A part of BMT in Energy and Environment

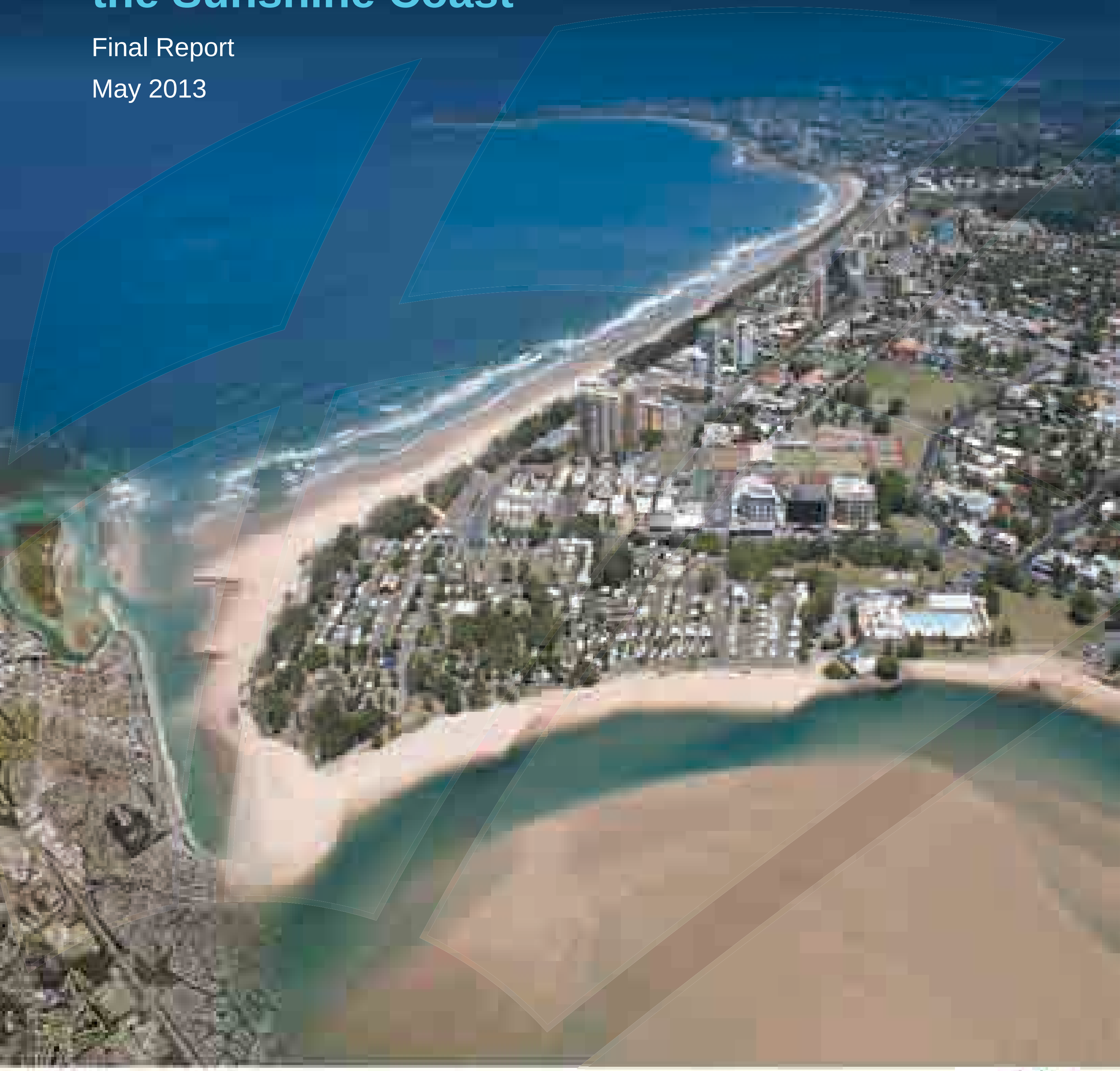
BMT WBM

"Where will our knowledge take you?"

Sunshine Coast Regional Council
Coastal Processes Study for the Sunshine Coast

Final Report

May 2013



Sunshine Coast Council

CARING FOR OUR COUNTRY

SEQ Catchments

Sunshine Coast Regional Council

Coastal Processes Study for the Sunshine Coast

Offices

Brisbane
Denver
Mackay
Melbourne
Newcastle
Perth
Sydney
Vancouver

Prepared For:	Sunshine Coast Regional Council
Prepared By:	BMT WBM Pty Ltd (Member of the BMT group of companies)

DOCUMENT CONTROL SHEET

BMT WBM Pty Ltd

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

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

ABN 54 010 830 421

www.wbmpl.com.au

Document :	R.B17314.004.04.Coastal_Processes.doc
Project Manager :	Malcolm Andrews
Client :	Sunshine Coast Regional Council
Client Contact:	Mark Breen
Client Reference	

Title :	Sunshine Coast Regional Council - Coastal Processes Study for the Sunshine Coast
Author :	Matt Barnes, Chris Huxley and Malcolm Andrews
Synopsis :	This technical report describes dominant coastal processes between Caloundra Head Bells Creek and Sunshine Beach *This report was commissioned by Sunshine Coast Council and was funded with support from Australian Government's Caring for our Country Program and SEQ Catchments.*

REVISION/CHECKING HISTORY

REVISION NUMBER	DATE OF ISSUE	CHECKED BY		ISSUED BY	
0	11 February 2011	DCP		MPB	
1	2 June 2011	MJA		MPB	
2	12 October 2012	MJA		MPB	
3	28 November 2012	MJA		MPB	
4	3 May 2013	MJA		MPB	

DISTRIBUTION

DESTINATION	REVISION				
	0	1	2	3	4
SCRC	PDF + 1	PDF + 2	PDF	PDF	PDF
BMT WBM File	PDF	PDF	PDF	PDF	PDF
BMT WBM Library	PDF	PDF	PDF	PDF	PDF

EXECUTIVE SUMMARY

This report addresses Sunshine Coast coastal processes, causes of erosion, and methodologies for calculating current and future erosion risks. A range of coastal processes assessments is provided and is intended to guide coastal management decisions throughout the Sunshine Coast. The assessment methods include:

- Consideration of the Sunshine Coast geological framework.
- A review of previous relevant studies.
- Analysis of historical photography.
- Analysis of historical data including:
  - Beach and offshore profile surveys;
  - Offshore bathymetry surveys;
  - Recorded prevailing and extreme wave conditions; and
  - Recorded tide and storm tide events.
- Numerical modelling of contemporary coastal processes, including:
  - Prevailing wave conditions;
  - Design wave conditions;
  - Tidal hydrodynamics;
  - Longshore sediment transport potentials; and
  - Storm erosion potentials.
- Climate change and sea level rise considerations.

With consideration to coastal shoreline erosion management, the assessments show that:

- The Sunshine Coast is largely disconnected from the prevailing northerly transport of sand along the Australian east coast that supplies Holecene sands to the Gold Coast, Stradbroke Island, Moreton Island and further north to Fraser Island. This suggests a relatively limited supply of sand to Sunshine Coast beaches.
- The beach profile survey data indicate that all beaches in the study area have experienced periods of erosion. However, following these periods of erosion, periods of accretion (beach recovery) have been recorded. Considering the historical survey data alone, there is no strong evidence to suggest a trend of ongoing shoreline erosion.
- Anecdotal evidence that shoreline recession may be occurring on a geological timescale is present at many locations and indicated by the exposure of humric sand (coffee rock).
- Wave and sand transport modelling suggests a net northerly longshore sand transport potential that progressively increases from Caloundra Headland to Sunshine Beach. The gradients in the average net annual longshore transport potential indicate that a long term trend of shoreline recession may be occurring, albeit at a very slow rate and possibly balanced by an onshore supply of sand.
- Despite the net northerly transport direction, persistent periods of southerly sand transport are also evident and typically occur when there is significant wave energy from the north easterly sector associated with Coral Sea tropical cyclones or low pressure systems.
- The predicted short term (storm) erosion potential varies along the coast due to differences in the design wave height, storm tide level, offshore profile and the volume of sand stored in the upper beach and dune system. The mean storm erosion potential width (short term shoreline setback distance) is estimated to be 37m. It is noted that the erosion potential estimates are likely to be

- conservative and less erosion would be expected in areas where coffee rock, dense dune vegetation and/or manmade structures exist.
- Erosion prone area calculations that consider short term erosion, long term shoreline recession and sea level rise projections suggest the 2060 erosion prone area exceeds 100m at some locations, measured landward from the existing shoreline position. This estimate does not imply that the shoreline will be setback 100m but rather defines an area that may be subjected to increased coastal erosion pressure.

The summary of the fundamental coastal processes affecting the shoreline between Bells Creek and Sunshine Beach provided in this report should be used as a starting point for coastal management decision making. More detailed assessments of, for example, shoreline response to a preferred management strategy may be required as part of an approvals processes.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

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.
BPA	Beach Protection Authority
Beach Scraping	The transfer of sand from the lower beach to the upper beach (within the beach system), usually by mechanical equipment, to re-distribute the sand to parts of the beach above tide level.
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.
Blowout	The removal of sand from a dune by wind drift after protective dune vegetation has been lost. Unless repaired promptly, the area of blowout will increase in size and could lead to the development of a migrating sand dune and its associated problems.
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.
Breakwater	Structure, usually detached from the shore, protecting a shoreline, harbour, anchorage or basin from ocean waves.
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 Act	*Queensland Coastal Protection and Management Act 1995* (Qld)
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.
CMD	Coastal Management District. Parts of the coastal zone declared under the Coastal Act as requiring special development controls and management practices.

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
Damage Potential	The susceptibility of coastline development to damage by coastline hazards.
DERM	Queensland Department of Environment and Resource Management
DEHP	Queensland Department of Environment, Heritage and Protection.
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 by the action of dune vegetation.
Dune Field	The system of incipient dunes, fore dunes and hind dunes that is formed on sandy beaches to the rear of the beach berm.
Dune Care	The program of dune management including dune maintenance activities implemented to prevent loss of 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.
Dune Protection	The management technique by which the dune system is protected from damage by recreational and development activities; dune protection activities generally include the use of fences, access ways and signposts to restrict and control access to dune systems.
Entrance Instability	Refer to the tendency of entrances to estuaries and coastal lakes to migrate along the shore, close up, reopen, form new entrances, etc. in response to wave and current action and freshwater flows.
Ebb Tide	The outflow of coastal waters from bays and estuaries caused by the falling tide.
EPBC Act	*Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (Cth)
ERA	Environmentally Relevant Activity as defined under the Queensland *Environmental Protection Act 1994*

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.
Greenhouse Effect	A term used to describe the likely global warming predicted to accompany the increasing levels of carbon dioxide and other “greenhouse” gases in the atmosphere.
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 SP Act
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 EPBC Act

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.
Pocket Beaches	Small beach systems typically bounded by rocky headlands. Because of the presence of the headlands and the small size of these beaches, longshore currents are relatively insignificant in the overall sediment budget.
QCP	Queensland Coastal Plan (2011)
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).
Rip Currents	Concentrated currents flowing back to sea perpendicular to the shoreline. Rip currents are caused by wave action piling up water on the beach. Feeder currents running parallel to the shore (longshore currents) deliver water to the rip current.
Salient	Shoreline protuberance typically behind a submerged reef or offshore island.
Sand Bypassing	A procedure whereby sand deposited on the up drift side of a training wall or similar structure is mechanically delivered to the down drift side. This facilitates the natural longshore movement of the sediment.
Sand Drift	The movement of sand by wind. In the context of coastlines, "sand drift" is generally used to describe sand movement resulting from natural or man-induced degradation of dune vegetation, resulting in either nuisance or major drift. Sand drift damage buildings, roads, railways and adjoining natural features such as littoral rainforest or wetlands; sand drift can be a major coastline hazard.
Sand Drift Control	The repair and maintenance of sand dunes to minimise sand drift. The protection and fostering of dune vegetation is an important element of such programs.
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.
Semi-Diurnal Tides	Tides with a period, or time interval between two successive high or low waters, of about 12.5 hours. Tides along the SEQ coast are semi-diurnal.
SEQ	South-east Queensland
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.
Shore	The narrow strip of land in immediate contact with the sea, including the zone between high and low water lines.
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 H1/3 or Hs.
Slope Readjustment	The slumping of a back beach erosion escarpment from its near vertical post-storm profile to a slope of about 1V:3H.
SP Act	*Sustainable Planning Act 2009* (Qld)
SPRP	State Planning Regulatory Provision
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.
Sub-Aerial Beach	The part of the beach typically exposed to the atmosphere.
Surf	The wave activity in the area between the shoreline and the outermost limit of wave breakers.
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.

Swept Prism	The active area of the coastal system in which sediment may be mobilised by the forces of wind and wave action. On a sandy beach, it extends into the dune system and offshore to the limit of the nearshore zone.
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 COASTAL PROCESSES AND CAUSES OF EROSION

1.1 General Considerations

A good understanding of the fundamental coastal processes affecting the shoreline between Bells Creek and Sunshine Beach is needed in order to make an informed decision on management strategies to be adopted. The key issues affecting shoreline erosion are:

- Wave energy in the nearshore zone;
- Supply of sand into the beach system;
- Sand movements within and through the beach system; and
- The potential for net losses of sand from the beach system.

A beach system includes not only the beach itself but also:

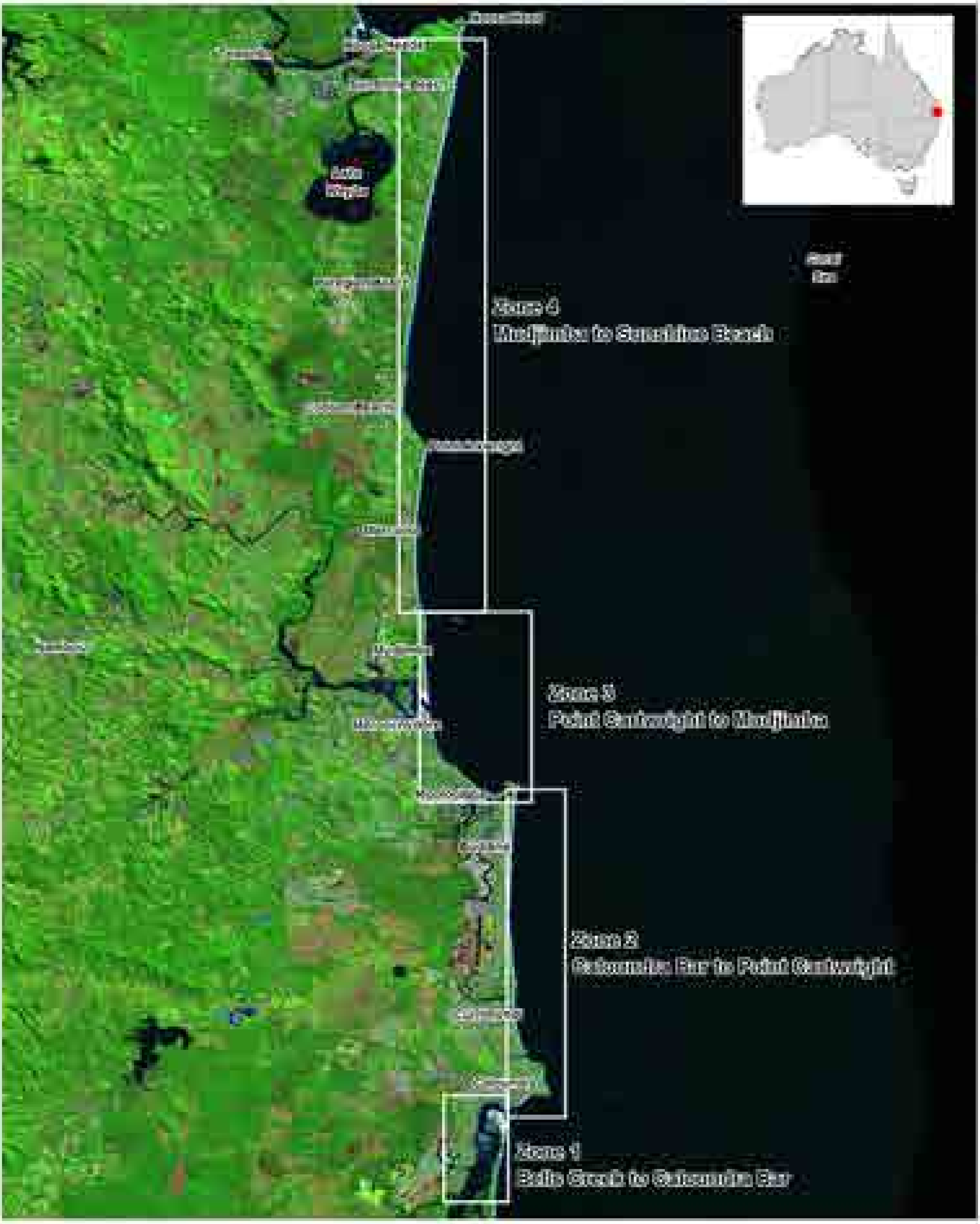
- The beach ridge that acts as a reservoir of sand for the beach during major erosion events and subsequently rebuilds gradually as the sand is moved onshore by wave and wind action; and
- The nearshore zone where sand movement is related to beach behaviour.

On a geological timescale the Sunshine Coast has experienced moderate change and currently experiences short term episodes of erosion and accretion. It remains uncertain whether there is an ongoing trend of sediment loss from the beaches. A comprehensive investigation over some years and involving substantial data collection would be needed to gain a full understanding of that issue. Despite the uncertainty, it is considered that the present level of understanding is sufficient to identify suitable engineering and management options for dealing with the erosion, as set out in this report. Within that context, relevant uncertainties and their significance are identified and discussed.

