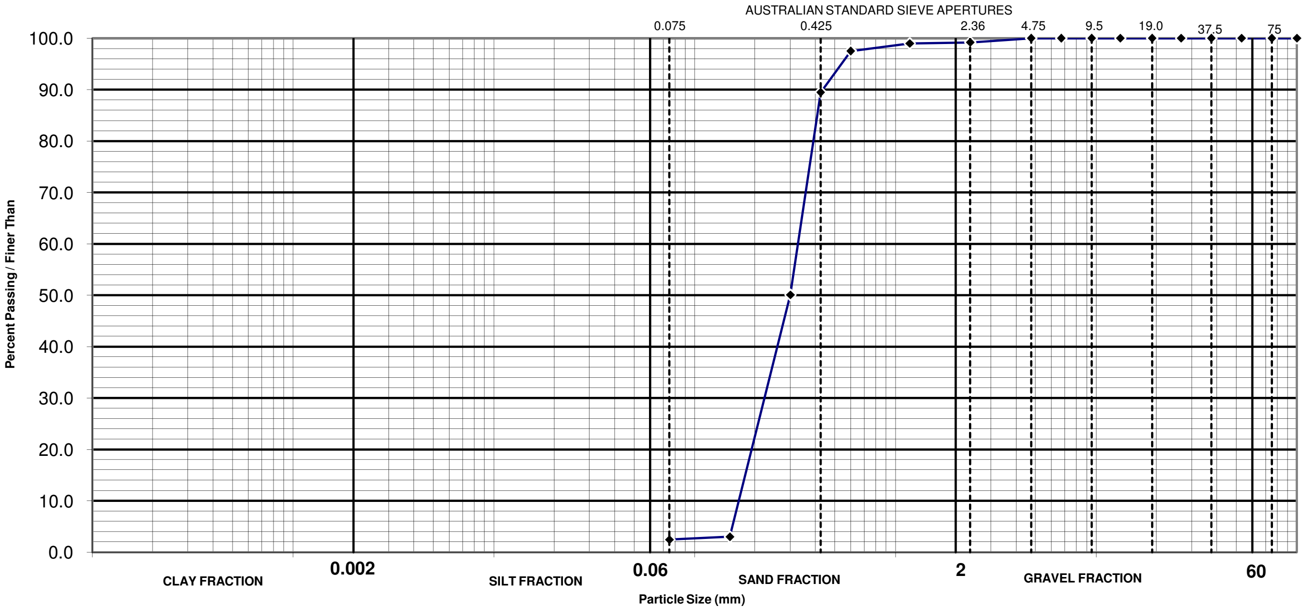
Sample Number: **3747/S/12870**
Sample Identification: **BH7: 1.5-2.0**
Date Sampled: **9/11/2011**

Report Number: **3747/S/12870Hyd**
Job Number: **3747/P/137**
Report Date: **14/12/2011**
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	89		
37.5		0.300	50		
26.5		0.150	3		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
2.36	99				

PARTICLE SIZE DISTRIBUTION



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Particle Size Distribution

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

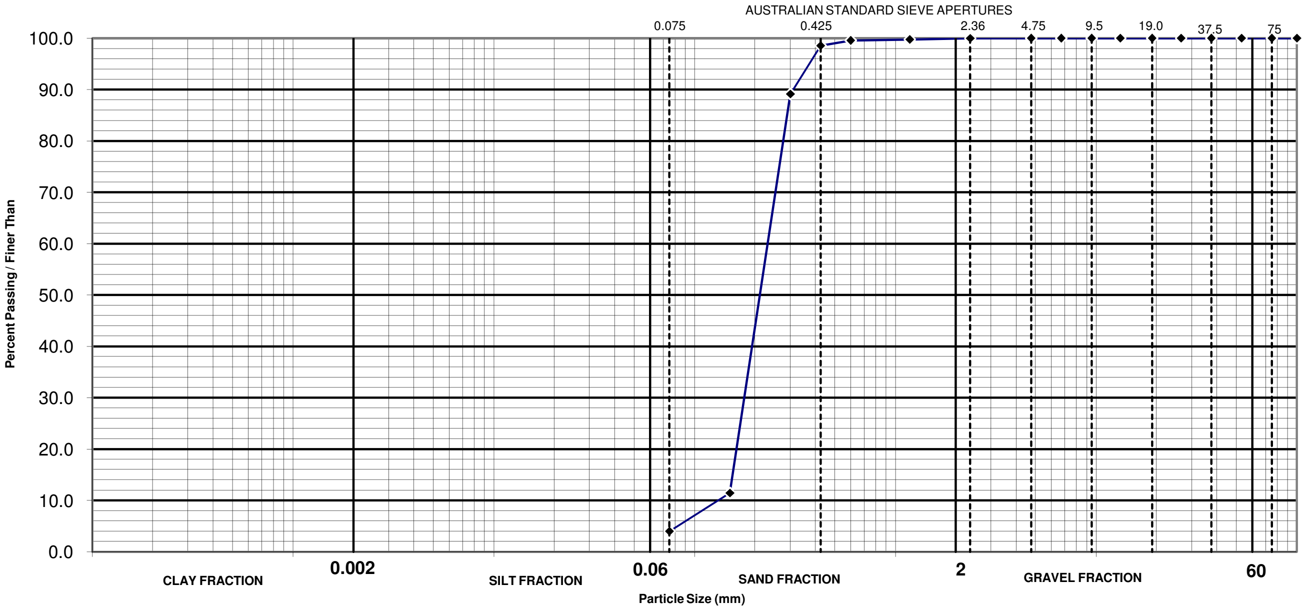
Sample Number: **3747/S/12789**
Sample Identification: **BH8: 0.0-0.5**
Date Sampled: **8/11/2011**

Report Number: **3747/S/12789Hyd**
Job Number: **3747/P/137**
Report Date: **14/12/2011**
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	89		
26.5		0.150	11		
19.0		0.075	4		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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SIGNATORY: Paul Mayes