This report describes the method and findings of a detailed coastal processes study within the project area, including:

- Reviewing previous studies and reports including historical aerial photography;
- Assessments of longshore sand transport and differentials causing long term changes;
- Cross shore sand transport processes during storms;
- Tidal velocities and impact on nearshore processes;
- Elevated water levels and inundation due to storm surge;
- The impacts of natural and manmade structures on these processes; and
- The impacts of climate change on these processes.

The entire study area is shown in Figure 1-1 and detail of individual zones from south to north in Figure 1-2 through Figure 1-5.



Title

Study Area Zones

Figure

1-1

Rev

A

N

0 5 10km

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : I:\B17914_I_BJA_SunshineCoast_CoastalProcesses\DRG\COA_038_130416_Study_Area_Zones.wor

Title:

Zone 1 Study Area - Bells Creek to Caloundra Bar

Figure:

1-2

Rev:

A

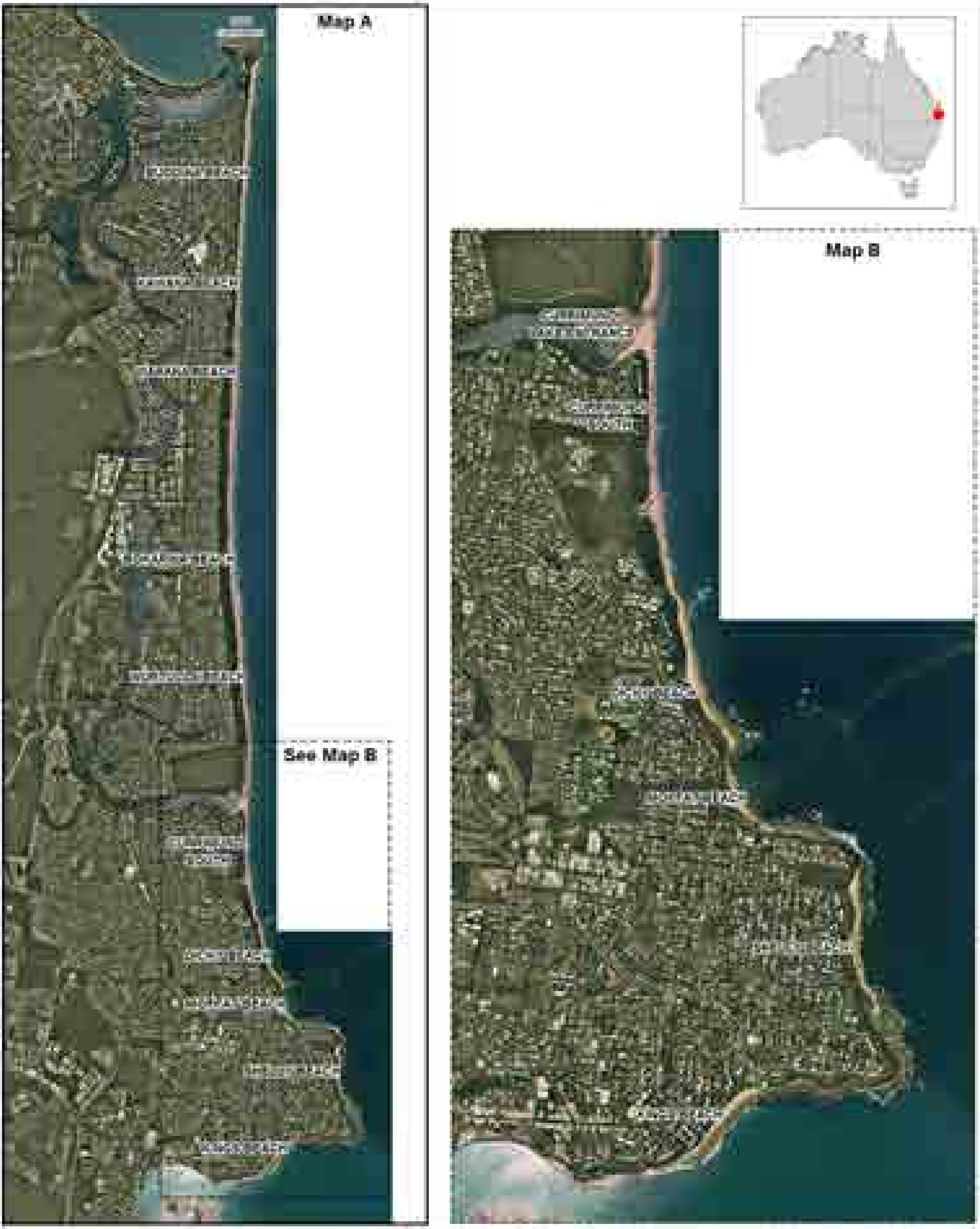
N

0 0.5 1km

Approx. Scale Key Map

www.bmtwbm.com.au

Filepath: [illegible]



Title:

Zone 2 Study Area - Caloundra Bar to Point Cartwright

Figure: 1-3

Rev: A

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B17514_I_MAA_SunshineCoast_CoastalProcesses\DRG\CGA_35_110301_Study_Area_Caloundra_to_PtCartwright.wor

Title

Zone 3 Study Area - Point Cartwright to Mudjimba

Figure

1-4

Rev

A

N

0 0.8 1.6km

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : I:\B17914_I_BJA_SunshineCoast_CoastalProcesses\DRG\COA_004_151130_Study_Area_PtCartwright_to_Mudjimba.wor

Title:

Zone 4 Study Area - Mudjimba to Sunshine Beach

Figure: **1-5**

Rev: **A**

N

0 1 2km

Approx. Scale Map A

BMT WBM

www.bmtwbm.com.au

Filepath : [illegible]

1.2 Previous Studies

Below is a brief summary of the main reports reviewed as part of the coastal processes investigation. A complete list of references is provided in Section 6.

1.2.1 Beach Erosion Control District Schemes, Landsborough Shire (BPA, 1974)

This report outlined the existing knowledge of beach processes for Beach Erosion Control District No.1 (between Bribie Island and Currimundi Creek). The report accompanied the *Scheme for Restoration and Management of the Beaches*.

1.2.2 Estuarine and Tidal Study Proposed Canal Development Caloundra (Riedel and Byrne, 1979)

The study explored the consequences of building the canal estate between Lamerough Canal and Bells Creek. In particular the report explored the effects of the canal estate on adjacent beaches, Pumicestone Passage and the entrance. In addition, options to armour the canal entrance and the likelihood of canal siltation was also assessed.

1.2.3 Mooloolah River Entrance Shoaling (Department of Harbours and Marine, 1987)

A persistent shoaling problem became evident in the Mooloolaba Harbour entrance in 1985. Despite three separate dredging exercises during 1986 and 1987, the problem remained. The shoal adversely affected navigation by craft using the harbour. This study provided a historical account of works within the harbour (canal estate development) and at the entrance (training walls) and discussed impacts to the local coastal processes. Options for maintaining a navigable depth were presented.

1.2.4 Quaternary Evolution of the Woorim-Point Cartwright Coastline (Jones, 1992)

The report provides a comprehensive assessment of the geology and geomorphology of Bribie Island and the Sunshine Coast coastline to Point Cartwright (refer Section 1.3).

1.2.5 Erosion Prone Area – Mudjimba to Coolum (WBM, 1996)

Due to development proposals being considered along the shoreline between Mudjimba and Coolum, WBM were commissioned to review and recalculate the Erosion Prone Area (EPA) previously defined by the Beach Protection Authority. The recalculation involved site-specific coastal processes investigations and lead to a small reduction in the EPA width.

1.2.6 Mooloolaba to Mudjimba Coastal Management Plan (WBM, 2002)

This initial plan was revised in line with the significant changes in legislation occurring at the time and reissued as the Maroochy Shire Shoreline Erosion Management Plan (WBM, 2007).

1.2.7 Tropical Cyclone-Induced Water Levels and Waves: Hervey Bay and Sunshine Coast (Marine Modelling Unit, James Cook University, 2004)

This study provided storm tide and wave statistics for the Hervey Bay and Sunshine Coast regions and was commissioned by the Queensland Environmental Protection Agency with support from the Commonwealth Bureau of Meteorology and the Greenhouse Special Treasury Initiative. The report included return period curves for storm tide and for significant wave height for return periods between 10 and 1000 years.

1.2.8 Maroochy Shire Storm Tide Study - Development Report (Connell Wagner, 2005)

This report for the previous Councils of Caloundra City and Maroochy Shire outlines a modelling study undertaken to identify risks associated with coastal inundation. The report provides estimates for extreme water levels along the Sunshine Coast between Coochin Creek and the Mooloolah River (Both for cyclone-induced and east coast low induced events).

1.2.9 Mooloolah River Entrance Shoal Development Indicator (WBM, 2006)

This report for Department of Transport and Main Roads outlines the coastal process influencing the sediment transport to the Mooloolah River Entrance and describes a tool that was developed by BMT WBM to predict the potential for a channel shoaling event at the Mooloolaba Boat Harbour.

1.2.10 Rock and Landscapes of the Sunshine Coast (Willmott, 2007)

A guide to the geological history of the Sunshine Coast and Gympie Districts, including a description of the regional coastal history (refer Section 1.3).

1.2.11 Draft Maroochy Shire Shoreline Erosion Management Plan (WBM, 2007)

The Draft Maroochy Shire Shoreline Erosion Management Plan (SEMP) was developed to set clear guidelines for the future protection and management of the shoreline from coastal erosion within the Maroochy Shire. The Draft Maroochy Shire SEMP covered the area from the Mooloolah River in the south (the southern Shire boundary), to Mudjimba in the north. This plan relied on previous assessments of erosion prone areas carried out by the then Beach Protection Authority (BPA) in the early 1980s.

After significant development in coastal areas in the 2000s, continued legislation changes and Council amalgamation in 2008, it was decided to review the draft SEMP and carry out a detailed assessment of the nearshore coastal processes using the latest modelling techniques.

1.2.12 Long Term Dredging Strategy Mooloolaba Boat Harbour - Final Report (BMT WBM, 2010)

This report for Department of Transport and Main Roads presents the recommended long term dredging strategies for the Mooloolaba Boat Harbour for the next 20 years. The report describes the key processes leading to sedimentation within the Mooloolaba Harbour and assesses options for maintenance dredging, including options for disposal of the dredged material.

1.2.13 Draft Shoreline Erosion Management Plan Caloundra Bar to Bells Creek (Aurecon, 2010)

This report provides shoreline management recommendations for the mainland shoreline between Caloundra Bar and Bells Creek (northern Pumicestone Passage).

1.2.14 Report for Beach Surveys and Data Assessment, Sunshine Coast Region (GHD, 2010)

This report reviews historical beach transects between Tooway Creek and Point Cartwright undertaken by the BPA between 1973 and 1993. As part of this study 16 of the original transect locations were resurveyed during July 2010. The report concluded that beaches within the study area were dynamically stable for the period of available measurements.

1.2.15 Lake Currimundi Dynamics Study (Griffith University Centre for Coastal Management Research, 2010)

Management options for the Currimundi Lake entrance are reported in this holistic study of the lake system. The report considers water quality and other environmental issues within the lake that are influenced by coastal processes and the flushing potential at the entrance.

1.3 Geological Framework

The coastal geology and geomorphology of the study area has been investigated by the Department of Minerals and Energy (Jones, 1992) and the Geological Society of Australia (Willmott, 2007). In addition, Riedel and Byrne (1979) summarise the geological history of the area south of Caloundra, including the formation of northern Pumicestone Passage. Information relevant to the coastal processes within the study area is presented below.

1.3.1 Geological History

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

- Approximately 120,000 years ago sea levels were 1-3m higher than present. Since this time the sea level varied due to numerous glacial cycles. The lowest sea level, 120m below the present level, is believed to have occurred approximately 18,000 years ago.
- Major sea level change occurred between 18,000 and 6,500 years ago. During this period the sea raised to its present level.
- Since the “stillstand”, 6500 years ago, sea levels have remained approximately at their present level. Along the Sunshine Coast however, the continued evolution and reshaping of the shoreline has occurred in response to gradients in littoral drift.

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

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

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

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

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

In addition to the low littoral drift rates, onshore sediment supply from the inner shelf may also reduce the magnitude of the shoreline erosion driven by the littoral drift gradients. Recent studies completed by Patterson (2009) for the Gold Coast, approximately 150km south of the Sunshine Coast, indicate that the supply of sediment to the nearshore active profile from the inner shelf may occur in locations where the offshore profile is milder than the equivalent deepwater equilibrium slope. This process is discussed further in Section 2.5.

2 CONTEMPORARY COASTAL PROCESSES

2.1 Water Level Variations

2.1.1 Astronomical Tide

The tides in the region are predominantly semi-diurnal. The mean spring tide range at Mooloolaba Beach, Maroochydore Beach and Coolum is 1.36m, while the extreme tidal range under astronomical conditions is 2.17m. The tidal planes for the Mooloolaba Standard Port are shown in Table 2-1

Table 2-1 Mooloolaba Standard Port Tidal Planes (Maritime Safety Queensland, 2010)

Tide	Height (mLAT)	Level (mAHD)
Highest Astronomical Tide (HAT)	2.17	+1.18
Mean High Water Springs (MHWS)	1.66	+0.67
Mean High Water Neaps (MHWN)	1.33	+0.34
Mean Sea Level (MSL)	0.96	-0.03
Mean Low Water Neaps (MLWN)	0.58	-0.41
Mean Low Water Springs (MLWS)	0.26	-0.73
Lowest Astronomical Tide (LAT)	0.00	-0.99

2.1.2 Extreme Water Levels

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

Extreme storm surge plus tide levels (excluding wave setup or runup processes) for the region were assessed as part of the ‘Maroochy Shire Storm Tide Study’ (Connell Wagner, 2005) and ‘Joint Probability Assessment – Storm Tide and Freshwater Flooding – Caloundra City Council’ (Aurecon, 2008). The storm surge plus tide levels reported in these studies are summarised in Table 2-2.

Regional tropical cyclone induced storm tide levels (including wave setup processes) were also assessed by Hardy et al. (2004) as part of the Queensland Climate Change and Community Vulnerability to Tropical Cyclones Ocean Hazards Assessment studies. The storm tide levels for locations within the study area are presented in Table 2-3.

Table 2-2 Storm Surge Plus Tide Levels within the Study Area (Connell Wagner, 2005)

Location	Storm Surge Plus Tide Level (Excluding Wave Setup and Runup) (mAHD)		
	20 year ARI	50 year ARI	100 year ARI
Caloundra	1.40	1.49	1.56
Minyama	1.50	1.53	1.56
Mooloolah River	1.50	1.54	1.58
Mooloolaba Beach	1.49	1.53	1.55
Maroochydore Beach	1.53	1.58	1.61
Pincushion Island	1.55	1.60	1.63
Cotton Tree Park	1.55	1.60	1.63
Chambers Island West	1.68	1.74	1.78
Mudjimba Beach	1.54	1.59	1.63
Mount Coolum	1.54	1.59	1.63
Stumers Creek	1.56	1.61	1.64
Peregian Beach	1.61	1.66	1.70

Table 2-3 Tropical Cyclone Induced Storm Tide Levels (Including Wave Setup) within the Study Area (Hardy et al., 2004)

Location	Storm Tide Level Including Wave Setup (mAHD)		
	100 year ARI	500 year ARI	1000 year ARI
Golden Beach*	1.05*	1.29*	1.41*
Caloundra	2.55	2.98	3.10
Buddina	2.55	2.90	3.02
Mooloolaba	2.37	2.63	2.74
Maroochy River	2.50	2.86	2.98
Coolum	2.44	2.76	2.88
Sunshine Beach	2.61	3.01	3.15

*Storm surge plus tide levels only, wave setup not included.

2.2 Wind Climate

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

The wind also plays an important role in coastal dune formation and dynamics. Sand dunes commonly consist of fine to medium sand that has been transported from the lower, exposed beach.

The threshold wind velocity for aeolian sand transport is typically 4-8m/s. Sand transport by wind is not expected for winds speeds less than 4m/s (e.g. Masselink and Hughes, 2003).

A long term average wind rose based on recorded data from Cape Moreton Lighthouse (BOM weather station 40043, indicated in Figure 3-1) is provided in Figure 2-1 and shows the directional spread of wind speed over the open ocean. It is noted that the Cape Moreton weather station is elevated and therefore the wind speeds are generally higher that those observed at the coast.

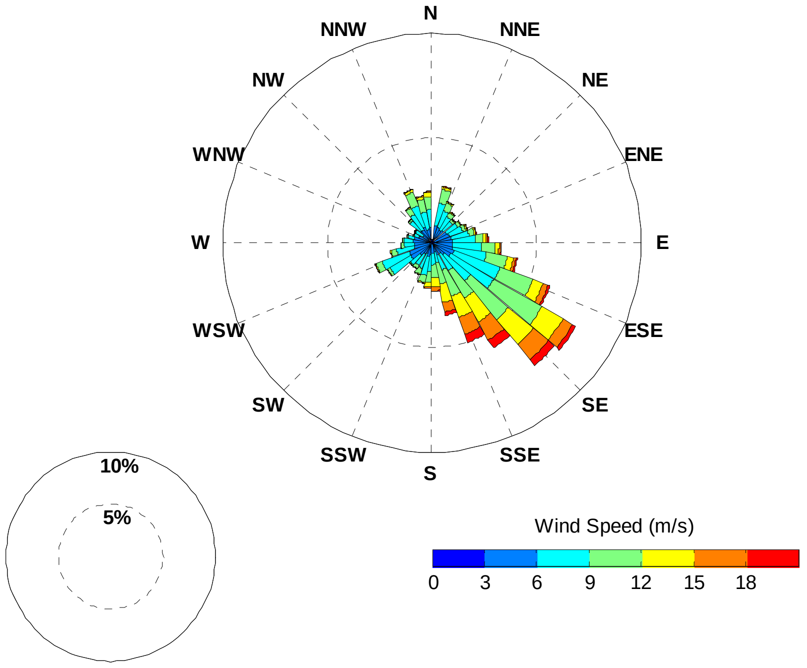


Figure 2-1 Cape Moreton Wind Rose – Recorded Data March 1996 to December 2009

2.3 Wave Climate

The Sunshine Coast wave climate is a combination of ocean swell and locally wind-generated "seas". The swell waves are of long period (typically 7-12 seconds) and experience significant modification due to refraction, bed friction and shoaling as they propagate to the shoreline from the deep ocean. The region experiences a persistent ground swell from the southeast however Moreton Island acts to shelter a large section of the Sunshine Coast from these swells. The sheltering influence from Moreton Island progressively decreases moving north along the Sunshine Coast. Locally, Caloundra Head, Point Cartwright and Point Arkwright also shelter adjacent beaches to the north from south/southeast swells. Wind generated sea waves are of relatively short period (generally less than 4 seconds) and are not substantially affected by the offshore bathymetry prior to breaking nearshore.

DEHP operate and maintain a wave buoy located due east of Yaroomba, commonly referred to as the "Mooloolaba Buoy". Non-direction wave recordings commenced 2000 and in 2005 a directional wave recorder was installed. The instrument is presently located approximately 8km offshore in a water depth of 33m and is indicated in Figure 3-1. A sample of recorded significant wave height and direction is provided in Figure 2-2 and a wave rose and wave frequency recurrence table based on recordings from July 2006 to April 2008 is provided in Figure 2-3 and Table 2-4. The available offshore wave data suggests:

- The offshore wave climate is of moderate to high energy, with a median significant height 1.3 metres. It is noted that a maximum wave height (Hmax) of 10.5m was recently recorded at this location during ex-Tropical Cyclone (TC) Oswald (January 2013). This is largest wave measured since the 2005 directional wave buoy installation.
- Both longer periods (8 to 15 seconds) swell and shorter period (5 to 7 seconds) sea waves are common along the open coast and at times may co-exist, sometimes with differing directions.
- The offshore swell waves are predominantly from the east-northeast to southeast directions. The east-northeast sector waves are seasonal, predominantly during spring through summer and are typically generated by local winds. These waves are typically of lower height and shorter period that the prevailing southeast sector swell waves. The exception is when an east coast low or tropical cyclone system develops in the Coral Sea and produces high-energy, north-easterly conditions.

Long term wave climates for nearshore locations throughout the study area calculated using hindcasting techniques are presented and described in Section 3.2.

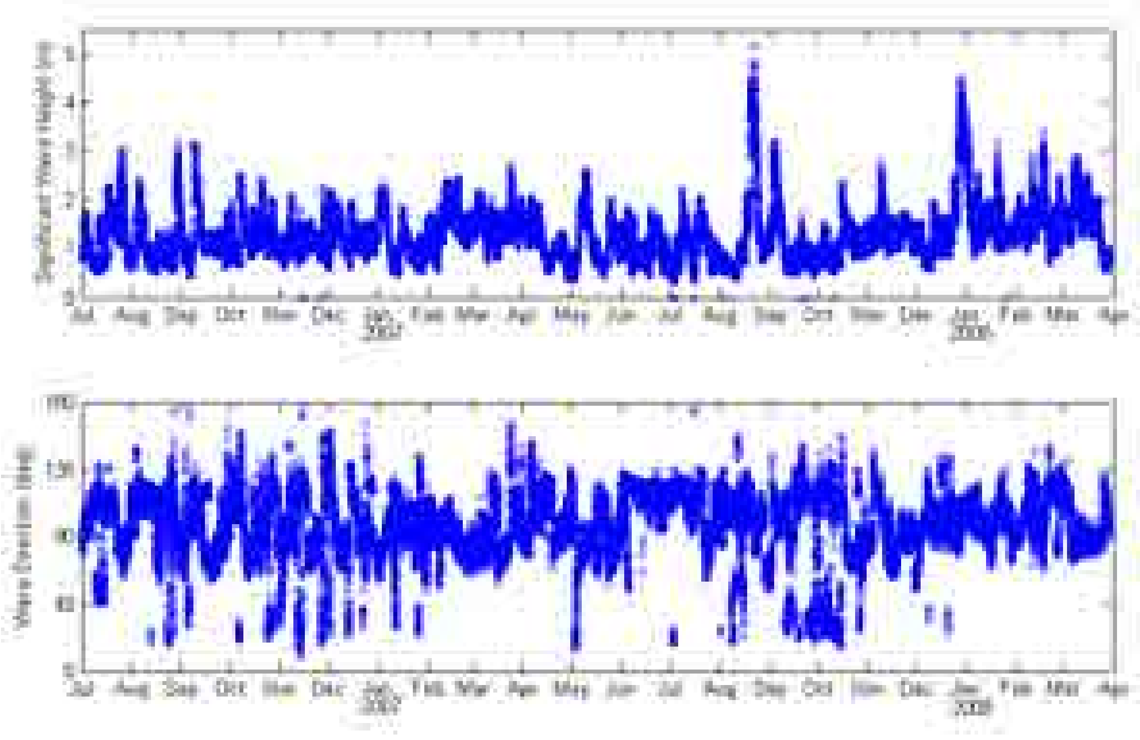


Figure 2-2 Recorded Significant Wave Height and Direction July 2006 to April 2008 - Mooloolaba Wave Buoy

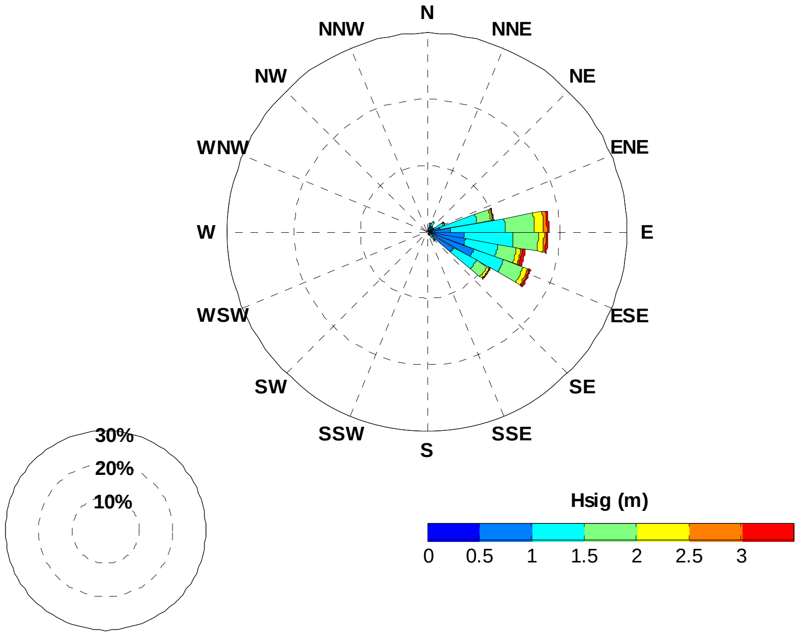


Figure 2-3 Mooloolaba Buoy Wave Rose – Recorded Data July 2006 to April 2008

Table 2-4 Wave Frequency (% Recurrence) Table July 2006 to April 2008 - Mooloolaba Wave Buoy

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

2.4 Sand Transport Mechanisms and Beach Dynamics

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

2.4.1 Cross-shore Sand Transport

Cross-shore sand transport is generally associated with:

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

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

2.4.2 Longshore Sand Transport

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

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

Recession tends to occur when:

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

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

2.4.3 Sand Transport within the Study Area

The shoreline between Caloundra Headland and Sunshine Beach (open coast areas) is morphologically dynamic and fluctuations in shoreline position are the result of the prevailing physical forcing.

The wave climate is a combination of ocean swell and locally wind-generated ‘seas’. The swell waves are of long period (typically 7-12 seconds) and propagate to the shoreline from the deep ocean. They experience significant modification by refraction, bed friction and shoaling. The region experiences a persistent ground swell from the south-east. However, Moreton Island acts as a major coastal feature sheltering a large section of the Sunshine Coast from the open ocean swell from south-easterly and southerly directions. The sheltering influence from Moreton Island progressively decreases moving north along the Sunshine Coast. Locally, Caloundra Headland, Point Cartwright, Point Arkwright and smaller rocky outcrops provide shelter to adjacent beaches from south/southeast swells.

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. Along the extended beach sections (e.g. Currimundi to Buddina, Mudjimba to Point Arkwright and Coolum to Sunshine Beach) and under prevailing conditions the longshore current generated by waves breaking at an angle to the shoreline will be the dominant sediment transport mechanism.

The currents in Mooloolaba Bay are more complex and may be driven by several factors including:

- Tidal flows;
- Wind stress on the sea surface;
- Wave radiation stresses causing longshore surf zone and other currents;
- Wave breaking and setup causing a bottom return flow in the surf zone; and
- Water level gradients in the nearshore causing longshore currents.

At any given time the sediment transport processes within Mooloolaba Bay may be influenced by a complex combination of some or all of the factors above.

Tidal currents dominate the sand transport in the northern section of Pumicestone Passage. The flood tide transports sand from north to south with flood tide sand transport observed in aerial photography as far south as Bells Creek. The small prevailing waves within the passage work the sand onto the shoreline. The existing geofabric sand container groynes at Golden Beach have accumulated sand on their southern side. This indicates a net northern sediment transport direction in the nearshore region, primarily driven by the small prevailing south easterly waves.

2.5 Sand Supply

The Sunshine Coast is largely disconnected from the prevailing northerly transport of sand along the Australian east coast that supplies Holecene sands to the Gold Coast, Stradbroke Island, Moreton Island and further north to Fraser Island. As discussed in Section 1.3, Jones (1992) suggests Caloundra Headland represents a divide in the current littoral drift, with slow northwards transport on its northern side and slow southward transport on its southern side.

The beaches around Caloundra Head (e.g. Shelly Beach) appear to have been supplied with beach material from local sources and comprise of a relative high portion of calcareous material (shell grit). These beaches are considered as pocket beaches with finite sand resources.

The fluvial sediment supply from Bells Creek, Lamerough Canal, Currimundi Lake, Mooloolah River and Maroochy River catchments consists mostly of fine sandy material but these rivers are considered to supply no significant amount of sand to the beach system.

As mentioned in Section 1.3.1, it is possible that a sediment source from the inner continental shelf may be acting to supply small volumes of sediment to Sunshine Coast beaches. This process has been hypothesised by Roy (2001), Cowell et al. (2001) and Goodwin et al. (2005) and is assumed to occur in areas where the offshore profile slope is flatter than the deepwater “equilibrium” slope, commonly observed to be approximately 1 in 55m (e.g. Patterson, 2009) . Figure 2-4 shows relatively flat offshore profiles throughout the study area compared to the deep water equilibrium slope. It is expected that a small supply of sediment from the inner shelf to the active beach system (shallower than approximately -15mAHD) will occur at these locations.

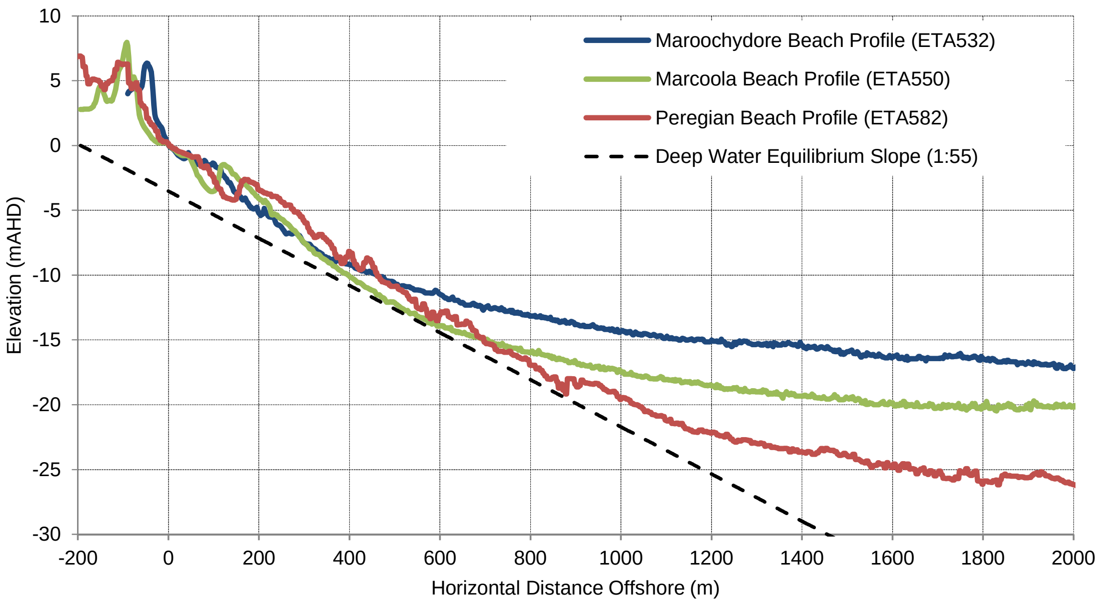


Figure 2-4 Sunshine Coast Beach Profiles Compared with Deep Water Equilibrium Slope

2.6 Assessment of Historical Shoreline Erosion

The evolution of the Sunshine Coast shoreline on a geological timescale is discussed in Section 1.3. More recent historical shoreline erosion events and site information has been derived from:

- Previous studies into the coastal processes and beach dynamics (see Section 1.2);
- Analysis of historical beach profile datasets; and
- Analysis of historical aerial photography.

The historical datasets and aerial photos are maintained by the Department of Environment, Heritage and Protection (DEHP) and are summarised below.

2.6.1 Analysis of Historical Beach Profile Data

Two beach profile survey datasets were obtained from DEHP and interpreted to assess the beach dynamics and shoreline behaviour in the study area:

- COPE (Coastal Observation Program-Engineering) station upper beach profile data; and
- ETA cross-shore beach profile surveys.

COPE was a coastal observation campaign developed by the BPA in the 1970s and ran until the late 1990s. As part of the COPE program, regular beach surveys (typically monthly) were undertaken from a specified location on the upper dune to the waterline. Beach profile data from five COPE stations within the study area have been assessed (locations shown in Figure 2-5):

- Buddina (March 1979 to August 1996);
- Mooloolaba 1 – Mooloolaba Surf Club (July 1985 to August 1996);
- Mooloolaba 2 – Central Mooloolaba Beach (July 1985 to August 1996);
- Maroochydore (May 1977 to November 1980); and
- Coolum (March 1984 to July 1996).

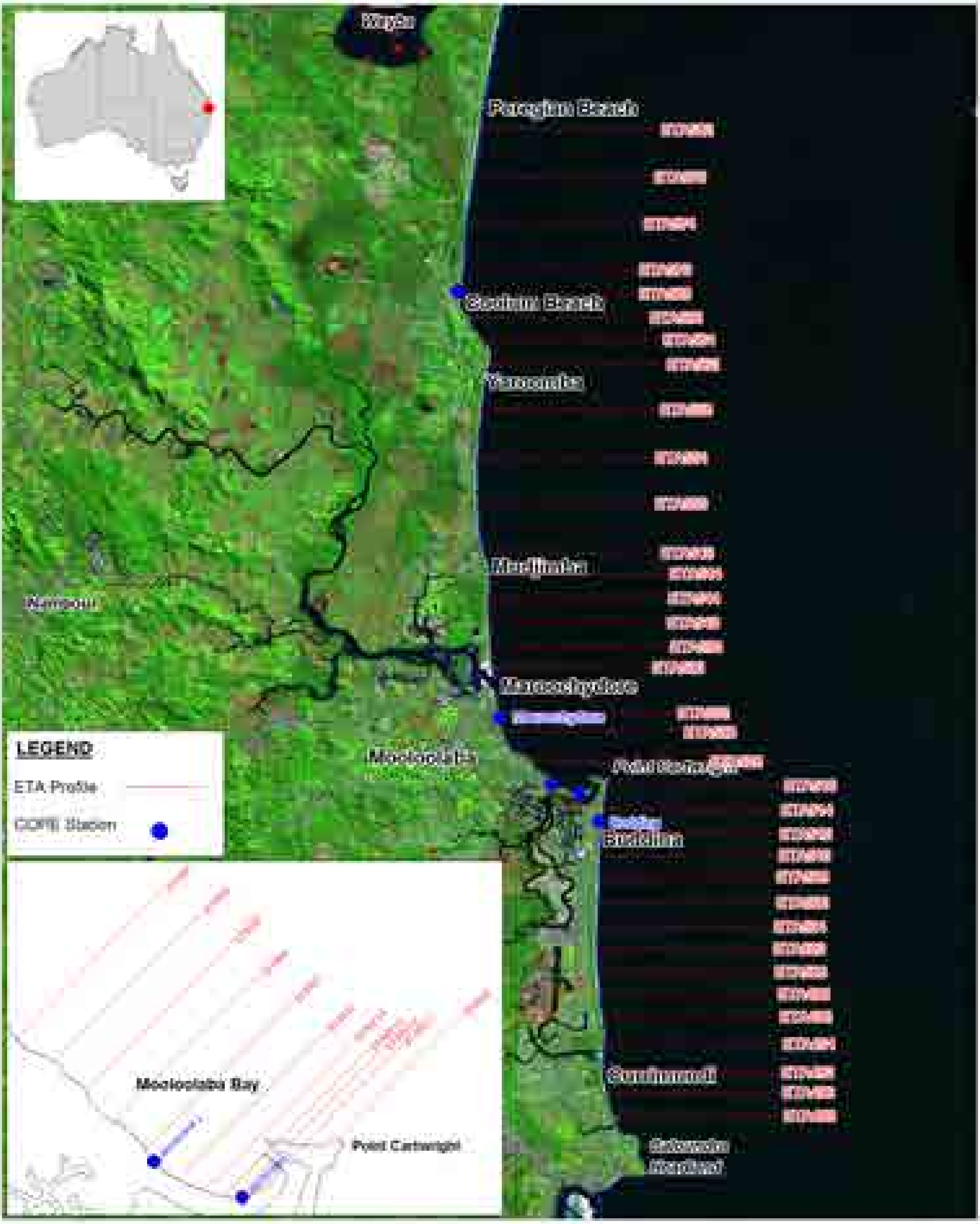
The COPE data has been used to assess the historical shoreline movement at each given location. To assist the analysis, the beach profiles at the COPE stations Mooloolaba 1 and Mooloolaba 2 were resurveyed during February 2010. The historical and resurveyed profiles for Mooloolaba 1 and Mooloolaba 2 are presented in Figure 2-6 and Figure 2-7. Additional figures summarising the COPE beach profile datasets are presented in Appendix A.