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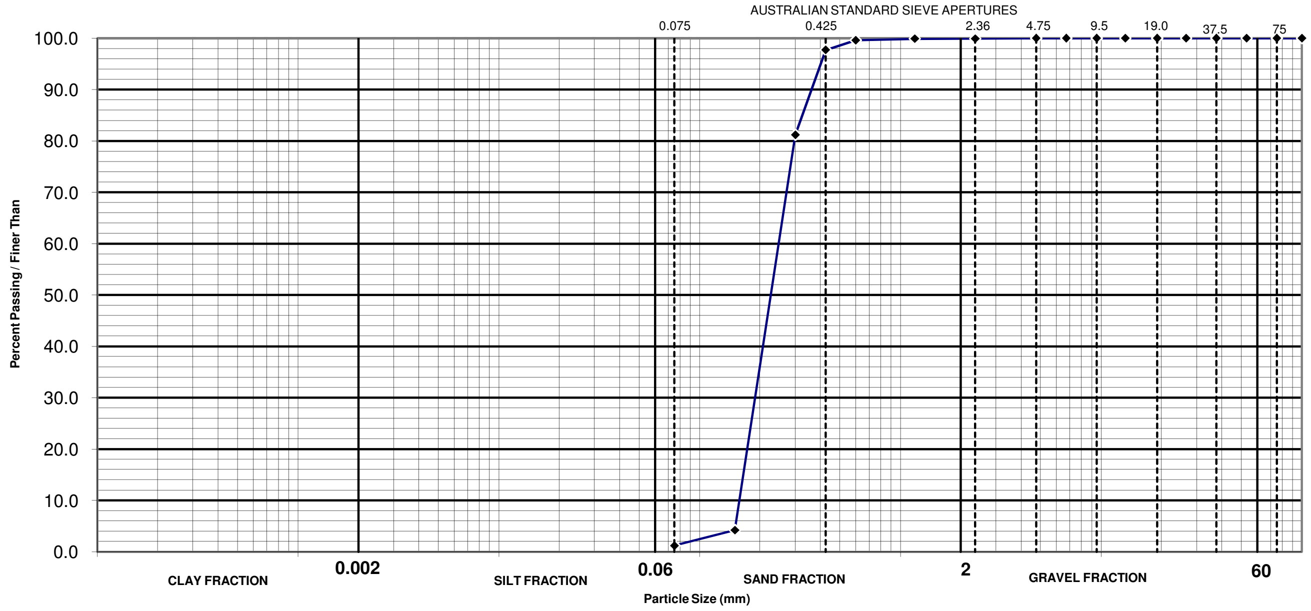
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12799Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12799**		
Sample Identification:	**BH9: 2.0-2.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**9/11/2011**	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	98		
37.5		0.300	81		
26.5		0.150	4		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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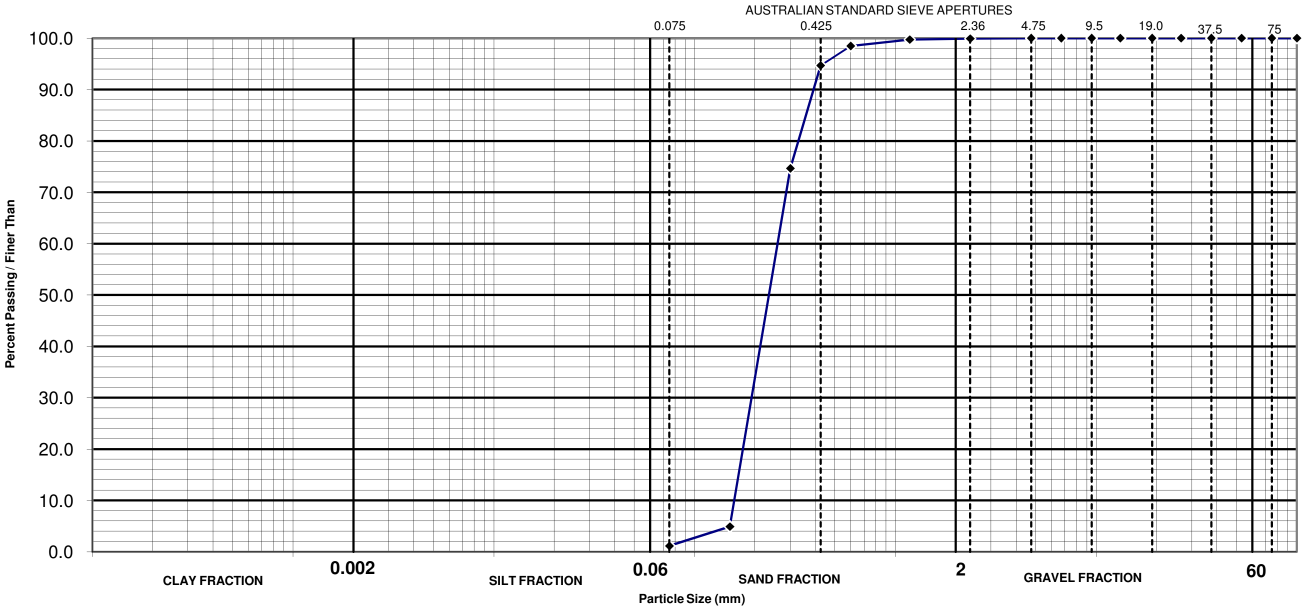
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12802Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12802**		
Sample Identification:	**BH10: 0.5-1.0**	Pre-treatment Loss:	**n/a**
Date Sampled:	**9/11/2011**	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	98		
53		0.425	95		
37.5		0.300	75		
26.5		0.150	5		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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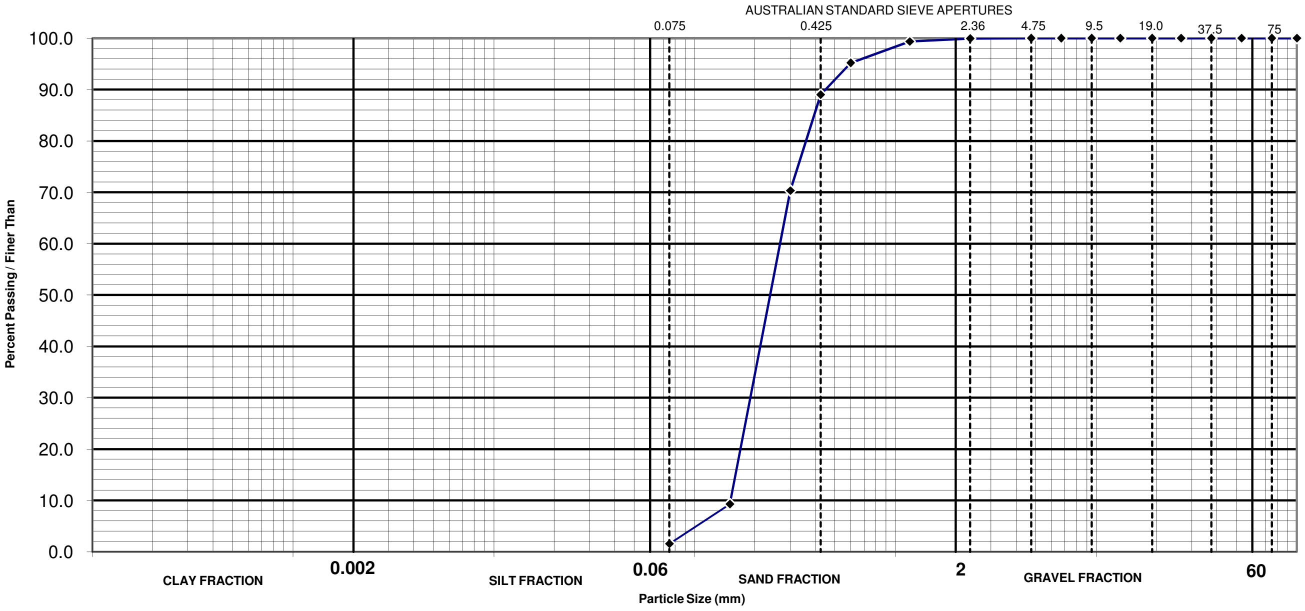
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12807Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12807**		
Sample Identification:	**BH11: 0.0-0.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**8/11/2011**	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	99		
75		0.600	95		
53		0.425	89		
37.5		0.300	70		
26.5		0.150	9		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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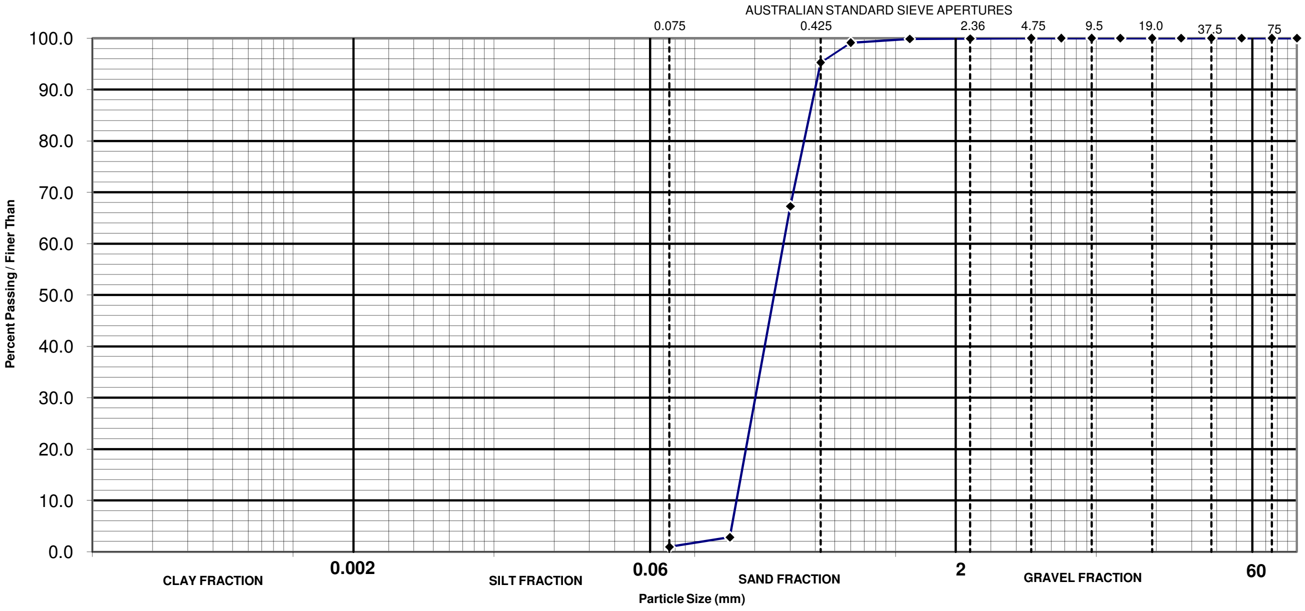
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12815Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12815**		
Sample Identification:	**BH12: 1.0-1.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**8/11/2011**	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	67		
26.5		0.150	3		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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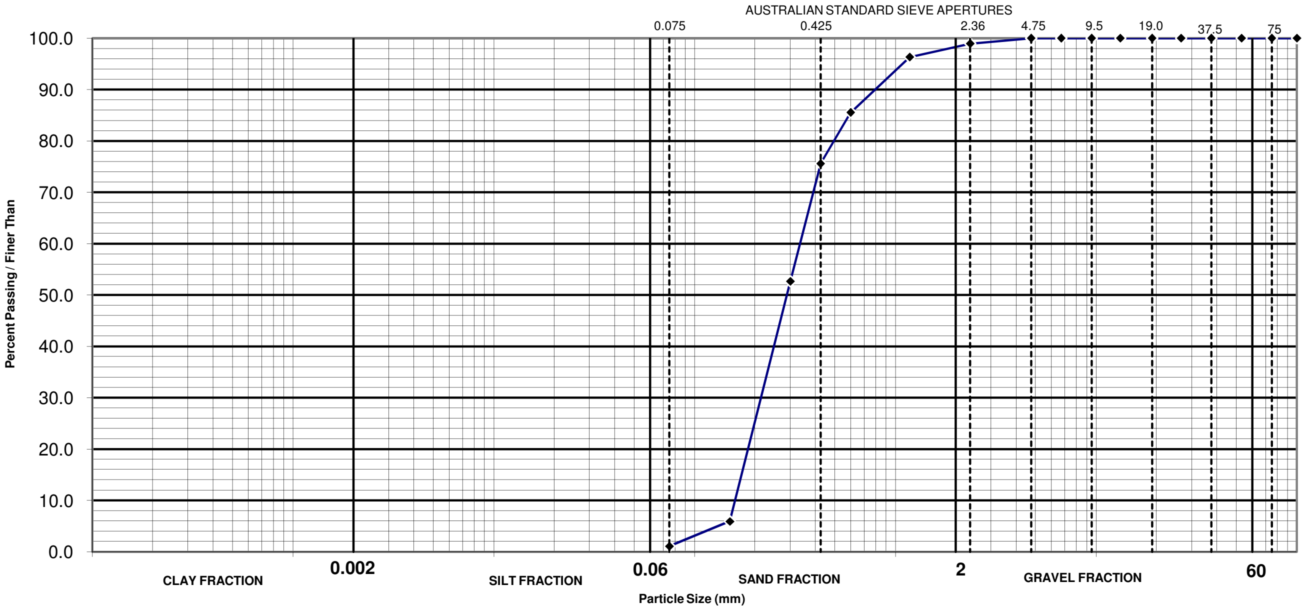
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12819Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12819**		
Sample Identification:	**BH13: 0.0-0.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**8/11/2011**	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	96		
75		0.600	86		
53		0.425	76		
37.5		0.300	53		
26.5		0.150	6		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	99				

PARTICLE SIZE DISTRIBUTION



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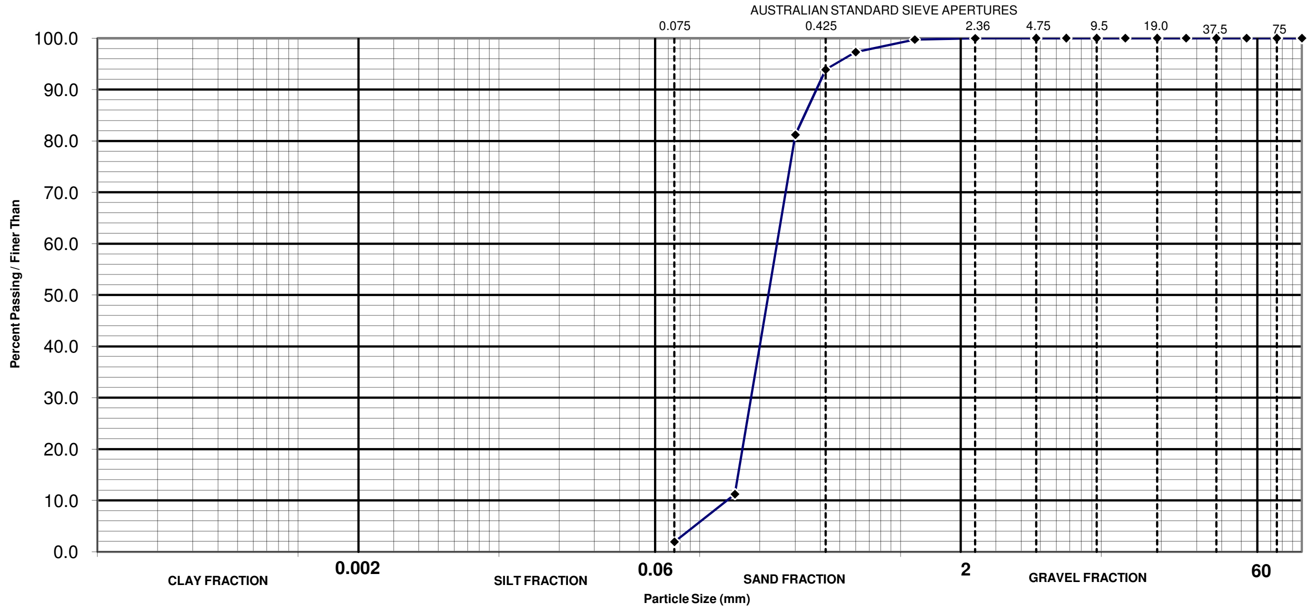
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/13808Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/13808**		
Sample Identification:	**BH14: 0.0-0.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**9/11/2011**	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	97		
53		0.425	94		
37.5		0.300	81		
26.5		0.150	11		
19.0		0.075	2		
13.2					
9.5					
6.7					
4.75	100				
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: **Maroochy River Sediment Investigation**

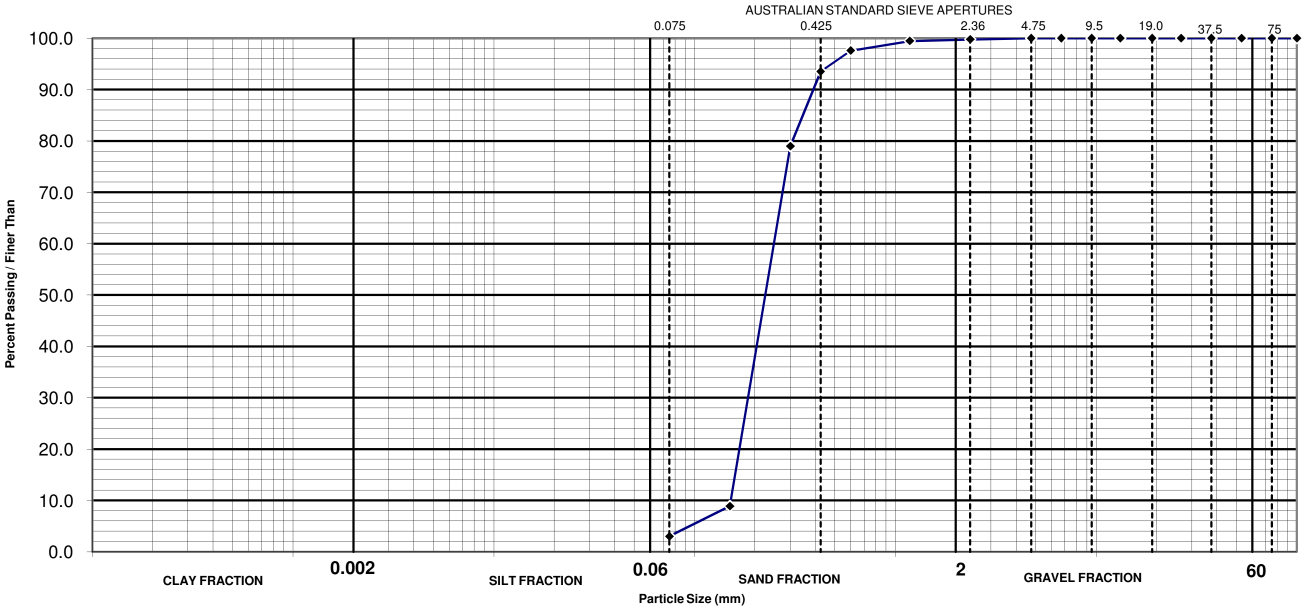
Sample Number: **3747/S/12826**
Sample Identification: **BH15: 0.5-1.0**
Date Sampled: **8/11/2011**

Report Number: **3747/S/12826Hyd**
Job Number: **3747/P/137**
Report Date: **14/12/2011**
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	79		
26.5		0.150	9		
19.0		0.075	3		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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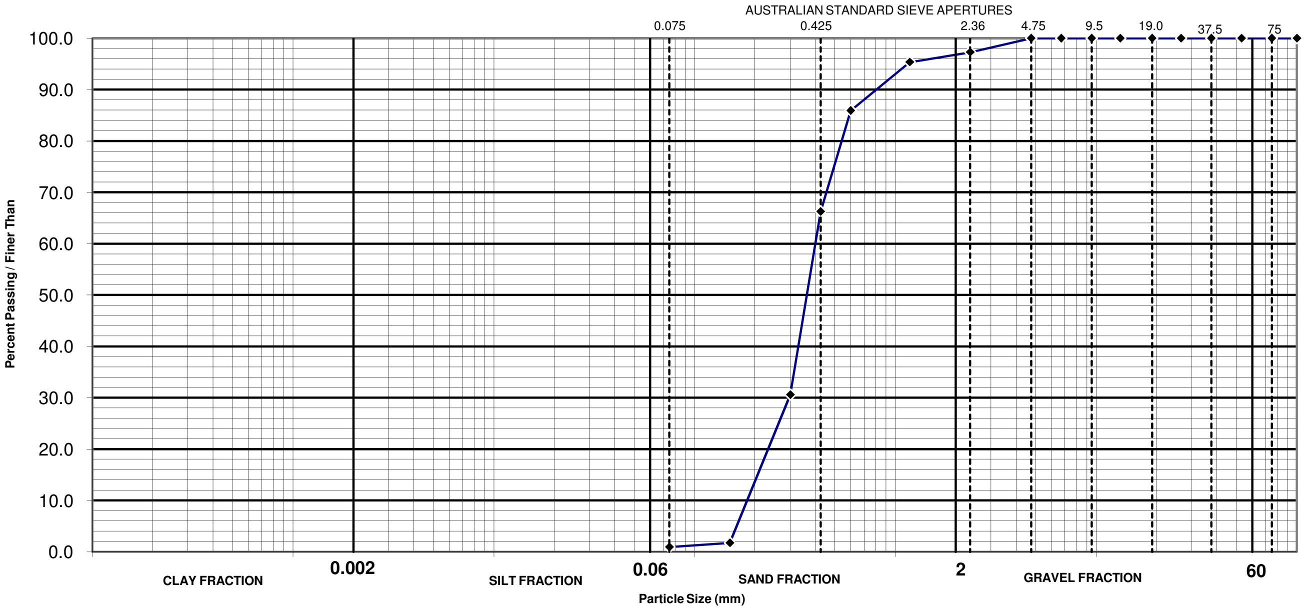
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12831Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12831**		
Sample Identification:	**BH16: 0.0-0.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**8/11/2011**	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	95		
75		0.600	86		
53		0.425	66		
37.5		0.300	31		
26.5		0.150	2		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	97				