The ETA beach survey program consisted of cross-shore survey lines from a given onshore location extending to a typical water depth of 15 - 20m. The ETA program was conducted between 1973 and 1993 and the locations assessed in this study are shown in Figure 2-5. Additional ETA profiles resurveyed specifically for this and another recent study (GHD, 2010). In addition, profiles at the ETA locations have been extracted from a Digital Elevation Model (DEM) created using a 2011 bathymetric/topographic survey of the study area north of Currimundi (Queensland Government, 2012). Appendix B presents historical ETA surveys for selected locations and includes profiles extracted from the 2011 DEM.

Analysing the historical and resurveyed beach profile data the following is noted:

- Generally the beach profiles in the study area are characterised by a relative mild offshore slope (the slope beyond the breaker zone), in particular the beach profiles north of Point Cartwright. The mild offshore slope suggests that there may be a gradual onshore sediment supply (refer Section 2.5).
- The beach profile surveys indicate that all beaches in the study area have experienced periods of erosion (most notably in 1974). However, following these periods of erosion, periods of accretion (beach recovery) have been recorded. Considering the historical survey data alone, there is no strong evidence to suggest a trend of ongoing shoreline erosion.
- The COPE station beach profile data shows a dynamic shoreline position over time. At the Buddina, Mooloolaba 1 and Mooloolaba 2 COPE stations the observed horizontal position of the shoreline (taken as 1mAHD) varies by up to 30m.
- The historical ETA profiles between ETA492 (Tooway Creek, south of Currimundi) and ETA516 (southern side of Point Cartwright) show significant variation in the vertical and horizontal planes in the area extending offshore from the toe of the frontal dune to 10m below AHD. This behaviour is considered typical of sandy coastlines exposed to waves. The ETA profiles resurveyed as part of a recent study (GHD, 2010) show that the July 2010 beach position is within the range of the historical surveys and indicates dynamic stability for close to 40 years.
- The surveys between ETA510 (Kawana Surf Life Saving Club) and ETA516 (southern side of Point Cartwright) show a well established hind dune. The hind dune elevation ranges between approximately 7m and 15mAHD. The toe of the hind (secondary) dune is typically between 40 and 80m landward of the MHWS water level and appears generally dissociated from wave processes. This section of coastline is dynamically stable with a sufficient dune buffer to allow unrestricted erosion/accretion.
- The 1974 ETA profiles were surveyed following TC Dinah (1966/67) and TC Daisy (1971/72) which caused significant erosion along the south east Queensland coast. During such events material is typically eroded from the upper beach and transported seaward. A large offshore sandbar can be clearly identified in the 1974 profiles along Marcoola Beach (e.g. ETA550) between depths of 5-15m below AHD. A general trend of onshore sandbar migration and a slight steepening of the offshore profile are evident throughout the study area in the subsequent 1993 and 2011 profiles.

- The open coast beaches are generally steeper than the more sheltered beaches. For example, the beach at Buddina has an average beach slope of about 1 in 10, while the beaches of Mooloolaba and Maroochydore have a typical beach slope of about 1 in 16. It is noted that resurveyed COPE station profiles at Mooloolaba 1 and Mooloolaba 2 (February 2010) are milder than the historical average with a beach slope of about 1 in 20. This is likely due to minor beach nourishment and re-profiling works that have been undertaken in recent years.
- The resurveyed beach profiles Mooloolaba 1 and Mooloolaba 2 show the high water line at a position landward of the average but seaward of the extreme position recorded during the COPE program period (1985 – 1996).



Title

ETA Profile and COPE Station Locations

Figure

2-5

Rev

A

N

0 2.5 5km

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath: I:\B17914_I_BJA_SunshineCoast_CoastalProcesses\DRG\COA_020_151214_ETA_COPE.wor

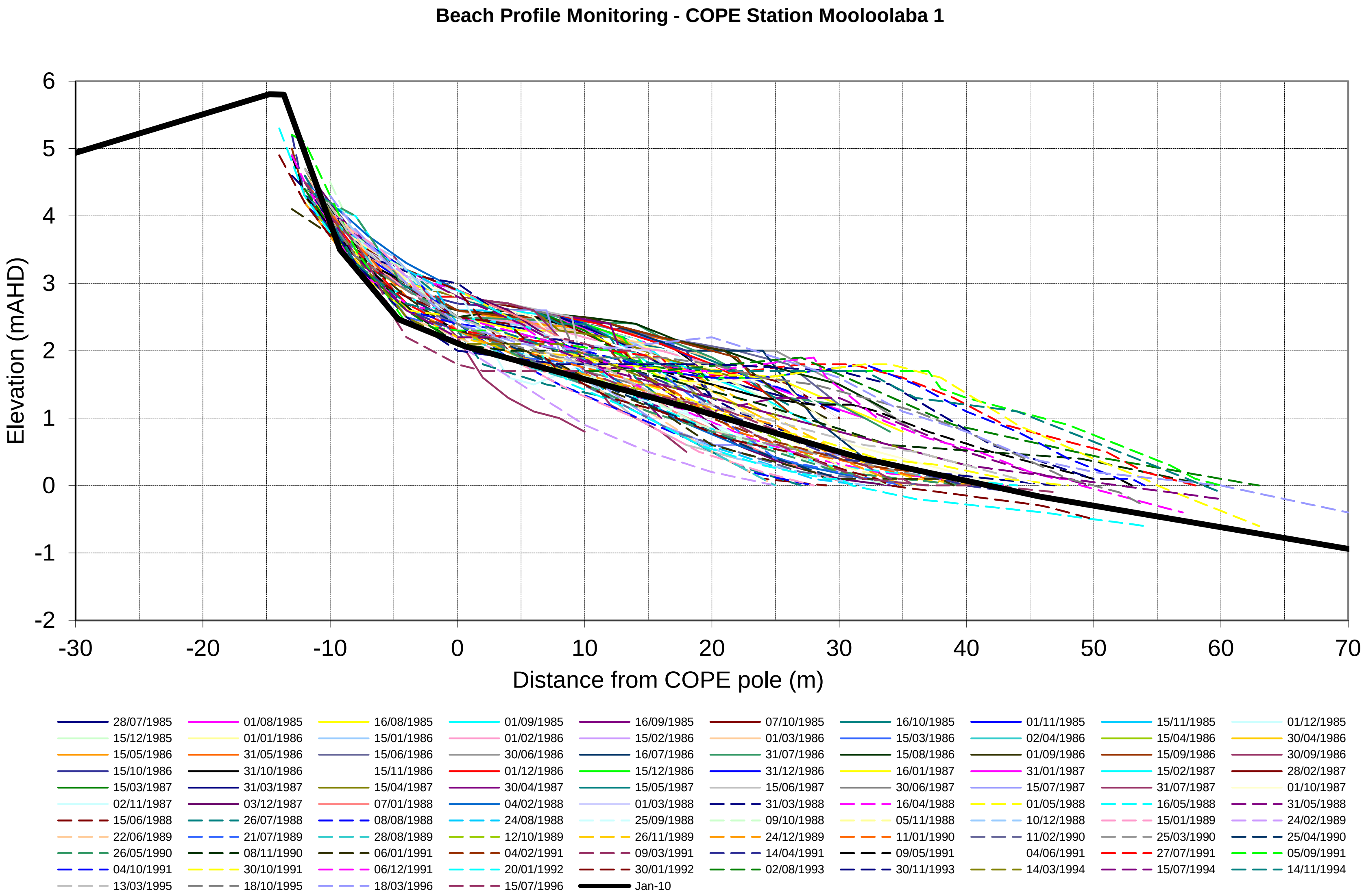


Figure 2-6 Mooloolaba 1 COPE Station Beach Profiles – February 2010 Resurvey (Solid Black Line) with 1985 to 1996 Historical Data (All Other Lines)

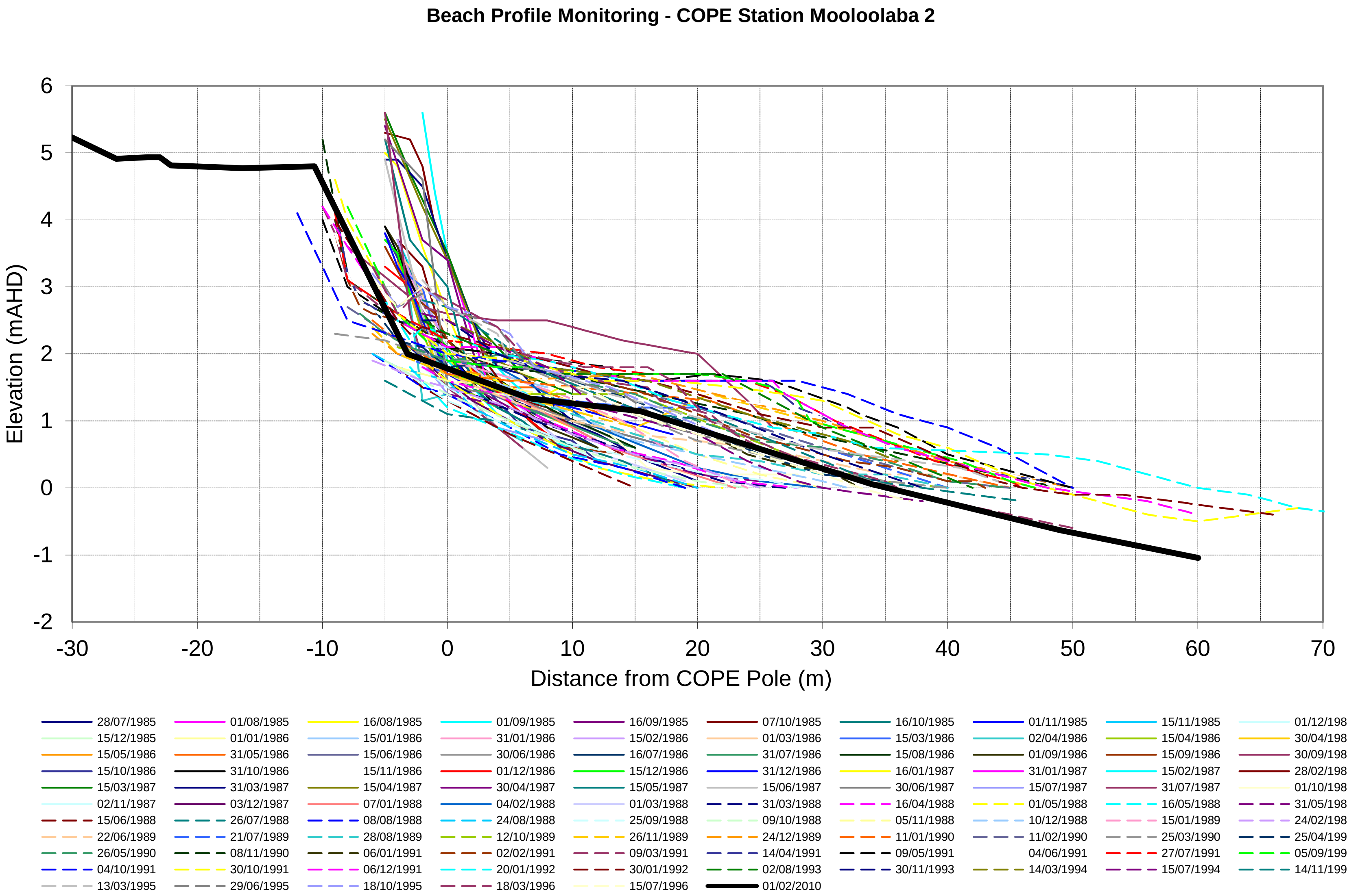


Figure 2-7 Mooloolaba 2 COPE Station Beach Profiles – February 2010 Resurvey (Solid Black Line) with 1985 to 1996 Historical Data (All Other Lines)

2.6.2 Analysis of Historical Aerial Photography

Historical aerial photography at selected locations sourced for this study extends from 1940 to 2007. Analysis of this photography has involved:

- Qualitative assessment of the state of the beach and dune system to determine changes in use and stability of the dunes, as indicated by the dune vegetation; and
- Measurement of changes in the seaward extent of the dune vegetation along the beach for various dates.

Dune edge movements were determined by reference to fixed features (e.g. roads) common to successive dates of photography. An accuracy of about ±2m was possible for each case.

Bells Creek to Caloundra Bar

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

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

Significant change along Nelson Street to Earnshaw Street shoreline has occurred, generally in response to the changes to the Pumicestone Passage northern entrance and flood/ebb channel morphology. Since 1999/2000 this section has been stabilised by a geofabric sand container groyne field. Prior to stabilisation, Riedel and Byrne (1979) described some of the changes along this section associated with the migration of the flood and ebb channels (accompanying illustrations in Figure 2-8):

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

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

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

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

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

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

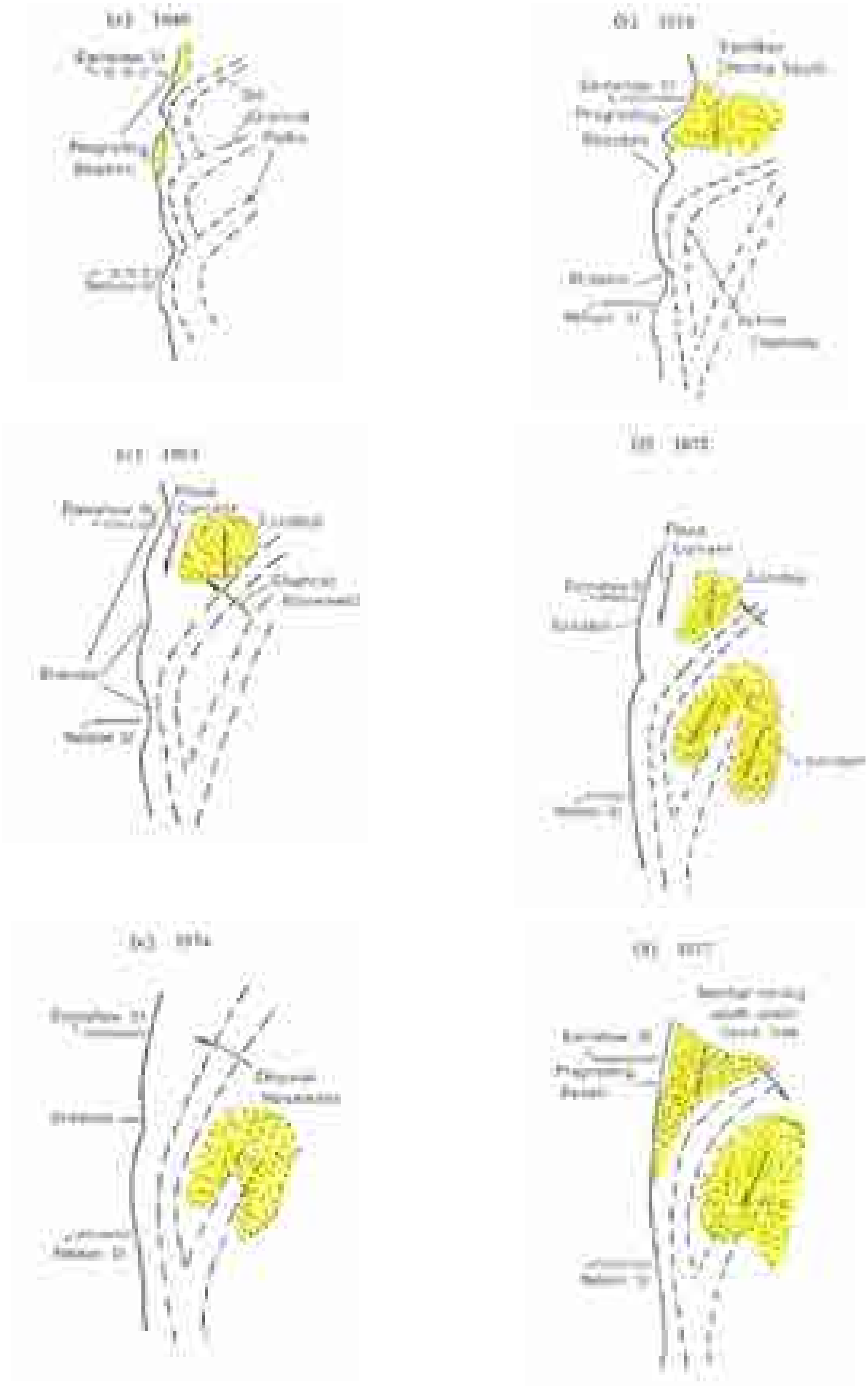


Figure 2-8 Illustrations Describing Golden Beach Shoreline Change Associated with Tidal Channel Migration between 1940 and 1977 (Riedel and Byrne, 1979)

Kings Beach, Shelly Beach and Moffat Beach

Kings Beach is sheltered from the prevailing wave climate by Moreton Island and wave refraction across the shallow banks at Caloundra Bar further reduces the wave energy reaching the nearshore area. The shoreline is aligned south-east and extends for 500m between a small groyne at the southern extent (built in the 1960s) and the southern facing rock face of Caloundra Headland. The groyne acts to interrupt the southerly directed longshore sediment transport.