PARTICLE SIZE DISTRIBUTION



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Particle Size Distribution

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

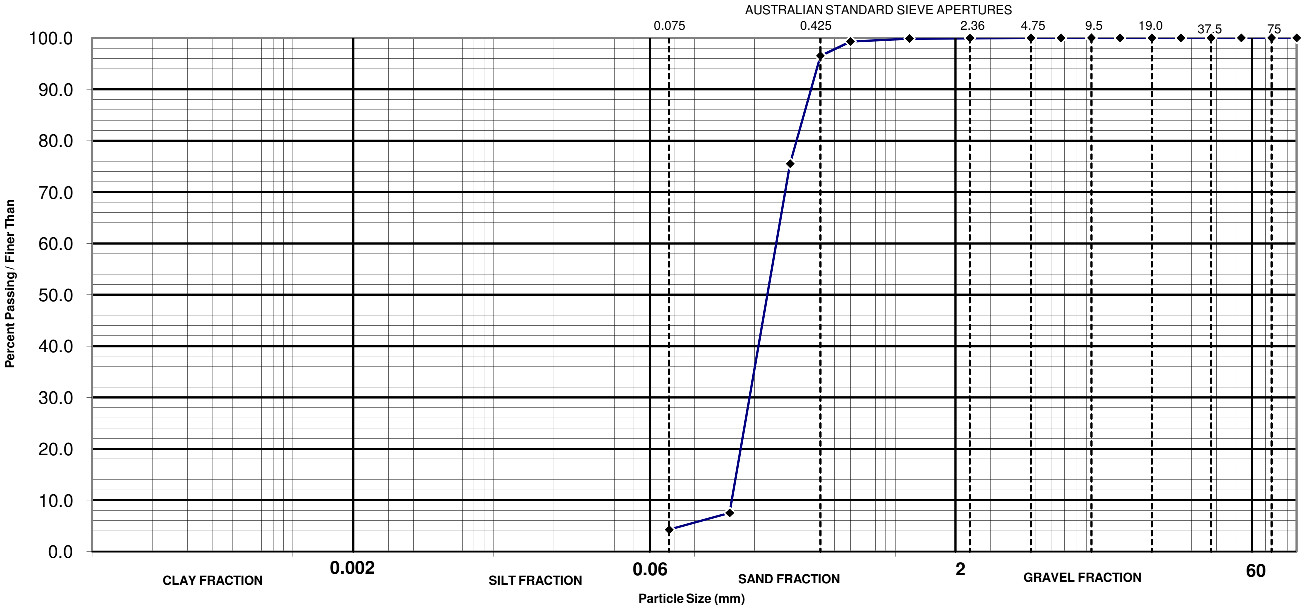
Sample Number: **3747/S/12841**
Sample Identification: **BH17: 2.0-2.5**
Date Sampled: **8/11/2011**

Report Number: **3747/S/12841Hyd**
Job Number: **3747/P/137**
Report Date: **14/12/2011**
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	76		
26.5		0.150	8		
19.0		0.075	4		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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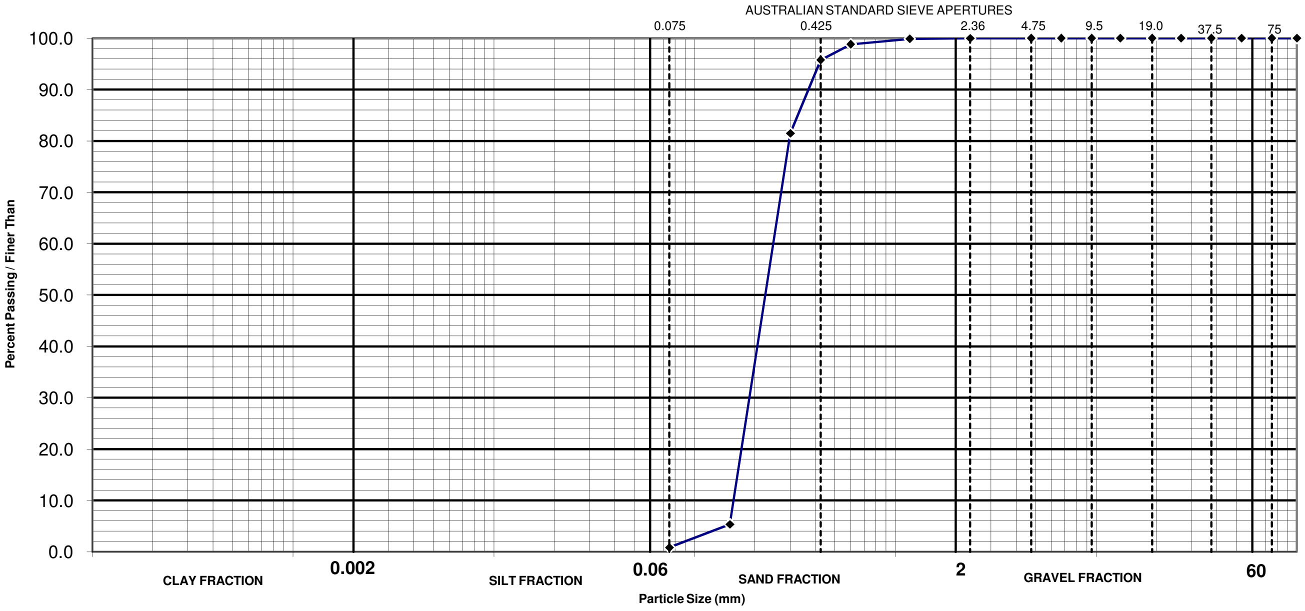
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12843Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12843**		
Sample Identification:	**BH18: 0.0-0.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**8/11/2011**	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	100		
75		0.600	99		
53		0.425	96		
37.5		0.300	81		
26.5		0.150	5		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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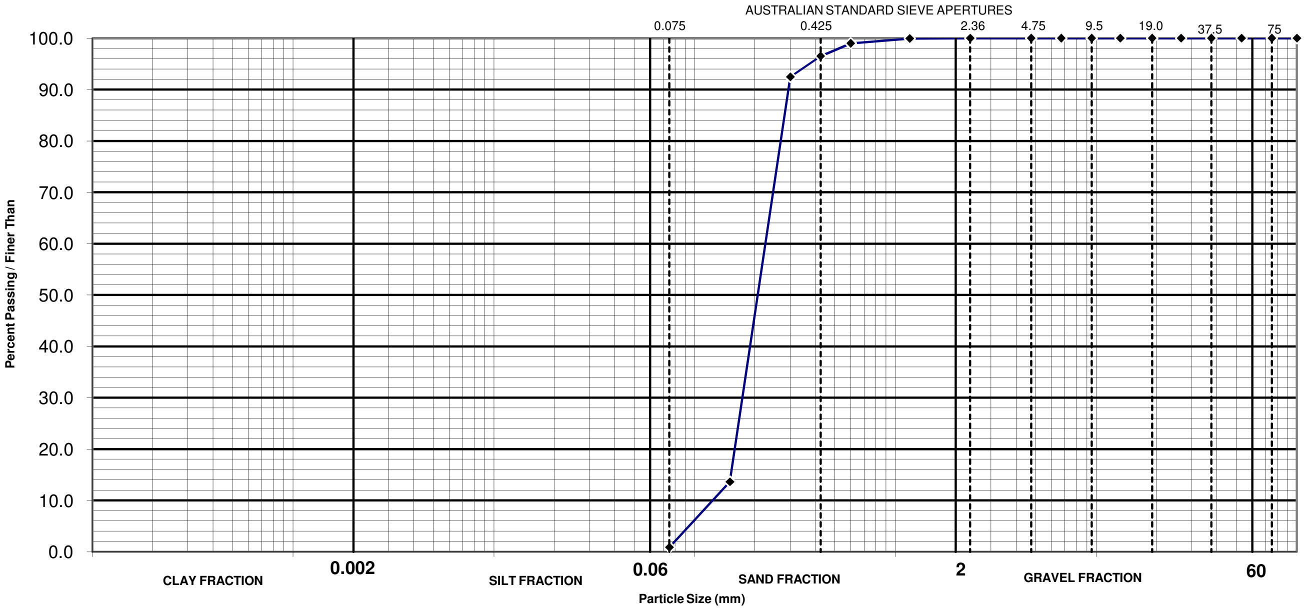
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12857Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12857**		
Sample Identification:	**BH19: 1.0-1.5**	Pre-treatment Loss:	**n/a**
Date Sampled:	**8/11/2011**	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	92		
26.5		0.150	14		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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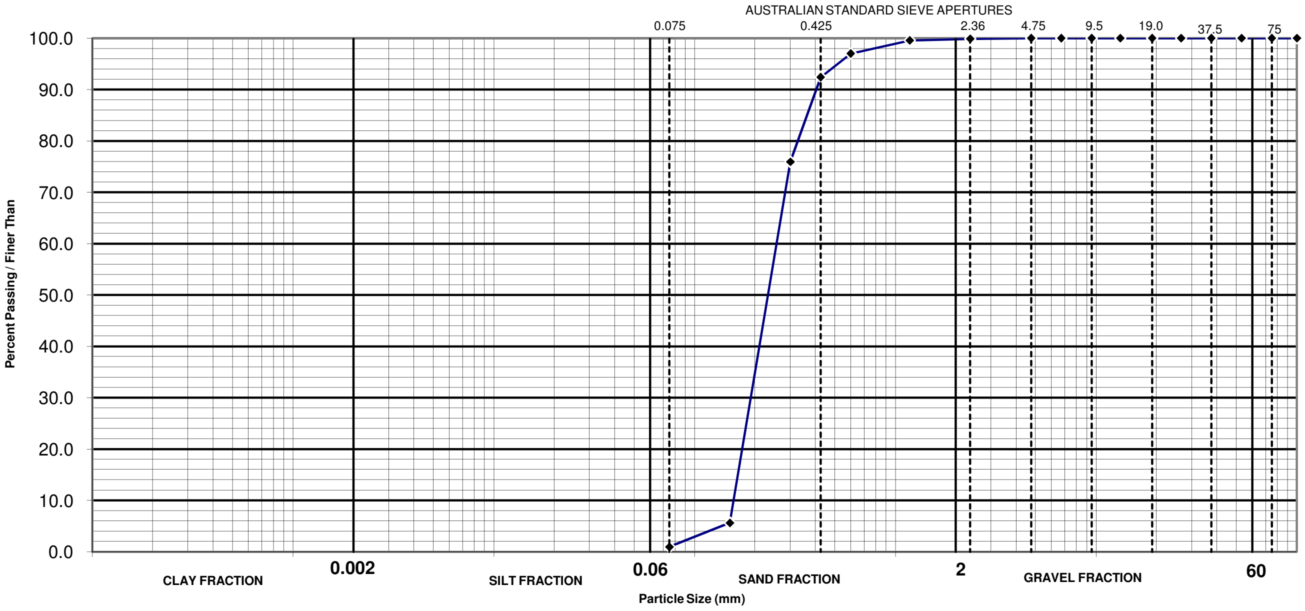
Particle Size Distribution