Terminal protection in the form of a low seawall extends along the northern half of the shoreline. Large boulders visible toward the southern end of the beach provide evidence of an earlier shoreline protection effort (likely placed in the 1960s). It appears some of the old boulder seawall is now buried within the small sand dunes. Observation suggests Kings Beach does not typically suffer severe erosion during storm events.

Shelly Beach is small pocket beach aligned north-south and extending for approximately 1km between Caloundra and Moffat Headlands. The rocky outcrops provide control points and stability to the beach. Shelly Beach is noticeably steeper and the sand is coarser (also containing more shell grit) than other beaches in the study area. The mixed beach material is likely to be locally derived from the nearshore zone with only a low supply from adjacent beaches. If the littoral transport rate was higher, the locally derived deposits would be masked by the quartz sand material typical of the neighbouring beaches (Jones, 1992).

Development along Shelly beach is protected by a narrow vegetated dune system. The width of the dune buffer is less than 20m at the central section where a stormwater flow path intersects the beach. Historical photos suggest the stormwater runoff has moved laterally along the shoreline and cut through the frontal dune before discharging to the sea.

Moffat Headland and the rocky outcrop at the northern extent of Moffat Beach provide control points for this beach unit. Due to the controls, the exchange of sand between the adjacent beaches (Shelly to the south and Dicky to the north) is expected to be low. With the exception of the Tooway Creek entrance, the upper beach is relatively narrow and typically less than 30m wide. A rock revetment seawall, upgraded by Council in 2008, extends for approximately 230m from Moffat Headland to the boat ramp at the Bryce Street car park. The seawall primarily protects the foreshore area and car parks against short term erosion events.

Dicky Beach to Currimundi

Between 1972 and 1974 the shoreline had been impacted by a series of short term erosion events. In 1974 a significant erosion threat was identified and due to continuing development on the main dune terminal protection was considered (BPA, 1974). Since this time the shoreline has naturally recovered and is generally in good condition. Despite obvious changes in the volume of sand at the mouth of Currimundi Lake, historical aerial photography shows little variation in the vegetation line and dune position between Dicky Beach and Currimundi.

Buddina to Point Cartwright

Aerial photographs of Buddina show a relatively constant beach width between 1961 and 2004. There is some evidence of short-term beach erosion likely to be associated with storm-driven cross-shore sediment transport. Nevertheless, the erosion threat along this section of beach appears low due to the steady sand supply, high sand dunes and well established vegetation buffer between the beach and residential development. The set of historical photographs presented in Appendix D are summarised below:

- In 1961 the Buddina coastline was in the initial stages of development. A large area had been cleared and exposed sand can be seen extending between Buddina Beach and the Mooloolah River estuary. South of the cleared area the vegetation line is set back approximately 50m from its present position.
- Between 1961 and 1974 significant residential development had occurred. The vegetation buffer that now exists was in an early growth stage in 1974. The beach width appears to be at its narrowest position within the historical record, particularly at the northern extent of Buddina Beach. This loss of sand is likely to be associated with the active tropical cyclone period that occurred during the early 1970's.
- In 1979 the vegetation buffer extends along the majority of Buddina Beach. The storage of sand on the beach and dune system appears to have recovered from the tropical storm related erosion of the early 1970s.
- The historical photographs of the 1980s show little change at Buddina. In 1985 a significant volume of sand is visible on the reef offshore from Point Cartwright.
- The beach width in 1994 appears to have narrowed and less sand is visible at Point Cartwright. In 1999 exposed coffee rock is visible toward the northern extent of Buddina Beach. Sand appears to have moved seaward with a visible sand bar up to 250m offshore from the vegetation line.
- In 2004 the beach shows signs of recovery with a sightly increased width and storage of sand visible at Point Cartwright.

Mooloolaba Bay

The beaches at Mooloolaba Bay are influenced by urban development including construction on the frontal dune system, training of the Mooloolah River entrance and dredging of the harbour. Aerial photography shows Mooloolaba Harbour as a small wave-dominated estuary prior to development. A tidal delta existed at the river entrance, predominately formed by wave-driven sediment transport around Point Cartwright. The set of historical photographs of Mooloolaba Bay are presented in Appendix E and summarised below:

- In 1961 a large storage of sand with tidal channels is present at the Mooloolah River entrance. Over time the wave-driven sand transport around Point Cartwright and into the river entrance caused a gradual infilling of the estuary. The sheltered waters behind Point Cartwright would have acted as a sediment sink until a flood event occurred that would return some of the sand to the active beach system. Exposed reef is visible inside the bay and indicates the prevailing sand transport route around Point Cartwright and to the north.
- By 1974 the river entrance was trained and the end of the spit (the south-east corner of the bay) was stabilised. Vegetation had established by 1979 resulting in further stabilisation of the beach adjacent to the training wall.
- Throughout the 1970s and early 1980s little reef is visible inside the bay suggesting a significant storage of sand.
- A persistent shoaling problem located seaward of the training walls and in the form of a sandbar became evident in 1985. Prior to this time, shoaling problems had been relatively minor and located between the training walls. The offshore shoaling problem was attributed to changes in

the tidal prism and sediment transport processes due to canal estate development (Department of Harbours and Marine, 1987).

- By 1987 the beach at the south-east corner of the bay has slightly narrowed and exposed reef is visible offshore. The dune vegetation is well established, stabilising the area adjacent to the training wall but also removing this storage of sand from the active beach system.
- Between 1987 and 1999 no major shoaling occurred at the entrance and dredging was not required. The beach width at the Mooloolaba Surf Club widened during this period.
- Strong and persistent shoaling occurred at the entrance during 2003 and early 2004 and dredging was undertaken three times during this period. A shoal offshore from the entrance and sand accumulation at Point Cartwright is visible in the 2004 aerial (photograph taken after the dredge works). Patches of rock offshore from the Mooloolaba Surf Club and toward the east of the bay visible in 1999 have been covered by sand in 2004.

Alexandra Headland and Maroochydore Beach

Sand supply to these beaches appears limited with the near shore seabed characterised by a thin layer of sand covering coffee rock (indurated sand). This section of coastline is influenced by urban development within the active beach zone, including Alexandra Parade, Alexandra Heads and Maroochy Surf Clubs, public foreshore areas and the Sea Breeze Caravan Park. Historical aerial photos show times when the shoreline is vulnerable and sand has been eroded from the beach with large sections of coffee rock exposed. Maroochydore Beach appears more vulnerable to erosion when the Maroochy River Entrance is to the south of Pincushion Island (refer below).

A deteriorating seawall and vegetated foredune provide some limited shoreline protection; however the close proximity of valuable infrastructure (in particular Alexandra Parade) to the foredune crest indicates future shoreline protection works may be necessary, particularly if sea level rise projections are realised.

Maroochy River Entrance

Aerial photographs since 1958 indicate that the Maroochy River is extremely dynamic and has seen significant variation in both the river the entrance location and estuary shoals.

Aerial photographs show the River entrance migrating approximately 600m either side of Pincushion Island between 1958 and 2005. This entrance movement is prominently driven by the river meandering, which results from complex interactions between offshore waves, coastal and fluvial sediment supply, tidal currents and catchment flood events.

Figure 2-9 shows a plot of the maximum envelope of variation in shoreline position adjacent to the Maroochy River entrance between 1958 and 2005. Appendix F presents the aerial photography used to derive the envelope of variation lines. In summary, the historical photography shows:

- In 1958 the Maroochy River entrance was located to the south of Pincushion Island. A narrow sand spit was located north of the island separating the main river channel from the Ocean.
- Sometime between 1958 and 1961 the narrow sand spit, adjacent to the main river channel between Pincushion Island and Mudjimba beach was breached. Once this breaching occurred, the river entrance realigned itself to the north of Pincushion Island allowing for sediment to build up and eventually join Pincushion Island to the southern bank of the Maroochy River.

- Between 1961 and 1999 the river entrance remained to the north of Pincushion Island, though significant variation in the estuary shoals is exhibited. The river meandering results in a narrow vegetated sand spit forming to the south of Pincushion Island.
- In 1999 the narrow vegetated sand spit is breached. This resulted in the rapid erosion of this section of coastline as the Maroochy River realigned itself south of Pincushion Island again. This rapid erosion threatened to cause damage to the neighbouring Caravan Park at the time, requiring council to undertaken emergency works to prevent property damage.
- Since 1999 the Maroochy River entrance has been relatively stable, confined between Pincushion Island and the geofabric seawall/groyne structures constructed by Council to stabilise the southern bank of the river entrance.

Recent site visits have identified that at high tide a small portion of the river flow is able to pass to the north of Pincushion Island, though the main channel remains to the south of the island. This is shown in Figure 2-9.

Mudjimba to Coolum

Analysis of historical aerial photography between 1940 and 1994 (WBM, 1996) identified a relatively stable shoreline with a slight trend of shoreline retreat (upper limit estimated at 0.2m per year). More recent aerial photography analysed in this study and recent site visits also suggest a stable shoreline, noting that at most locations the beach has sufficient buffer to respond naturally to episodic storm erosion events.

Sunshine Beach

Significant residential development between Coolum and Sunshine Beach has occurred since the early 1970s. Generally the development is landward of the active beach zone, allowing the beach to naturally respond to erosion and subsequent accretion events. The erosion threat to development is considered low due to the well established dune and vegetation buffer. In some locations the existing vegetation line is seaward of the 1974 position, indicating recovery of the hind (secondary) dune and the gradual development of frontal (primary) dune system.

Title

Maroochy River Entrance Movement 1958 to 2005

Figure

2-9

Rev

A

N

0 1 2km

Approx. Scale Map A

BMT WBM

www.bmtwbm.com.au

Filepath : I:\B17914_I_BJA_SunshineCoast_CoastalProcesses\DRG\COA_003_100318 Maroochy to Buddina.wor

2.7 Recently Observed Shoreline Erosion

A trend of erosion has been recently observed at many Sunshine Coast beaches. The erosion trend has not been quantified however site inspections of the coastline following ex-TC Oswald (January 2013) confirmed significant erosion throughout the study area. For example, at Marcoola Beach an erosion scarp approximately 3m high and exposed coffee rock was observed (refer Figure 2-10) and at Maroochydore Beach the existing erosion pressure was intensified (refer Figure 2-11) . It is expected that the material eroded from the upper beach and dune system has been deposited offshore and will gradually move onshore if, on average, conditions that promote accretion (i.e. low wave energy) occur in the following months and years.

Water level and wave data recordings during ex-TC Oswald are presented in Figure 2-12 and Figure 2-13. The water level data at Mooloolaba suggest a residual tide (storm surge) peak close to 0.5m and a recorded water level (storm tide) close to Highest Astronomical Tide (HAT) occurred. This water level is approximately 1.25m lower than the 100 year ARI water level report by Hardy et al. (2004) suggesting the study area is vulnerable to significantly higher extreme water levels than that experienced during ex-TC Oswald.

A maximum wave height (H_{max}) of 10.5m was recorded by the Mooloolaba buoy during ex-TC Oswald. This is the largest wave measured since the 2005 directional wave buoy installation. The recorded significant wave height conditions with a peak of approximately 5.5m are significantly smaller than the 100 year ARI wave conditions ($H_{sig} \approx 9.5$m) estimated by Hardy et al. (2004), again suggesting that the study area may be vulnerable to short periods of more extreme storm induced wave events. It is notable that the peak wave conditions occurred from the east to north-easterly directional sector which many Sunshine Coast beaches are particularly exposed to. Significant historical coastal erosion events along the Sunshine Coast are expected to be associated with waves from this sector.

Figure 2-10 Marcoola Beach Erosion Following ex-TC Oswald (January 2013)

Figure 2-11 Maroochydore Beach Erosion Following ex-TC Oswald (January 2013)

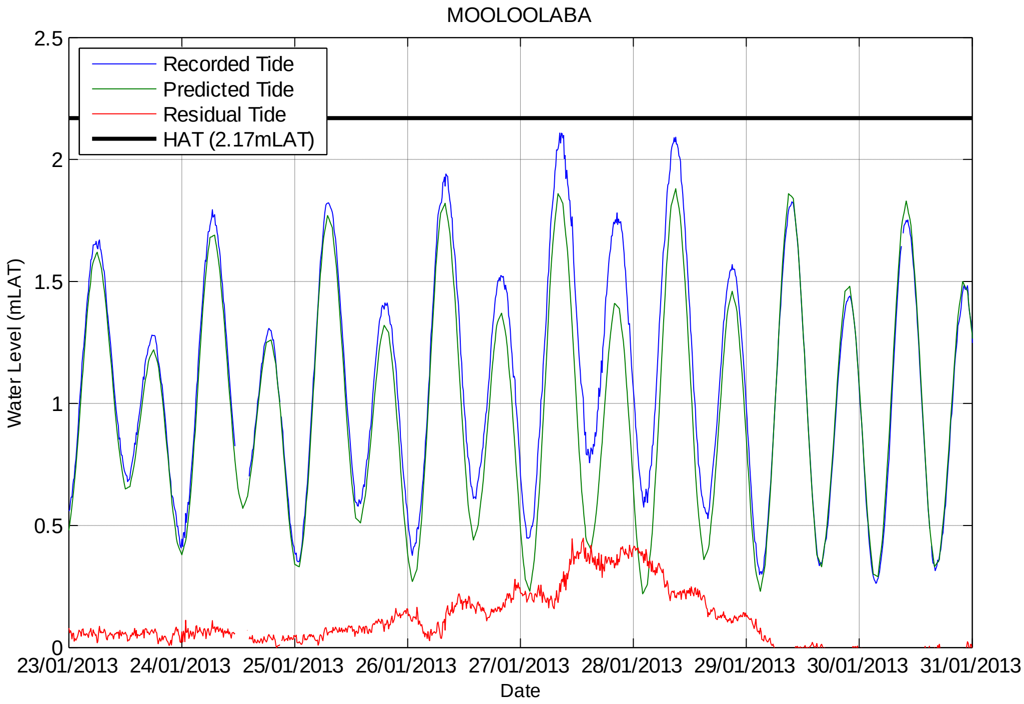


Figure 2-12 Recorded, Predicted and Residual Tide at Mooloolaba Storm Tide Gauge during ex-TC Oswald (Data provided by DSITIA)

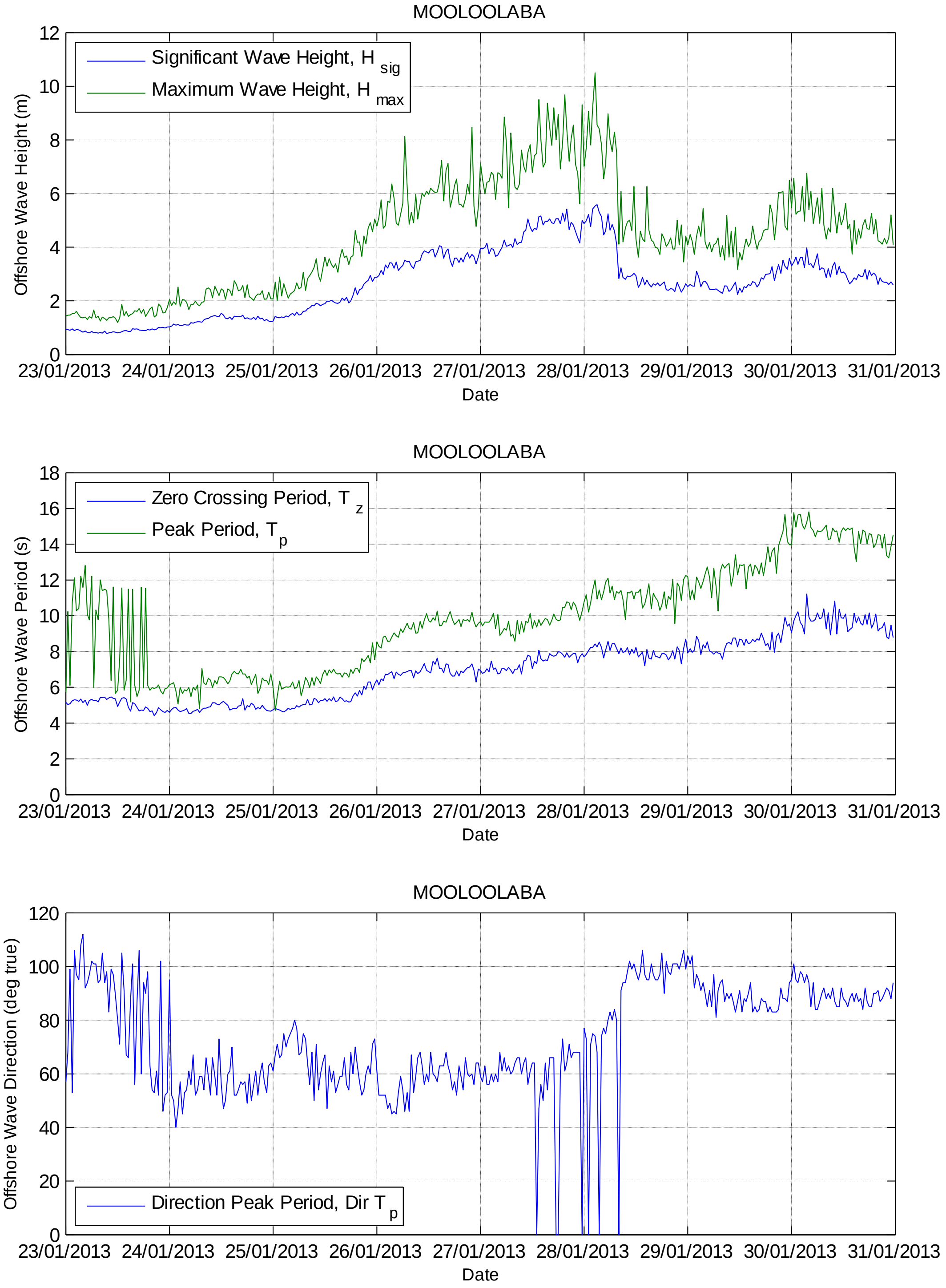


Figure 2-13 Recorded Wave Conditions Offshore from the Study Area during ex-TC Oswald (Data provided by DSITIA)

3 MODELLING OF COASTAL PROCESSES

3.1 Introduction

Numerical modelling has been undertaken to obtain a better understanding of key coastal processes occurring within the study area. The assessments included:

- Wave modelling;
- Tidal hydrodynamic modelling (integrated with the wave modelling);
- Longshore sand transport and differentials causing long-term changes; and
- Cross-shore sand transport processes during storms.

The modelling tools applied in this study provide both qualitative insights and quantitative information about the processes influencing shoreline change. However, it must be recognised that the modelling of coastal processes remains an imperfect science and obtaining a high level of quantitative accuracy is dependent on:

- Suitable representation of the area being modelled (e.g. bathymetry, seabed characteristics, appropriate computational grid or mesh resolution);
- Model boundary condition assumptions; and
- Model validation to ensure the physical processes is being appropriately simulated in the model.

The modelling assessments combined with a general understanding of the Sunshine Coast coastal processes allow the important sediment transport mechanisms to be identified. The key findings from the modelling assessments include:

- There is a net drift of sand towards the north along the majority of Sunshine Coast.
- The average net rate of sand transport along the Sunshine Coast is not constant and increases progressively from Caloundra to Noosa.
- Sand from Buddina Beach will only travel around Point Cartwright when significant quantities of sand build up at the northern end of Buddina Beach and favourable wave conditions occur (assumed to be persistent south easterly conditions). Most of this sand passes directly to Mooloolaba Beach, with a portion of the sand diverted further to the north.

3.2 Wave Modelling

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

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

- A Coarse (500m grid resolution) offshore model extending from Point Lookout north to Double Island Point. To the east the model extends seaward approximately 90km east of the study area;

- A medium-scale (50m grid resolution) model representing the nearshore regions from Caloundra to Noosa Heads was nested within the coarse model;
- A Fine-scale (10m grid resolution) model was further nested within Mooloolaba Bay, between Point Cartwright and Alexandra Headland; and
- The nested wave model extents are shown in Figure 3-1.

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

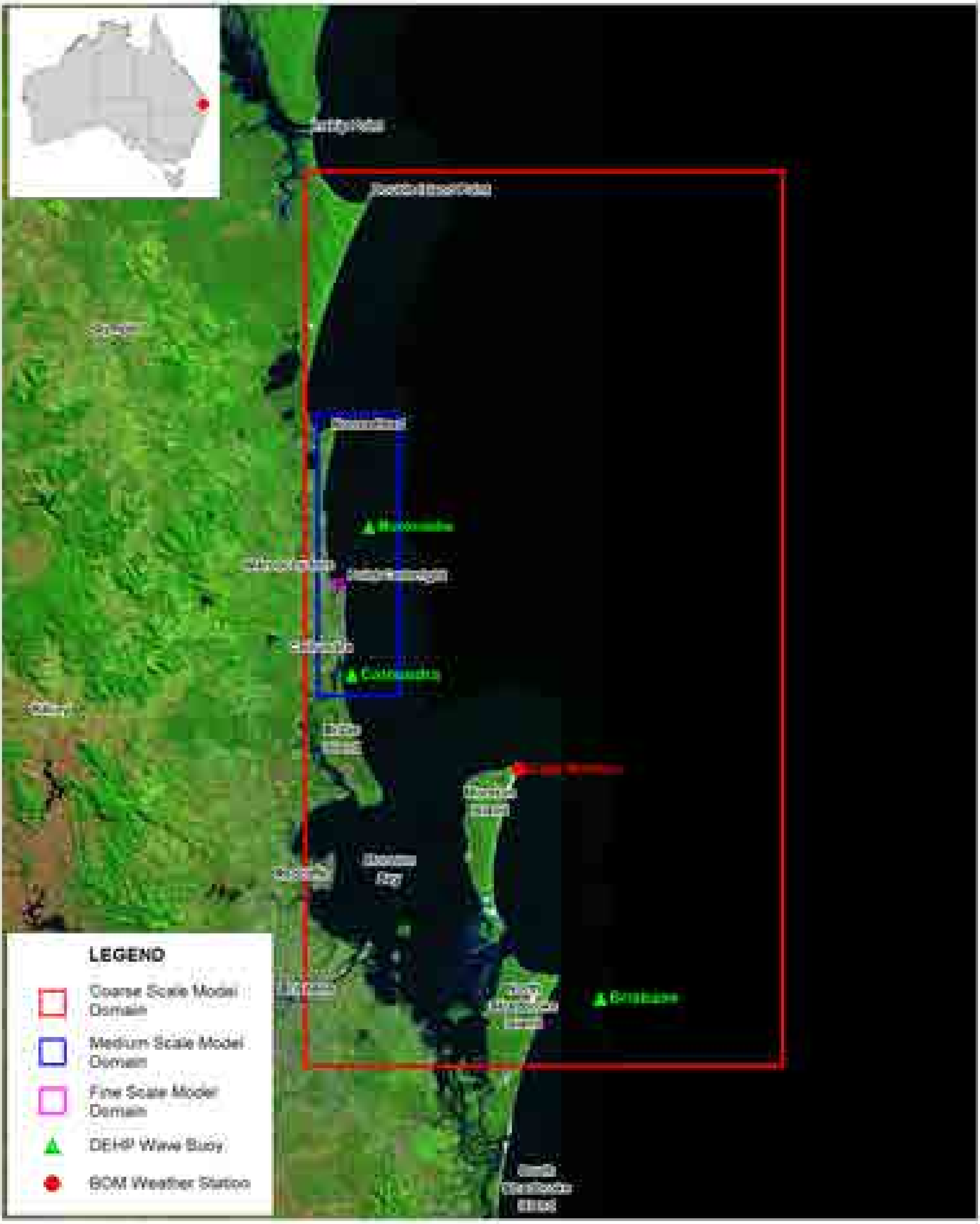
- DEHP ETA survey data;
- Queensland Transport Survey;
- Royal Australia Navy Survey Data; and
- Global Bathymetry DEM.

The extent of each of these datasets is shown in Figure 3-2.

SWAN uses offshore wind and/or wave boundary condition input to calculate the nearshore wave conditions within the study area. Both types of boundary condition input have been used for the wave assessment. This approach ensures the dominating combination of sea/swell waves is resolved and later applied in the sediment transport calculations.

The boundary condition data used during the modelling included (locations indicated in Figure 3-1):

- Directional wave data, supplied by DEHP, recorded at the Brisbane Waverider buoy; and
- Directional wind data, supplied by the Bureau of Meteorology (BoM), sourced from BoM's Cape Moreton Weather Station.



Title:

SWAN Wave Model Extent

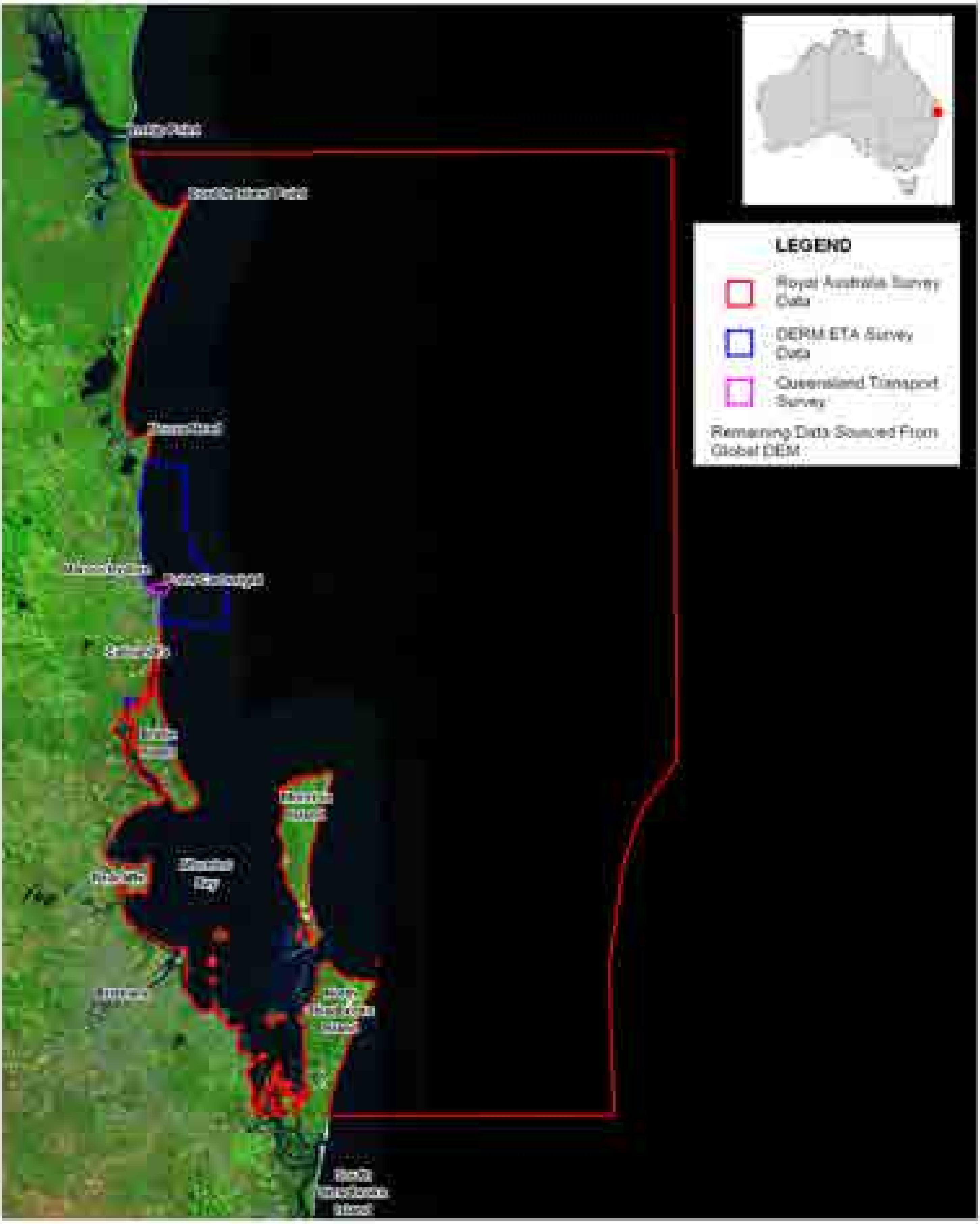
Figure:
3-1

Rev:
A

0 20 40km
Approx. Scale

www.bmtwbm.com.au

Filepath : [illegible]



Title:

Bathymetry Data Sources

Figure: 3-2

Rev: A

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B17514_I_BGA_SunshineCoast_CoastalProcesses\DRG\COA_005_110408 SAW.wor

3.2.1 Wave Model Validation

To calculate the wave climate within the study area, two sets of nested wave models have been developed:

1. A “swell state” model that uses recorded wave data from the Brisbane wave rider buoy as an input boundary condition. SWAN refracts the input waves to calculate the nearshore wave conditions within the study area.
2. A “sea state” model that uses the recorded wind data from Cape Moreton as a boundary condition. SWAN calculates the resulting wave height given the wind speed, direction and fetch length interacting with the model bathymetry.

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

Wave model prediction was validated with recorded wave data from the Mooloolaba Waverider buoy (operated by DEHP) and the Caloundra wave station (jointly operated by DEHP and the Port of Brisbane) between 2006 and 2008. The wave recording locations are indicated in Figure 3-1. The following wave model output validation is presented:

- A time series of wave height and direction recorded by the Mooloolaba Waverider buoy (Figure 3-3);
- A time series of wave height recorded at the Caloundra wave station (Figure 3-4); and
- Wave height exceedance curves for Mooloolaba and Caloundra (Figure 3-5 and Figure 3-6).

The recorded wave data is generally well represented by the wave model. This predictive capability is considered to be appropriate for wave climate and subsequent sediment transport assessments.

Figure 3-3 Wave Model Validation with Data Recorded by the Mooloolaba Wave Buoy

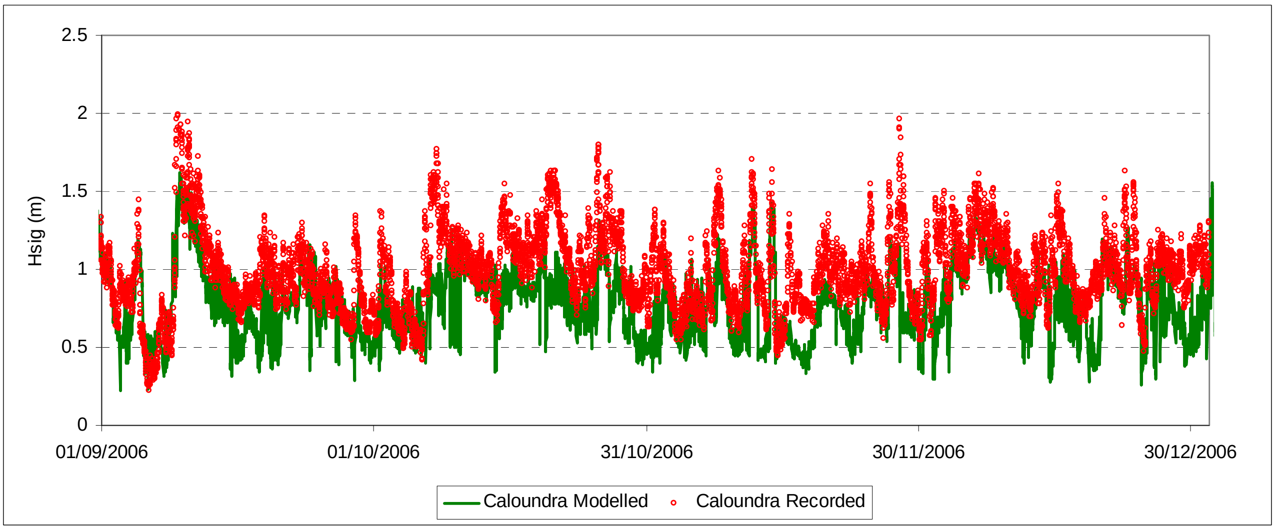


Figure 3-4 Wave Model Validation with Data Recorded by the Caloundra Wave Station