Client:	**Sunshine Coast Council**	Report Number:	**3747/S/12866Hyd**
Clients Address:	**Locked Bag 72, SCMC 4560**	Job Number:	**3747/P/137**
Project:	**Maroochy River Sediment Investigation**	Report Date:	**14/12/2011**
		Test Methods:	**AS1289.3.6.1**
Sample Number:	**3747/S/12866**		
Sample Identification:	**BH20: 2.5-3.0**	Pre-treatment Loss:	**n/a**
Date Sampled:	**9/11/2011**	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	97		
53		0.425	92		
37.5		0.300	76		
26.5		0.150	6		
19.0		0.075	1		
13.2					
9.5					
6.7					
4.75	100				
2.36	100				

PARTICLE SIZE DISTRIBUTION



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Annex E – Acid Sulfate Soils Test Results

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CHROMIUM SUITE TEST REPORT

Report Number: 3747/S/12819CRS
Client: Sunshine Coast Council
Client Address: Locked Bag 72, Sunshine Coast Mail Centre
Project: Maroochy River Sediment Investigation
Job no. 3747/P/137
Sampled by: Cardno Bowler (Sunshine Coast)
Date Sampled: 10/11/2011
Date Received: 10/11/2011
Date Tested: 28/11/2011
Date Reported: 28/11/2011
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/12819	BH13 0.0-0.5	9.8	0	0.000	0.008	<0.02	nr	2.11	-876	-1.404	No Liming Required
3747/S/12820	BH13 0.5-1.0	9.7	0	0.000	<0.007	0.020	nr	1.62	-661	-1.060	No Liming Required
3747/S/13808	BH14 0.0-0.5	9.8	0	0.000	<0.007	<0.02	nr	1.52	-632	-1.013	No Liming Required
3747/S/13810	BH14 1.0-1.5	9.8	0	0.000	<0.007	<0.02	nr	1.57	-654	-1.049	No Liming Required
3747/S/12826	BH15 0.5-0.1	9.6	0	0.000	<0.007	<0.02	nr	1.22	-506	-0.812	No Liming Required
3747/S/12828	BH15 1.5-2.0	9.6	0	0.000	<0.007	<0.02	nr	1.78	-741	-1.187	No Liming Required
3747/S/12831	BH16 0.0-0.5	9.7	0	0.000	<0.007	<0.02	nr	1.13	-472	-0.756	No Liming Required
3747/S/12833	BH16 1.0-1.5	9.5	0	0.000	<0.007	<0.02	nr	1.06	-439	-0.704	No Liming Required
3747/S/12840	BH17 1.5-2.0	9.7	0	0.000	<0.007	<0.02	nr	1.17	-487	-0.780	No Liming Required
3747/S/12841	BH17 2.0-2.5	9.6	0	0.000	<0.007	0.022	nr	1.42	-576	-0.923	No Liming Required
3747/S/12843	BH18 0.0-0.5	9.7	0	0.000	<0.007	<0.02	nr	1.26	-523	-0.838	No Liming Required
3747/S/12845	BH18 1.0-1.5	9.8	0	0.000	<0.007	<0.02	nr	1.41	-587	-0.941	No Liming Required
3747/S/12857	BH19 1.0-1.5	9.7	0	0.000	<0.007	<0.02	nr	1.20	-498	-0.799	No Liming Required
3747/S/12858	BH19 1.5-2.0	9.7	0	0.000	<0.007	<0.02	nr	1.57	-652	-1.045	No Liming Required
3747/S/12861	BH20 0.0-0.5	9.8	0	0.000	<0.007	<0.02	nr	1.66	-688	-1.104	No Liming Required
3747/S/12866	BH20 2.5-3.0	9.7	0	0.000	<0.007	<0.02	nr	1.09	-453	-0.726	No Liming Required
Blank		5.6	2.5	0.004							

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.
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Sydney, Deniliquin, Melbourne, Bendigo, Dandenong

CHROMIUM SUITE TEST REPORT

Report Number: 3747/S/12753CRS
Client: Sunshine Coast Council
Client Address: Locked Bag 72, Sunshine Coast Mail Centre
Project: Maroochy River Sediment Investigation
Job no. 3747/P/137
Sampled by: Cardno Bowler (Sunshine Coast)
Date Sampled: 10/11/2011
Date Received: 10/11/2011
Date Tested: 28/11/2011
Date Reported: 28/11/2011
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/12753	BH1 0.0-0.5	9.1	0	0.000	<0.007	<0.02	nr	0.65	-269	-0.431	No Liming Required
3747/S/12757	BH1 2.5-2.5	7.3	0	0.000	<0.007	0.021	nr	0.52	-202	-0.323	No Liming Required
3747/S/12760	BH2 0.5-1.0	8.3	0	0.000	<0.007	<0.02	nr	0.57	-237	-0.381	No Liming Required
3747/S/12761	BH2 1.0-1.5	8.6	0	0.000	<0.007	0.030	nr	0.68	-265	-0.426	No Liming Required
3747/S/12765	BH3 0.0-0.5	8.7	0	0.000	<0.007	0.022	nr	0.50	-195	-0.313	No Liming Required
3747/S/12767	BH3 1.0-1.5	8.1	0	0.000	<0.007	0.041	nr	0.51	-186	-0.299	No Liming Required
3747/S/12772	BH4 0.5-1.0	8.9	0	0.000	0.020	0.032	nr	0.46	-170	-0.272	No Liming Required
3747/S/12776	BH4 2.5-3.0	9.0	0	0.000	<0.007	0.041	nr	0.63	-235	-0.377	No Liming Required
3747/S/12777	BH5 0.0-0.5	9.3	0	0.000	<0.007	<0.02	nr	0.61	-254	-0.407	No Liming Required
3747/S/12780	BH5 1.5-2.0	9.2	0	0.000	<0.007	0.037	nr	0.62	-233	-0.373	No Liming Required
3747/S/12783	BH6 0.0-0.5	9.4	0	0.000	<0.007	<0.02	nr	0.69	-286	-0.459	No Liming Required
3747/S/12784	BH6 0.5-1.0	9.3	0	0.000	<0.007	<0.02	nr	0.66	-273	-0.438	No Liming Required
3747/S/12869	BH7 1.0-1.5	9.1	0	0.000	<0.007	0.023	nr	0.63	-247	-0.396	No Liming Required
3747/S/12870	BH7 1.5-2.0	9.0	0	0.000	<0.007	0.033	nr	0.57	-216	-0.346	No Liming Required
3747/S/12789	BH8 0.0-0.5	9.3	0	0.000	<0.007	0.030	nr	0.68	-266	-0.426	No Liming Required
3747/S/12790	BH8 0.5-1.0	9.2	0	0.000	<0.007	0.033	nr	0.63	-242	-0.389	No Liming Required
3747/S/12797	BH9 1.0-1.5	9.1	0	0.000	<0.007	0.027	nr	0.59	-229	-0.368	No Liming Required
3747/S/12799	BH9 2.0-2.5	9.1	0	0.000	<0.007	0.034	nr	0.71	-275	-0.441	No Liming Required
Blank		5.8	2.0	0.003							

Notes:
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CHROMIUM SUITE TEST REPORT

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Project: Maroochy River Sediment Investigation
Job no. 3747/P/137
Sampled by: Cardno Bowler (Sunshine Coast)
Date Sampled: 10/11/2011
Date Received: 10/11/2011
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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/12802	BH10 0.5-1.0	9.5	0	0.000	0.010	<0.02	nr	1.04	-432	-0.693	No Liming Required
3747/S/12804	BH10 1.5-2.0	9.1	0	0.000	<0.007	0.139	nr	1.58	-570	-0.915	No Liming Required
3747/S/12807	BH11 0.0-0.5	9.7	0	0.000	0.013	<0.02	nr	1.25	-521	-0.836	No Liming Required
3747/S/12808	BH11 0.5-1.0	9.6	0	0.000	<0.007	<0.02	nr	0.95	-395	-0.634	No Liming Required
3747/S/12815	BH12 1.0-1.5	9.6	0	0.000	<0.007	<0.02	nr	1.03	-430	-0.689	No Liming Required
3747/S/12818	BH12 2.5-3.0	9.6	0	0.000	0.023	0.024	nr	1.02	-411	-0.659	No Liming Required
Blank		5.8	2.0	0.003							

Notes:
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LOR: Limit of Reporting
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[a] **S_{KCl} determined as sulfate by turbidimetric method.**
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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.

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* 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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THE ASSOCIATION
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PRACTICING IN THE GEOSCIENCES

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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.

This report is the subject of copyright, and shall not be reproduced either totally or in part without the express permission of this firm.

APPENDIX F: BEACH NOURISHMENT LONGEVITY ESTIMATE

PROJECT HALF-LIFE ESTIMATE

Analytical methods to predict shoreline change due to wave driven sediment transport have been developed following simple relationships that are described in the Coastal Engineering Manual (USACE, 2002). Assuming that the breaking wave angle is small, the 'shoreline diffusivity 'or the rate at which material leaves a defined beach system can be predicted following:

$$\varepsilon = \frac{KH_b^2 C_{gb}}{8}\left(\frac{\rho}{\rho_s-\rho}\right)\left(\frac{1}{1-n}\right)\left(\frac{1}{d_B+d_c}\right)$$

Equation F-1

The parameters in the above equation are defined below together with the values adopted for this study:

K = is the longshore transport parameter = 0.77

H_b = is the breaking wave height = take from wave assessment (refer below)

C_g = wave group celerity at the break point = $\sqrt{gh}_b$ where g is the acceleration due to gravity and hb is the wave breaker depth (assumed $h_b = \frac{H_b}{0.78}$)

d_B = is the berm height above still-water level = 2m

d_c = is the depth of appreciable sand transport = 12m

ρ = sea water density = 1025kg/m3

ρ_s = sediment density = 2700kg/m3

n = sediment porosity = 0.4

The average annual wave climate for Maroochydore Beach developed as part of the coastal processes studies undertaken for the Sunshine Coast SEMP (BMT WBM, 2011b) was used to guide the breaking wave height value used in Equation F-1. The Maroochydore Beach wave rose and wave height and direction frequency recurrence are provided below in Figure F-1 and Table F-1.

The 'half-life' of the proposed initial nourishment project refers to the time taken for 50% of the nourishment material to move out of the beach system and was estimated following:

$$t_{50\%} = \frac{a^2\pi}{4\varepsilon}$$

Equation F-2

Where *a* is half the length of the project shoreline (total length is 1.7km) and ε is the shoreline diffusivity estimated from Equation 2.

The 'half-life' for each wave height condition in Table F-1 was calculated and factored (multiplied) by its percentage recurrence. The total 'half-life' is then the sum of the 'factored half-life' (calculated for each wave condition) and is therefore representative of the annual average wave climate for Maroochydore Beach. Table F-2 provides a summary of project 'half-life' assessment results. The estimated 'half-life' of the proposed initial nourishment works is 2.9 years. It is noted that this estimate is based on the long-term annual average wave climate and that annual losses are likely to vary from year to year because of the dependency on storm activity.

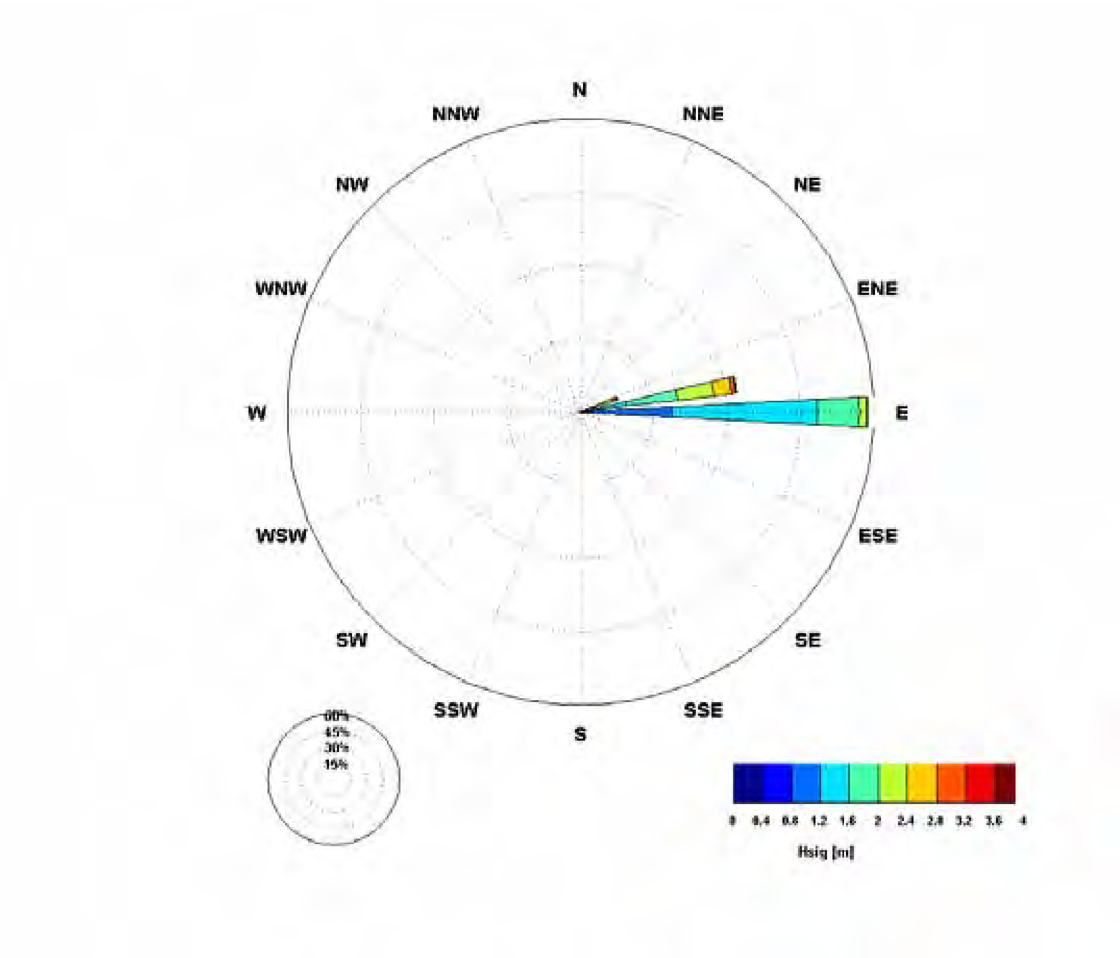

Figure F- 1 Maroochydore Wave Rose Plot

Table F-1 Maroochydore Wave Height and Direction Recurrence Frequency (% of time)

	Dir [m]												
Hs [m]	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**Total**
0.1 - 0.3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%		0.1%
0.3 - 0.5		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	18.8%	0.1%		19.6%
0.5 - 0.7			0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	8.8%	29.6%	0.2%	0.0%	39.0%
0.7 - 0.9			0.0%			0.1%	0.2%	2.0%	10.6%	8.6%	0.1%		21.5%
0.9 - 1.1						0.0%	0.0%	2.6%	7.4%	1.5%	0.0%		11.6%
1.1 - 1.3						0.0%	0.0%	2.1%	3.6%	0.2%	0.0%		5.9%
1.3 - 1.5							0.0%	0.7%	0.9%	0.0%			1.6%
1.5 - 1.7								0.2%	0.2%	0.0%			0.4%
1.7 - 1.9								0.1%	0.0%				0.1%
1.9 - 2.1								0.0%	0.0%				0.0%
> 2.1								0.0%	0.0%				0.0%
Total	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	8.1%	32.3%	58.8%	0.4%	0.0%	100.0%

Table F-2 **Estimated Longevity of Initial Nourishment Based on the Annual Average Incident Wave Climate (refer Appendix F)**

Wave Height (m)	Wave Height % of year	ε (m^2/s)	*Factored* $t_{50\%}$ (sec)
0.1 - 0.3	0.1%	0.0004	1288036
0.3 - 0.5	19.6%	0.0025	44628174
0.5 - 0.7	39.0%	0.0069	32224746
0.7 - 0.9	21.5%	0.0141	8653993
0.9 - 1.1	11.6%	0.0246	2672766
1.1 - 1.3	5.9%	0.0388	861791
1.3 - 1.5	1.6%	0.0571	158966
1.5 - 1.7	0.4%	0.0797	28462
1.7 - 1.9	0.1%	0.1071	5301
1.9 - 2.1	0.1%	0.1393	4073
>2.1	0.1%	0.1768	3210
		Total (sec)	90529516
		Total (years)	2.9

APPENDIX G: OUTCOMES OF COMMUNITY CONSULTATION

COMMUNITY CONSULTATION

Various community groups and stakeholders have been presented with details of the proposed Maroochydore Beach nourishment works and a summary of the feasibility studies regarding the project. All attendees were encouraged to participate in discussion, raise potential concerns and provide feedback. Attendee details and minutes from the meetings are provided in the following pages.

A stakeholder survey was distributed to each attendee at the meeting. The survey was completed and returned to Council at a later date. The survey questionnaire form and responses are also provided in the following pages. A response percentage breakdown summary is provided below:

- 100% of respondents agree foreshore erosion is an issue on Maroochydore Beach;
- 87% of respondents agreed foreshore protection measures are needed for Maroochydore Beach;
- 93% of respondents had a better understanding of technical aspects of foreshore protection following meeting;
- 67% of respondents had further comments regarding the proposal;
- 53% of respondents did not have further comments or concerns with the proposal;
- 73% of respondents were supportive of the proposal;
- 20% of respondents were neutral in terms of supporting the proposal;
- 100% of respondents wish to be kept informed.