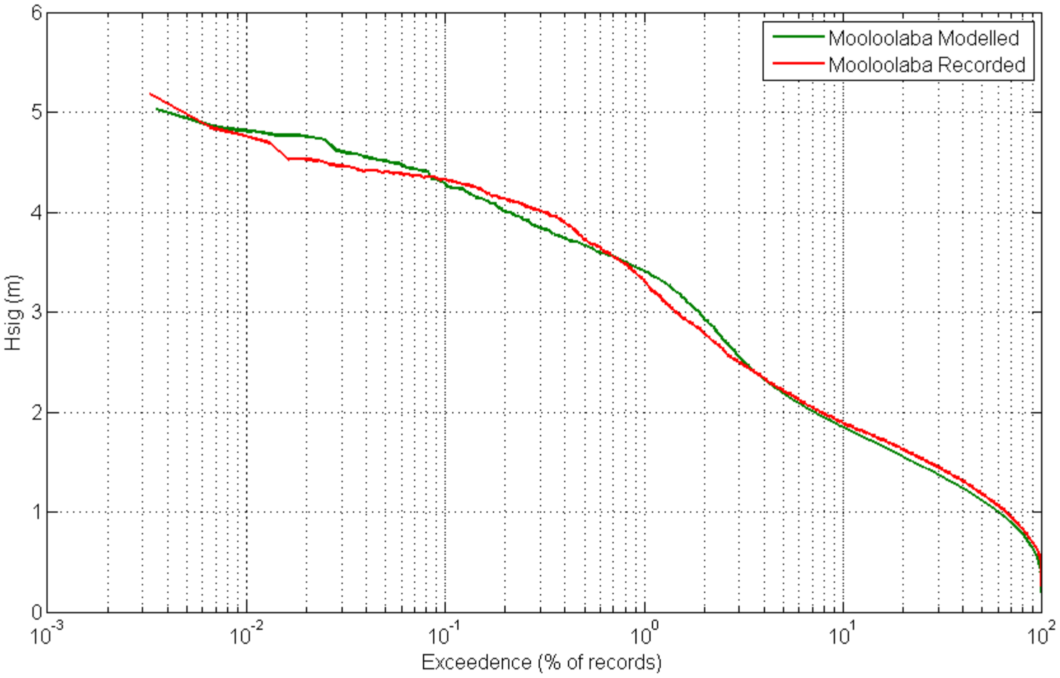


Figure 3-5 Wave Model Validation: Wave Height Exceedance – Mooloolaba

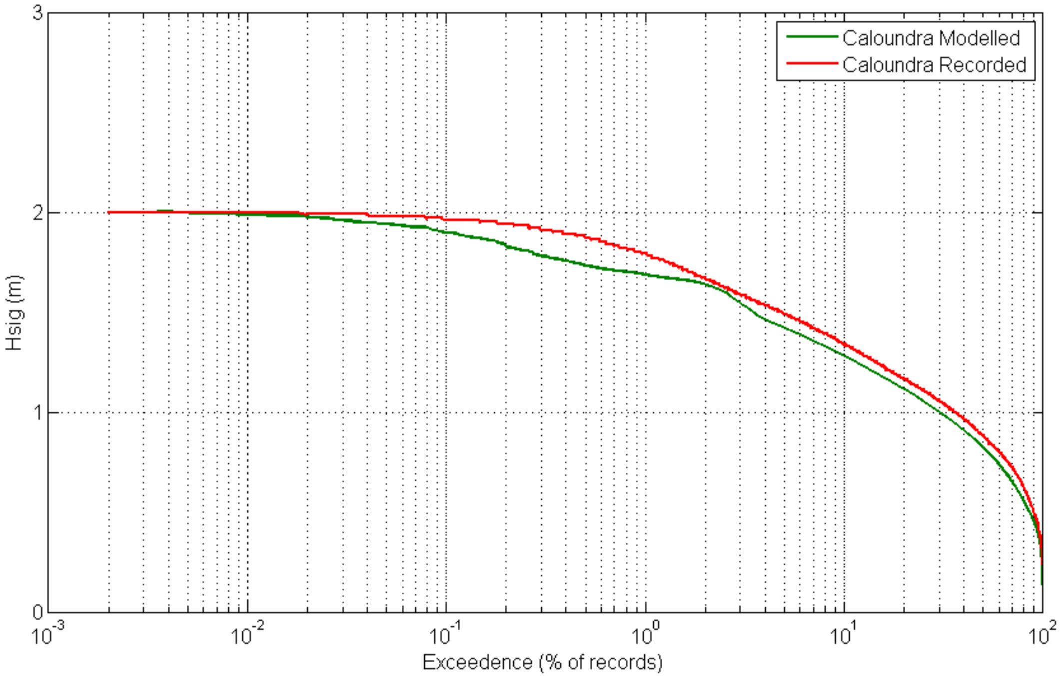


Figure 3-6 Wave Model Validation: Wave Height Exceedance – Caloundra

3.2.2 Wave Climate Analysis

Typically the Sunshine Coast is fully exposed to wave conditions originating from the north through east. During events from the south/southeast, Moreton Island acts as a major coastal feature sheltering a large section of the Sunshine Coast from the open ocean swell. The sheltering influence progressively decreases in magnitude moving north along the Sunshine Coast. All of the beach units within the study area are affected by this sheltering. Locally, Caloundra Head, Point Cartwright and Point Arkwright also shelter adjacent beaches to the north from south/southeast swells. Using wave model output, the sheltering influence of Point Cartwright on Mooloolaba Bay is illustrated in Figure 3-7.

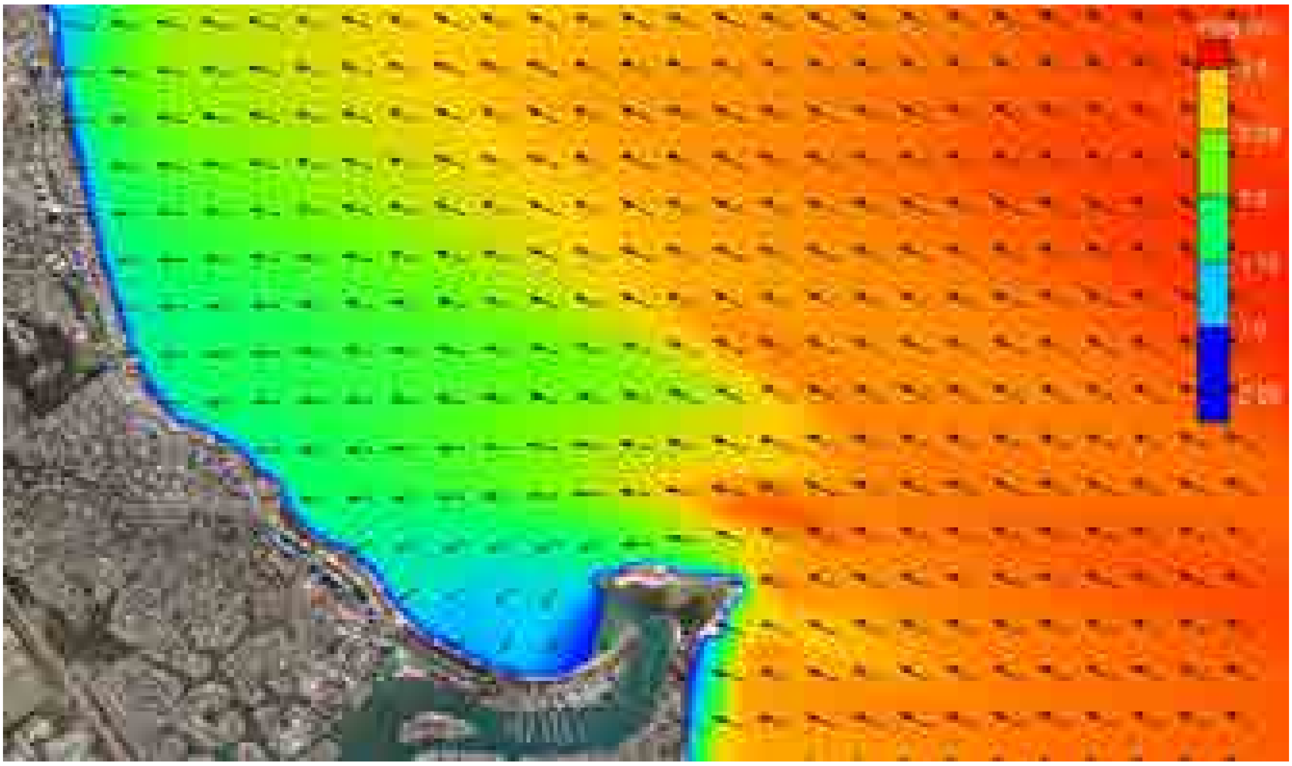


Figure 3-7 South-Easterly Swell Wave Refraction at Point Cartwright

The wave climate for the entire study area has been assessed for the period 21/11/1996 to 31/5/2009. This period corresponds to the available directional wave data for the Brisbane Waverider buoy that is necessary for the modelling assessment. The wave climate at selected locations along the Sunshine Coast is presented below in the following formats:

a) Wave rose plots illustrating the distribution of wave height and direction (Figure 3-9 to Figure 3-18); and
b) Wave height and direction frequency recurrence tables (Table 3-1 through Table 3-10).

The locations of the wave climate analysis presented below are indicated in Figure 3-8. The depth at each location is 7m below MSL, with the exception of Mooloolaba Bay where the depth is 4m below MSL. At these nearshore locations and depths, wave refraction causes the swell directional window to narrow and become more closely parallel with the bottom contours and shoreline alignment. The nearshore model output provides key input to the longshore sediment transport calculations described in Section 3.3. It is noted that occasional significant wave energy from the north easterly sector associated with Coral Sea tropical cyclones or low pressure systems is not well captured in this analysis. Extreme wave conditions throughout the study area are assessed in Section 3.2.3.

Title

Wave Climate Analysis Locations

Figure

3-8

Rev:

A

N

0 5 10km

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : I:\B17914_I_SLA_SunshineCoast_CoastalProcesses\DRG\COA_017_151120_WaveClimateLocations.wor

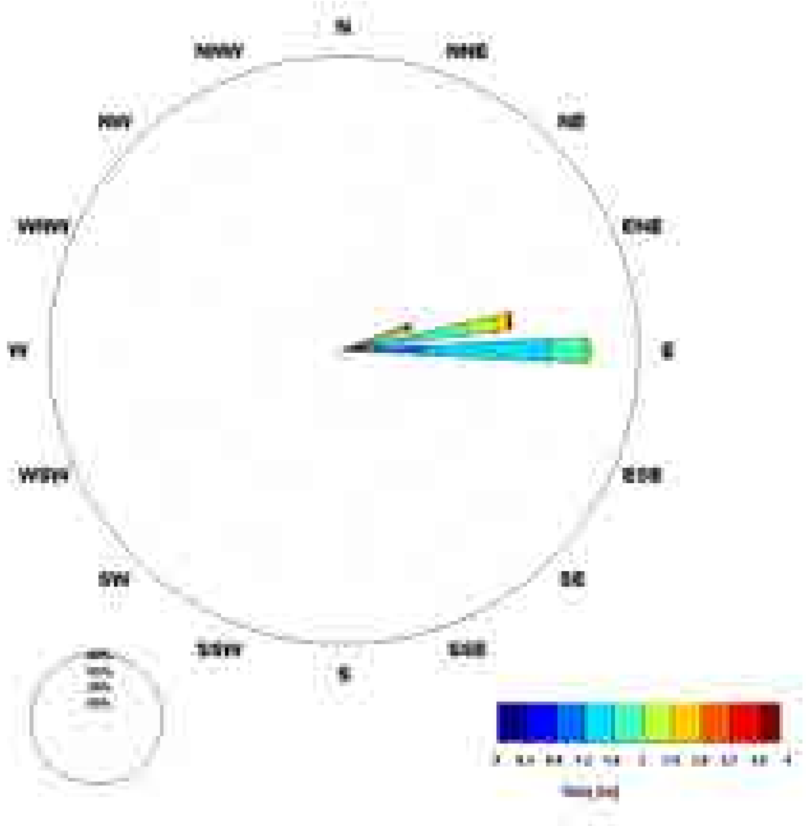


Figure 3-9 Dicky Beach Wave Rose Plot

Table 3-1 Dicky Beach Wave Height and Direction Recurrence Frequency (% of time)

	Dir [deg]														
Hs [m]	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**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%	0.0%	0.0%	0.0%	0.1%
0.3 - 0.5		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.2%	16.1%	0.1%	0.0%			17.4%
0.5 - 0.7			0.0%		0.0%	0.0%	0.1%	1.0%	13.1%	25.7%	0.0%	0.0%	0.0%		40.0%
0.7 - 0.9					0.0%	0.1%	0.2%	4.5%	11.0%	6.9%	0.0%	0.0%			22.7%
0.9 - 1.1			0.0%		0.0%	0.0%	0.1%	5.0%	6.0%	1.2%	0.0%				12.3%
1.1 - 1.3					0.0%	0.0%	0.0%	2.3%	2.7%	0.1%	0.0%				5.1%
1.3 - 1.5					0.0%	0.0%	0.0%	1.2%	0.4%	0.0%	0.0%				1.6%
1.5 - 1.7							0.0%	0.2%	0.1%	0.0%					0.3%
1.7 - 1.9							0.0%	0.2%	0.0%						0.2%
1.9 - 2.1								0.1%	0.0%	0.0%					0.1%
>2.1							0.0%	0.0%	0.0%						0.0%
Total	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.5%	14.5%	34.6%	50.0%	0.2%	0.0%	0.0%	0.0%	100.0%

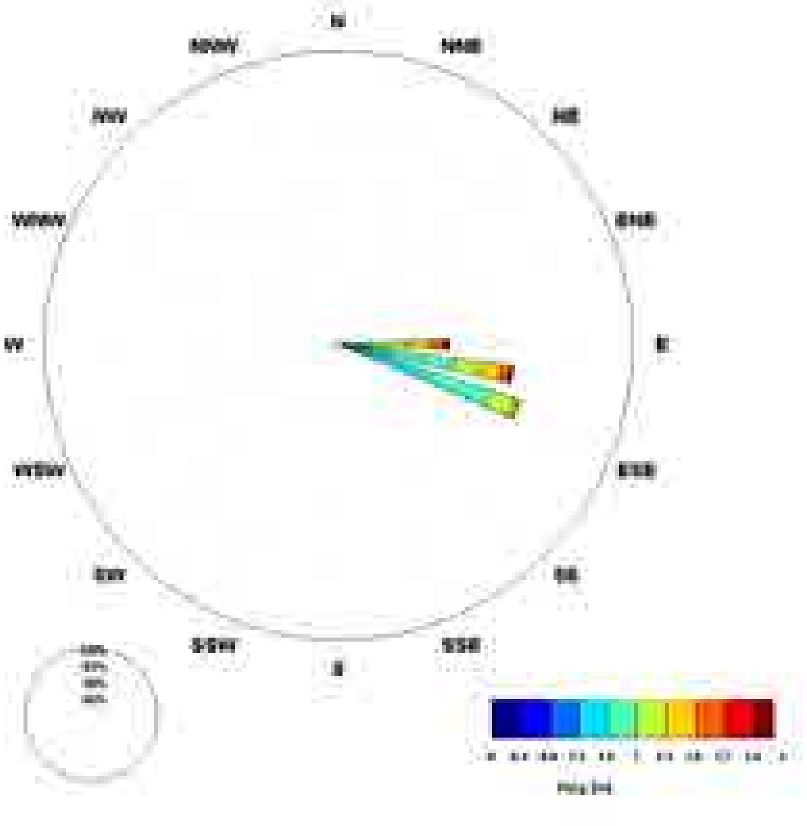


Figure 3-10 Currimundi Wave Rose Plot

Table 3-2 Currimundi Wave Height and Direction Recurrence Frequency (% of time)

	Dir [deg]															
Hs [m]	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**Total**
0.1 - 0.3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%
0.3 - 0.5			0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.8%	3.8%	0.0%	0.0%	0.0%	4.6%
0.5 - 0.7			0.0%	0.0%		0.0%	0.0%	0.1%	0.2%	1.7%	11.0%	14.9%	0.0%	0.0%		27.8%
0.7 - 0.9						0.0%	0.1%	0.2%	0.8%	4.9%	12.2%	13.9%	0.0%			32.0%
0.9 - 1.1			0.0%				0.0%	0.0%	0.8%	7.5%	5.3%	4.9%	0.0%			18.6%
1.1 - 1.3							0.0%	0.0%	0.2%	4.9%	4.2%	1.1%	0.0%			10.4%
1.3 - 1.5								0.0%	0.1%	2.5%	1.9%	0.2%	0.0%			4.6%
1.5 - 1.7									0.0%	0.7%	0.5%	0.0%	0.0%			1.2%
1.7 - 1.9									0.0%	0.3%	0.1%	0.0%	0.0%			0.5%
1.9 - 2.1										0.1%	0.0%					0.2%
>2.1									0.0%	0.0%	0.0%	0.0%				0.1%
Total	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	2.1%	22.8%	35.9%	38.7%	0.0%	0.0%	0.0%	99.9%

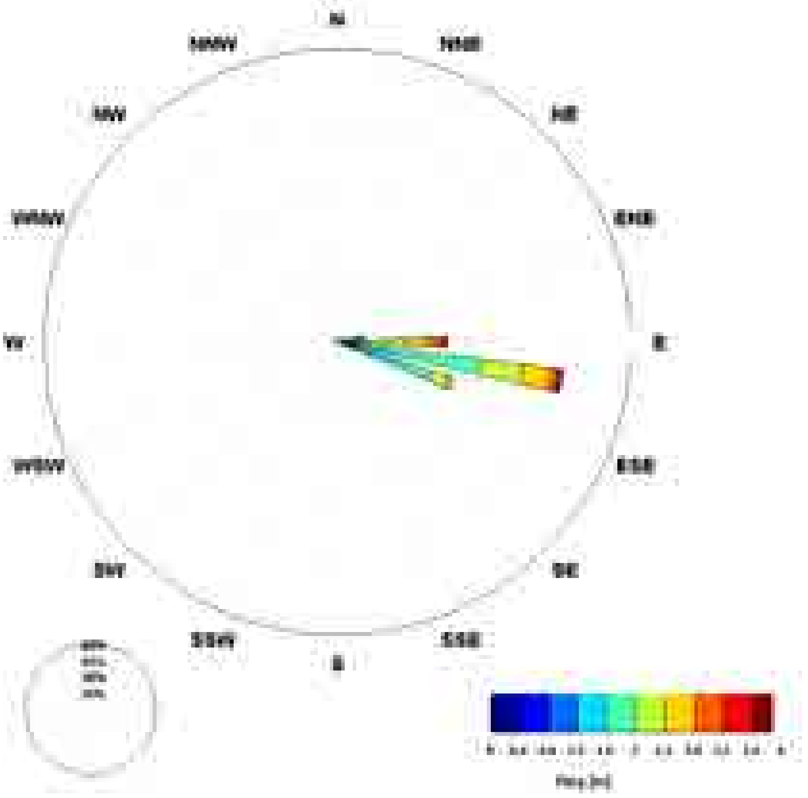


Figure 3-11 Warana Wave Rose Plot

Table 3-3 Warana Wave Height and Direction Recurrence Frequency (% of time)