ORGANISATION	ADDRESS	PRESIDENT	MOBILE	EMAIL	SECRETARY	MOBILE	EMAIL
Sunshine Coast Environment Council	3 Porters Lane Nambour QLD 4560	Annie Nolan	07 5441 5747	info@scec.org.au	Michelle McInnes	07 5441 5747	info@scec.org.au
Sunshine Coast Environment Council	Executive Officer	Weibe ter Bals	0420 370 948	executive@scec.org.au			
Coolum District Coast Care Group Inc	157 Warran Rd Yaroomba QLD 4573	Leigh Warneminde	07 5473 9322	info@coolumcoastcare.org.au	Stephanie	0412 904 216	info@coolumcoastcare.org.au
Coolum District Coast Care Group Inc and Coordinator Marcoola Coast Care	6/903 David low Way Marcoola 4564	Tony Gibson	0419 791 860	tony.gibson@spirit3h.com.au			
Mudjimba Residents Association		Helen and Foy Leckie		helenandfoy@bigpond.com			
Wildlife Preservation Society Queensland		Jill Chamberlain		sunshine@wildlife.org.au			
		Jan England		janengland8@bigpond.com			
Maroochy Waterwatch	PO Box 311 Nambour QLD 4560	Mr John Dillon	07 5476 4777	info@maroochycatchmentcentre.org.au	Shalin Day	07 5476 4777	info@maroochycatchmentcentre.org.au
Maroochy Waterwatch	803 Hunchy Road, Hunchy, QLD 4555	John and Joan Dillon	07 5442 9165	johnf.dillon@bigpond.com			
Maroochy Waterwatch	PO Box 311 Nambour QLD 4560	Cerran Fawns, CEO	07 5476 4777	cerran@maroochycatchmentcentre.org.au			
QLD Wader Study Group		Jon Coleman		janetandjon@hotmail.com	Peter Rothlisberg		Peter.rothlisberg@csiro.au
QLD Wader Study Group		Rick Barrett		rb_terab@hotmail.com			
QLD Wader Study Group		Jill Denning		jilldening@bigpond.com			
President, Birds Queensland		Richard Noske		rnoske@tpg.com.au			
Surfrider Foundation Sunshine Coast		Sally Atkinson	0405 567 930	surfridersunshine@live.com	n/a	n/a	n/a
Maroochydore Residents Association	PO Box 652 Maroochydore QLD 4558	Mr Allen Reed	07 54433868 0410 151 774	reedy@tadaust.org.au	Rob Kavanagh	07 5443 9883 0419 551 180	rojoka@optusnet.com.au
					Geoffrey Makara		g_makara@optusnet.com.au
Maroochydore Surf Life Saving Club	PO Box 390 Maroochydore Q 4558	Tim Ryan	07 5443 1323	enquiries@maroochysurfclub.com.au	n/a	n/a	n/a
	General manager	Mr Kerry Taylor	07 5443 1298				
	Director of Life Saving	Mr Todd Sweeney		lifesaving@maroochysurfclub.com.au			
Alexandra Headland Community Association	PO Box 1111 Cotton Tree QLD 4558	Peter Desbrow	0400 750 888	info@alexandraheadland.qld.au			peterdesbrow@bigpond.com
Beach Beat Maroochydore	164 Alexandra Parade Alexandra Headland QLD 4572	Noel or Gary	07 5443 2777	noel@beachbeat.com.au gary@beachbeat.com.au			
Alex Surf Lifesaving Club	167 Alexandra Parade Maroochydore QLD 4558	Ashley Robinson, General Manager	07 5443 6677 07 54567877	admin@alexsurfclub.com.au; ashley@alexsurfclub.com.au	Andrew Wallace	0412 227 332	n/a
		Mr Peter Duffy	07 5456 7804	lifesavers@alexsurfclub.com.au		07 5456 7804	
Alex Forest Community Conservation Group		Lindsay Hope		sunventure@bigpond.com			
Maroochy Sailing Club	PO Box 83 Maroochydore QLD 4558	Commodore Ms Gard Saunders	n/a	commodore2011@bigpond.com	David Thomson	n/a	n/a

Boat Shed Restaurant	The Esplanade Cotton Tree QLD 4558	Maryanne & Adam	07 5443 3808	boatshed@bigpond.net.au		boatshed@bigpond.net.au
Maroochydore RSL	Memorial Avenue, Maroochydore QLD 4558 or PO BOX 5824, Maroochydore BC QLD 4558	Chairman, Board of Directors Mr Leslie D'Alton	07 5443 2211	info@maroochyrsl.com.au	Cassandra Cook Marketing Manager	cassandrac@maroochyrsl.com.au
Maroochydore Chamber of Commerce	PO Box 181 Maroochydore QLD 4558	Mr Ross Hepworth	07 5443 5661	enquiries@maroochy.org	Susi Priest	enquiries@maroochy.org
Maroochydore Chamber of Commerce	Manager - Signature Events	Ms Melinda Shelton	0414 643 566	melinda@maroochy.org		
Brian Weir	Inside Edge Surf Shop 14 Memorial Avenue Cotton Tree QLD 4558		07 5443 4143			
Col and Lorraine Pritchard	604/45 The Esplanade Cotton Tree		0418 887 185	collor@iprimus.com.au		
Cotton Tree Bushcare Group		John King	(07) 5479 5529	john.king40@bigpond.com		
Cr Debbie Blumel			07 5475 8745 0448 122 948			
Cr Chris Thompson			07 5420 8975			
Department of Transport & Main Roads						
Fiona Simpson, MP	www.fionasimpson.com.au			maroochydore@parliament.gov.au		
Council staff: Chris Allan Denis Shaw Adam Britton Mick Smith						
Ian Layton	Civil Designer		0413 125 244	ian.layton@sunshinecoast.qld.gov.au		
BMT WBM	Level 8, 200 Creek St Brisbane QLD 4000		07 3831 6744	bmtwbm@bmtwbm.com.au		
GHD	PO Box 1540 Buddina QLD 4575	Mr Bruce Johnson	07 5413 8100			

Maroochy Beaches Foreshore Protection Targeted Stakeholder meeting
08-Mar-2012
Location: Quad Park Stadium, Corporate Lounge

Session 1	**Sunshine Coast Environment Council**
Attendees	
Weibe ter Bals	Sunshine Coast Environment Council
Presentation;	
Chris Allan	*Introduction*
Mick Smith	*SEMP presentation*
Informal Discussion	
Weibe	Noted cyclone change and change in ocean temp
Mick Smith	Occurance not likely to increase
	Intensity may increase
	Need to adapt across a lot of areas
Malcom Andrews	Sea level rise is dominant threat
Matt Barnes	Water level rise considered
	SCC adopted more conservative level than QCP
	May consider Monte Carlo approach
Presentaion;	
Matt Barnes	*Coastal Processes Presentation*
Questions and Answers	
Weibe	Why has beach changed?
	No changes to process, just assets at risk
Matt Barnes	Not a natural dune system
	Beach cant migrate as would like to
Chris Allan	Interim solution
	Buys time
	Noting less than 20mtrs to assets requiring protection
	Any glaring red lights for SCEC?
Weibe	Commend Council
	Know this is an issue
	Ludicrous to sacrifice Alex parade
	great project
	Chance to monitor soft option
	Need to consider bigger picture - what have we done in past to upset natural processes? What is 'original' profile? What was the earlier regime? What have we done to upset that? Can we better understand beach/natural processes over the longer term? Can we create a natural flow pattern so as to use 'soft' rather than 'hard' engineering solutions.
	Sensible project
	Genuine community need
	Sensible approach to mimic nature
Chris Allan	This infers our position?
	Observations also important
Weibe	Monitoring to be set up for weather events
	?? Sea level rise and storm events for this location
Matt Barnes	?? Of modelling difficult

Maroochy Beach Att 2 Feasibility Report

Session 2	**Environmentally Focussed Groups**
Attendees	
Jill Dening	Waderbird Group
Sally Atkinson	Surfrider Foundation
Cerran Fawes	Maroochy Water Watch
Stephanie Phillips	Cooum Coast Care
Leigh Warneminde	Coolum Coast Care
Jan England	Bird Aus
Tony Gibson	Marcoola Coast Care & Coolum Coast Care
John Dillon	Maroochy Water Watch - Confirm
Jill Chamberlain	Queensland Wildlife Protection
Presentations;	
Chris Allan	*Introduction*
Mick Smith	*SEMP presentation*
Matt Barnes	*Presentation*
Questions and Answers	
John Dillon	Questioned hydrological processess What are impacts from increased flow
Matt Barnes	Not significant
John Dillon	Question sand cycles
Matt Barnes	Over the last 6000 years the major change has come from development including training walls. Overall the coast is in recession over a long term.
Leigh Warneminde	When was survery taken
Matt Barnes	Noted date of survery and that monitoring will be repeated.
Sally Atkinson	Suggested use of University for monitoring
Jill Dening.	Birds do use this area If dredging birds may or may not dissappear Noted this shoal not available at high tide Sand not enriched so doesn't support a food supply for shorebirds Jill showed a number of slides, one showing 1076 terns using the identified shoal. Also noted terns were not feeding. Jill later emailed to clarify that only a small number of the counted terns were the protected species Area E near Goat Island is the most important for feeding Birds will relocate provided they can Some may go to Area A (north of dredge area in FHA) Birds do already have to deal with a lot of people and disturbance Note cant count confidently unless from a boat. (previously done from shore and without a telescope resulting in in accurate data)
Chris Allan	Asked Jill of any risks to shore birds
Jill Dening	Don't think the risk is high, birds will go somewhere else if they can.
	Ideally recreation use can be limited to allow brids somewhere to go. Asked Matt what are implications by sand removal

Matt Barnes	Volume taken over 10 weeks, infilling as occurs, not a big hole at once
Jill Dening	Will sand creep
Matt Barnes	Yes
Sally Atkinson	What are the proposed dredge times
Matt Barnes	likely to be 6 days per week
Jill Dening	Dredging will not be a problem at right time of year Ideally start in May and go through winter Ideally cut off southern tip of north shore to exclude dogs.
Chris Allan	Ill follow up. And talk further with Jill Dening Any red lights over all from the group at this stage?
Cerran Fawes	Will sand come back?
Matt Barnes	Not denying less sand afte works in the river, but sand will probably move back into river.
Jill Dening	I never saw adverse impacts at Pumicestone passage in terms of impacts to shorebirds from dredge operations
Leigh Warneminde	Did study review sand run to the north Did this study include old Beach Protection Authority study Note SLSC can help with data collection This project has sand profiles based on one survey, need more, nice to use BPA and other data
Matt Barnes	BMT WBM have used BPA data in SEMPS work to date
Leigh Warneminde	Asked about SEMP process
Mick Smith	Council will revisit a monitoring programme as part of the SEMP Ensuring we don't monitor for monitoring sake
Session 3	**Local Businesses and Chamber**
Attendees;	
Dion?	Boatshed Restaurant
Melinda Shelton	MaroochyChamber of Commerce
Cr Chris Thompson	SCRC
Presentations	
Chris Allan	*Introduction*
Mick Smith	*Not available*
Matt Barnes	*Presentation*
Question and Answers;	
Dion	What works are proposed for around Cotton Tree
Matt Barnes	Referred to Cotton Tree plan

Melinda	Explain the operation of placement, how much beach will be closed
Matt Barnes	Explained the 50mx50m approx area as sand is piped via flexible lines off the main pipeline .
Melinda	Queried the protection of Norfolk pines
Dion	What will the changes in flow be?
Matt Barnes	Changes may adjust, flows may change, no real significant changes
Dion	Hoped that chocked up sand could flush out
Melinda	Stormwater drain blocks near caravan park
Chris Allan	Described next steps Noted election dependent, ie DERM possible restructure
Melinda	So long as consulted with community groups in particular re migratory birds pipeline limit impact and you will have a lot covered Advise impacts to locals using beach.
Chris Allan	Catch walkers on the beach and talk through issues of project
Dion	Noted sustainability of solution ie sand gone in storms and comes back.
Matt Barnes	Bit like a sand recycling system Not adding issues to Mudjimba
Dion	Noted system is similar to Noosa
Chris Allan	Also similar to Mooloolaba Allows a degree of resilience to allow community to discuss issues.
Session 4	**Local Clubs and Associations**
Attendees;	
Sue Hope	Alex Heads Community Association
Lindsay Hope	Alex Heads Community Association
Ian Layton	MSLSC
Peter Desbow	Alex Heads Community Association
Todd Sweeny	MSLSC
Kerry Taylor	MSLSC
Tim Ryan	MSLSC
Ashley Robinson	ASLSC
Cr Chris Thompson	SCRC
Presentations	
Chris Allan	*Introduction*
Mick Smith	*Not available*
Matt Barnes	*Presentation*
Questions and Answers	
Kerry Taylor	Disagrees with comments re groynes, feels groynes would work
Matt Barnes	Noted that old photos show that even with Puncushion acting as a groyne in the past there has been excessive erossion in the past.

Tim Ryan	Noted list of events due to occur on beach and that cant do it with beach as is today.
All	General discussion regarding overall enthusiasm for project

Sunshine Coast Council

2012 Maroochy beaches foreshore protection
Stakeholder survey

1. Survey

Council welcomes your input regarding Maroochydore beaches foreshore protection and thank you for taking a few minutes to provide this valuable feedback.

2. Do you agree that foreshore erosion is an issue on Maroochydore beaches?

☐ Yes	☐ No

Why or why not?

3. Do you agree that foreshore protection measures are needed for Maroochydore beaches?

☐ Yes	☐ No

Why or why not?

4. Following today’s meeting, do you have a better understanding of the more technical aspects of foreshore protection associated with foreshore erosion?

☐ Yes	☐ No

Comments:

5. Do you have any comments or suggestions that will assist council in finalising its interim foreshore protection proposal for the Maroochydore beaches?

☐ Yes	☐ No

Comments:

6. Do you have any concerns about the feasibility study recommendations for interim foreshore protection for the Maroochydore beaches as presented today?	
☐ Yes	☐ No
Comments:	

7. Overall, how supportive are you of the proposal to dredge sand from the Maroochy River mouth for renourishment of Maroochydore beaches?				
Strongly supportive	Agree	Neutral	Disagree	Very disagree
1	2	3	4	5

8. Would you like council to keep you informed of progress regarding this project?	
☐ Yes	☐ No

9. Communication details			
How would you like to be contacted			
☐ Email	☐ SMS text	☐ Telephone	☐ In person
Name:			
Group / Business / Assoc name:			
Email:			
Phone:			
Mobile:			
Address:			

Thank you, your expertise, experience and valuable input into this project is very much appreciated and will help council to make more informed decisions as planning for foreshore protection progresses.

Adam Britton
Project Co-ordinator

PLEASE RETURN BY 5PM FRIDAY 23 MARCH 2012

Email: foreshoreprotection@sunshinecoast.qld.gov.au

Fax: 07 5447 1062

FORESHORE PROTECTION - Maroochydore Beaches stakeholder engagement meetings

Date 8 March 2012

ORGANISATION	**ATTENDEES**	**ATTENDED**	**SURVEY RETURNED**		**Responses to questions**								
		22 / 26	**15 / 26**	**Responses**	**Question 2**	**Question 3**	**Question 4**	**Question 5**	**Comments (refer individual surveys for full responses)**	**Question 6**	**Comments (refer individual surveys for full responses)**	**Question 7**	**Question 8**
		85%	**58%**	**Yes**	100%	87%	93%	67%		47%		73%	100%
				No	0%	0%		33%		53%		7%	
				Undecided/NA		13%	7%					20%	
Session one - 9am to 10am													
Sunshine Coast Environment Council	Wiebe ter Bals	Y	N										
Session two - 10.30am to 11.30am													
Coolum District Coast Care Group Inc	Tony Gibson (V President)	Y	Y		Y	Y	Y	Y	Questioned sand loss for northern beaches; comment re QPC identified dune losses at Mudjimba; Monitor turtle nesting; Impacts of dog off leash area to north shore and shorebird impacts	Y	Commented that 'interim solution has problems with holistic long term approach in line with QPC'; longitudinal studies needed and BPA data needs refreshing	Unsure - Neutral to Strongly unsupportive	Y
	Leigh Warneminde (President)	Y	N										
	Stephanie Phillips	Y	N										
Wildlife Preservation Society Queensland	Jill Chamberlain	Y	N										
Maroochy Waterwatch	Cerran Fawns	Y	Y		Y	Undecided	Y	Y	More information on economics of cost of pumping vs loss of economy from poor beach quality	Y	Happy if goes ahead….	Neutral	Y
	John & Joan Dillon	Y	Y		Y	Undecided	Y	Y	Continue community consultation; consider scenarios for weather patterns	Y	Monitoring to include weather and environmental events; the general approach is supported	Neutral	Y
QLD Wader Study Group / Fauna Watch	Richard (Rick) Barrett	Y	N										
Birds Queensland	Jill Denning	Y	Y		Y	Y	Y	N		Y	Honour obligations to migratory birds	Agree	Y

Surfrider Association QLD	**Sally Atkinson**	Y	Y		Y	Y	Y	Y	Questioned need for more detailed fauna assessment; holistic planing - interim and short term solutions to be decided at same time;	Y	see comments to Q5	Neutral	Y
Birds Aus	Jan England	Y	Y		Y	Y	Y	N		N		Supportive	Y
Session three - 2pm to 3pm													
Maroochydore Residents Association													
Alexandra Headland Community Association	Peter Desbrow	Y	N										
Maroochydore Surf Life Saving Club	Kerry Taylor (General manager)	Y	Y		Y	Y	Y	N		N		Strongly supportive	Y
	Tim Ryan (President)	Y	Y		Y	Y	Y	Y	No need to attend further workshops	N		Strongly supportive	Y
	Todd Sweeney (Director of Life Saving)	Y	Y		Y	Y	Y	Y	Develop ideal due profle	Y	Concerns over dredging in river due to deep channel	Strongly supportive	Y
	Ian Layton	Y	Y		Y	Y	Y	Y	Be able to adjust plan in future	N		Strongly supportive	Y
Alex Surf Lifesaving Club	Ashley Robinson	Y	Y		Y	Y	Y	N		N	Lack of alternatives make difficult decision easy	Supportive	Y
Beach Beat Maroochydore	not available to attend - keep in touch	N	Y		Y	Y	N/A	Y	Beach is No1 priority; sand replenishment seems to work at	N		Strongly supportive	Y
Alex Forest Community Conservation Group	Lindsay Hope	Y	Y		Y	Y	Y	N		Y	Make pipeline nonvisible as possible	Strongly supportive	Y
	Sue Hope	Y	Y		Y	Y	Y	Y	Build dune	N		Strongly supportive	Y
Session four - 3.30pm to 4.30pm													
Maroochy Sailing Club	email x 2, no response (no listed phone #)	N	N										
Boat Shed Restaurant	Dion	Y	N										
Maroochydore RSL	tbc	N	N										
Maroochydore Chamber of Commerce	Melinda Shelton	Y	Y		Y	Y	Y	Y	Cheaper to build dune than replace Aerodrome Rd	N		Strongly supportive	Y
Brian Weir Inside Edge surf shop	Brian Weir	N	N										
Cotton Tree resident	Col Pritchard	Y	N										

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