	Dir [deg]															
Hs [m]	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**Total**
0.1 - 0.3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%
0.3 - 0.5			0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.1%	0.6%	1.2%	0.0%	0.0%	0.0%	1.8%
0.5 - 0.7	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	1.4%	11.1%	11.4%		0.0%		24.1%
0.7 - 0.9				0.0%		0.0%	0.1%	0.3%	0.9%	4.8%	17.7%	7.1%	0.0%	0.0%		30.9%
0.9 - 1.1						0.0%	0.0%	0.1%	1.5%	7.3%	8.9%	3.9%	0.0%			21.8%
1.1 - 1.3			0.0%			0.0%	0.0%	0.0%	1.3%	4.9%	5.6%	1.1%	0.0%			12.9%
1.3 - 1.5						0.0%	0.0%	0.0%	0.8%	2.7%	1.8%	0.1%	0.0%			5.4%
1.5 - 1.7								0.0%	0.4%	1.0%	0.7%	0.0%	0.0%			2.2%
1.7 - 1.9									0.1%	0.3%	0.1%	0.0%	0.0%			0.4%
1.9 - 2.1								0.0%	0.1%	0.1%	0.0%	0.0%	0.0%			0.3%
>2.1								0.0%	0.1%	0.1%	0.0%	0.0%	0.0%			0.1%
Total	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.5%	5.4%	22.7%	46.4%	24.8%	0.0%	0.0%	0.0%	99.9%

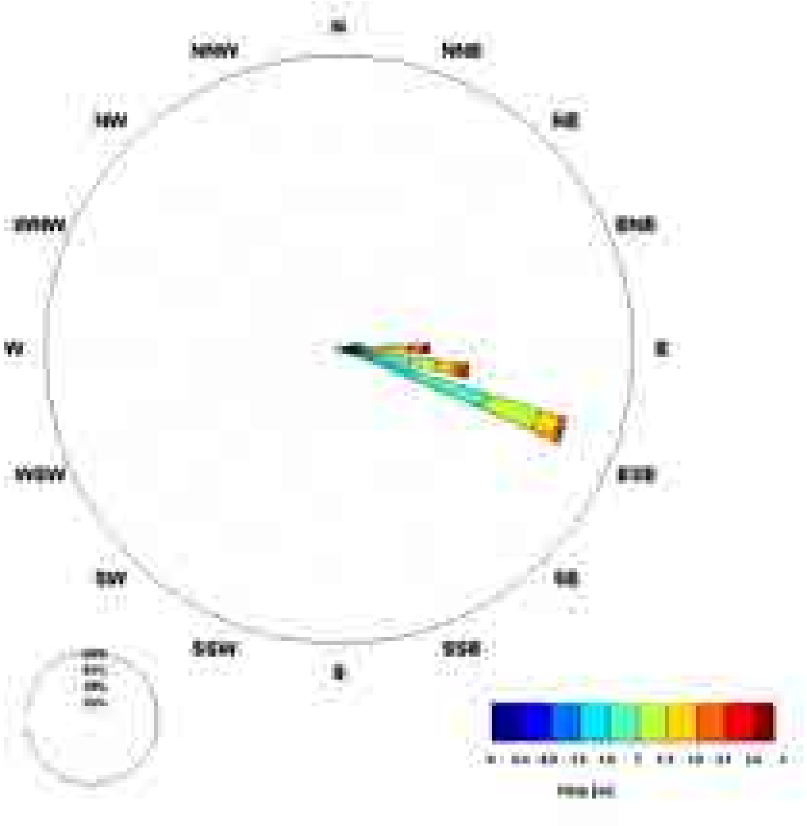


Figure 3-12 Buddina Wave Rose Plot

Table 3-4 Buddina Wave Height and Direction Recurrence Frequency (% of time)

	Dir [m]														
Hs [m]	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**Total**
0.1 - 0.3	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%
0.3 - 0.5		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.9%	0.0%		1.2%
0.5 - 0.7			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.6%	5.7%	15.3%	0.1%	0.0%	21.8%
0.7 - 0.9						0.1%	0.1%	0.2%	0.7%	3.5%	9.0%	15.9%	0.0%	0.0%	29.6%
0.9 - 1.1			0.0%		0.0%	0.0%	0.0%	0.1%	1.3%	6.5%	5.3%	10.8%	0.1%	0.0%	24.1%
1.1 - 1.3						0.0%	0.0%	0.0%	1.1%	3.6%	3.7%	4.4%	0.1%	0.0%	13.0%
1.3 - 1.5						0.0%	0.0%	0.0%	0.7%	2.9%	1.8%	1.2%	0.0%	0.0%	6.6%
1.5 - 1.7							0.0%	0.0%	0.4%	1.2%	0.8%	0.1%	0.0%		2.5%
1.7 - 1.9								0.0%	0.1%	0.3%	0.2%	0.0%			0.7%
1.9 - 2.1								0.0%	0.1%	0.1%	0.1%	0.0%			0.3%
> 2.1								0.0%	0.1%	0.1%	0.0%	0.0%			0.1%
Total	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.4%	4.6%	18.9%	26.8%	48.6%	0.3%	0.0%	100.0%

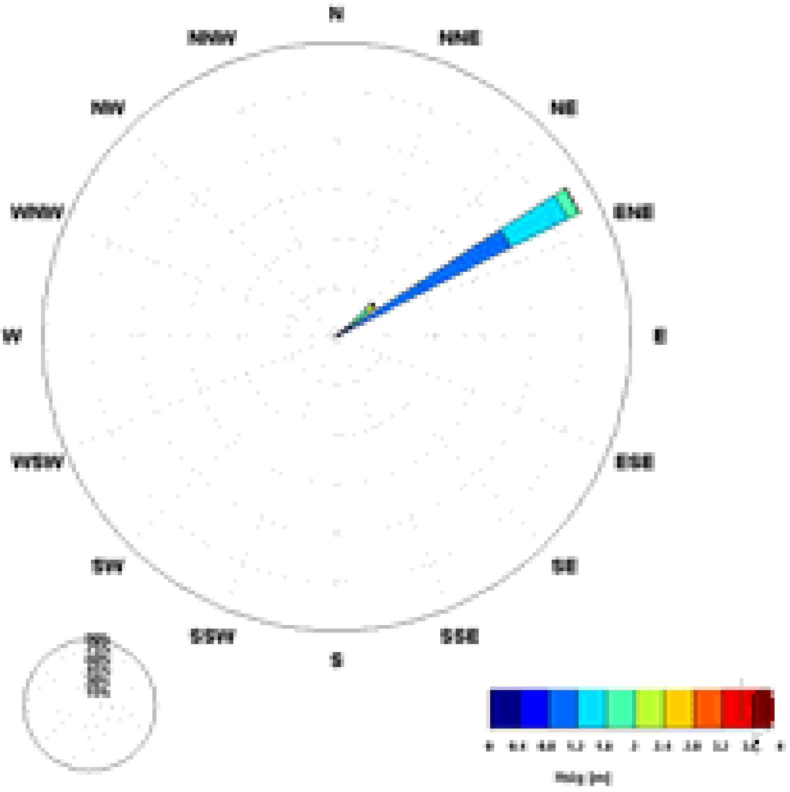


Figure 3-13 Mooloolaba Wave Rose Plot

Table 3-5 Mooloolaba Wave Height and Direction Recurrence Frequency (% of time)

	Dir [m]											
Hs [m]	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**Total**
0.1 - 0.3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.6%	0.5%	0.0%	0.0%		5.1%
0.3 - 0.5		0.0%	0.0%	0.0%	0.0%	0.3%	55.2%	0.4%	0.2%	0.0%	0.0%	56.2%
0.5 - 0.7		0.0%	0.0%	0.0%	0.1%	4.8%	19.6%	0.1%	0.1%	0.0%		24.7%
0.7 - 0.9				0.0%	0.1%	6.8%	3.8%	0.0%	0.0%			10.7%
0.9 - 1.1				0.0%	0.0%	2.2%	0.3%	0.0%				2.5%
1.1 - 1.3				0.0%	0.0%	0.5%	0.0%					0.5%
1.3 - 1.5				0.0%	0.0%	0.1%	0.0%					0.2%
1.5 - 1.7					0.0%	0.0%	0.0%					0.0%
1.7 - 1.9						0.0%	0.0%					0.0%
1.9 - 2.1					0.0%	0.0%	0.0%					0.0%
> 2.1						0.0%						0.0%
Total	0.0%	0.0%	0.0%	0.0%	0.2%	14.8%	83.5%	1.0%	0.3%	0.0%	0.0%	100.0%

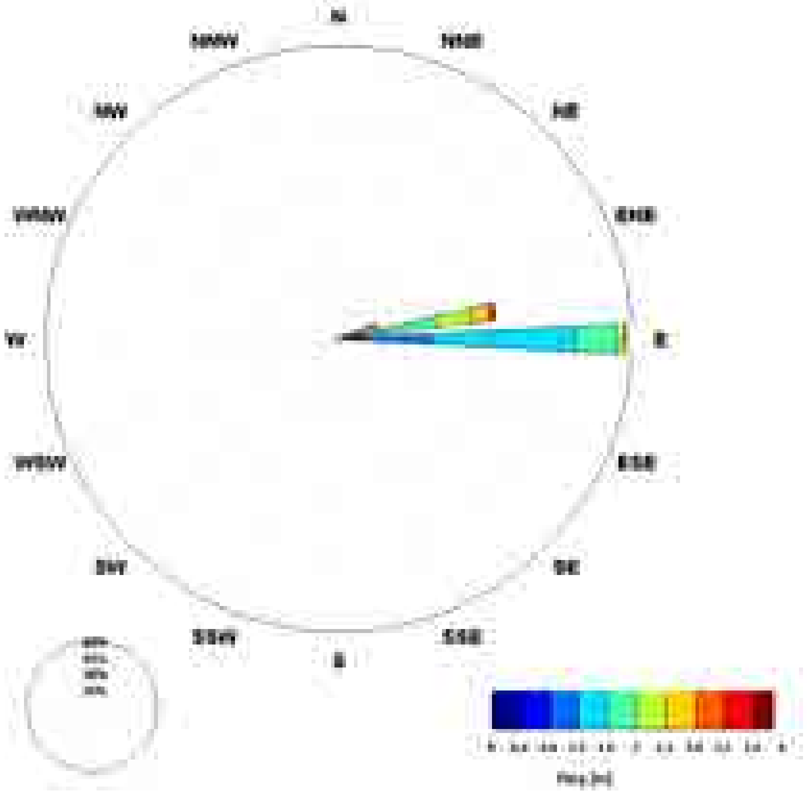


Figure 3-14 Maroochydore Wave Rose Plot

Table 3-6 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%

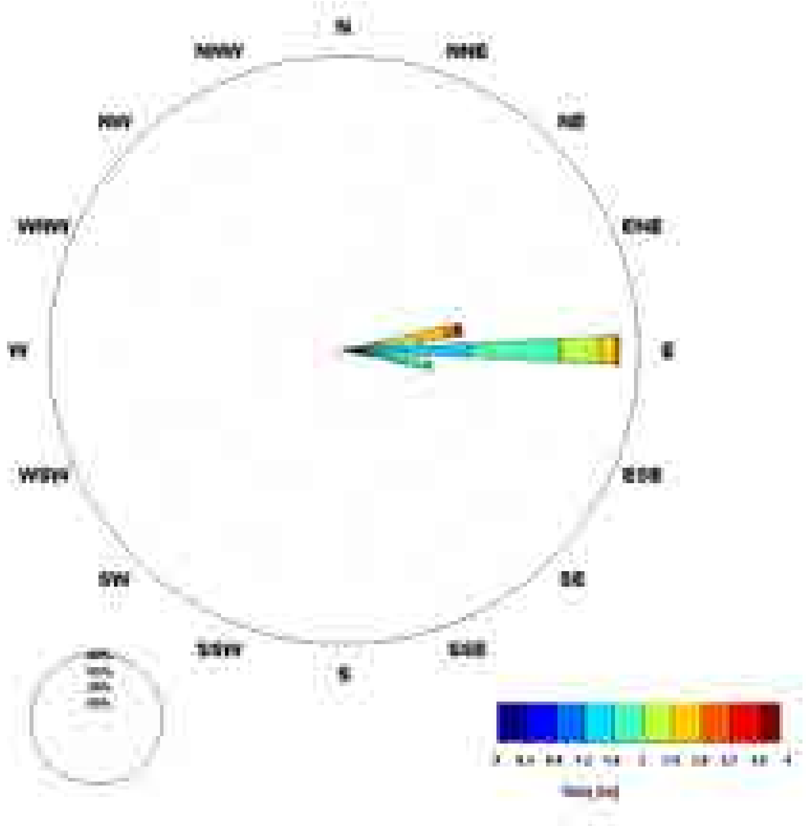


Figure 3-15 Mudjimba Wave Rose Plot

Table 3-7 Mudjimba 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%	0.0%	0.0%		0.0%
0.3 - 0.5		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	2.6%	5.0%	0.0%	7.7%
0.5 - 0.7			0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	1.3%	23.0%	7.8%	0.0%	32.5%
0.7 - 0.9			0.0%			0.0%	0.1%	0.4%	6.2%	18.4%	4.3%	0.0%	29.4%
0.9 - 1.1						0.0%	0.0%	0.4%	7.5%	8.0%	0.8%	0.0%	16.7%
1.1 - 1.3						0.0%	0.0%	0.1%	5.7%	3.3%	0.0%		9.2%
1.3 - 1.5							0.0%	0.1%	2.5%	0.7%	0.0%		3.3%
1.5 - 1.7								0.0%	0.7%	0.1%			0.8%
1.7 - 1.9								0.0%	0.2%	0.0%			0.3%
1.9 - 2.1								0.0%	0.1%	0.0%			0.1%
> 2.1								0.0%	0.1%	0.0%			0.1%
Total	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	1.3%	24.4%	56.1%	18.0%	0.0%	100.0%

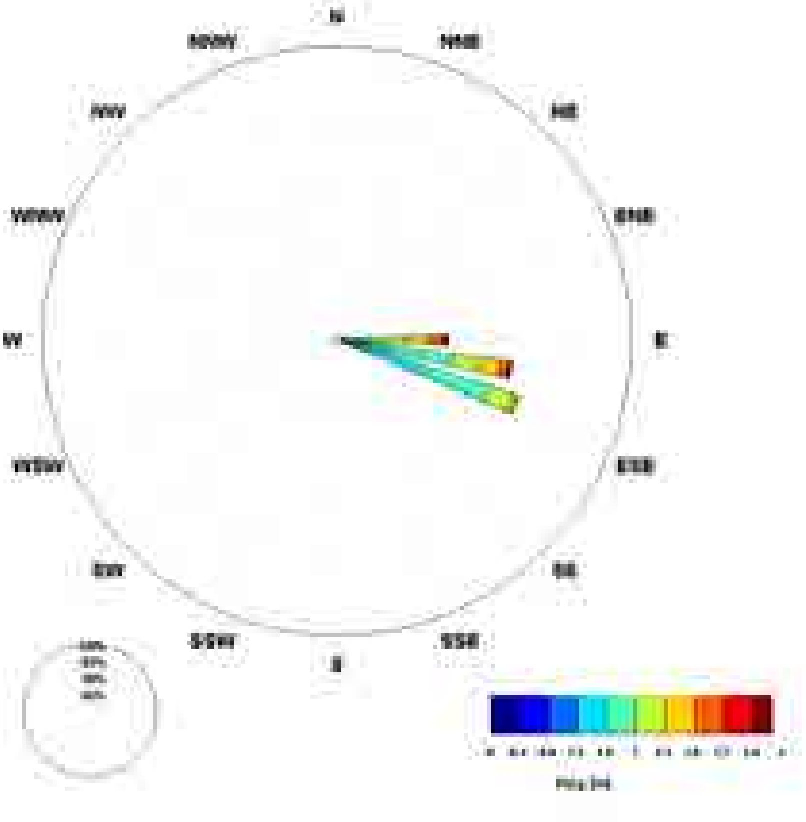


Figure 3-16 Coolum Wave Rose Plot

Table 3-8 Coolum Wave Height and Direction Recurrence Frequency (% of time)

	Dir [deg]														
Hs [m]	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**Total**
0.1 - 0.3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%
0.3 - 0.5			0.0%	0.0%	0.0%			0.0%	0.0%	0.0%	0.1%	0.3%	0.0%	0.0%	0.0%	0.4%
0.5 - 0.7			0.0%	0.0%		0.0%	0.0%	0.0%	0.1%	0.2%	2.1%	9.6%	0.2%	0.0%		12.3%
0.7 - 0.9				0.0%	0.0%	0.0%	0.1%	0.2%	0.3%	2.2%	9.9%	12.0%	0.0%			24.7%
0.9 - 1.1			0.0%			0.0%	0.0%	0.0%	0.8%	4.8%	12.9%	4.4%	0.0%			23.0%
1.1 - 1.3						0.0%	0.0%	0.0%	0.5%	5.6%	9.1%	1.0%	0.0%			16.2%
1.3 - 1.5							0.0%	0.0%	0.3%	5.9%	7.6%	0.0%	0.0%			13.9%
1.5 - 1.7									0.2%	3.3%	1.6%	0.0%	0.0%			5.1%
1.7 - 1.9									0.1%	2.2%	0.1%	0.0%				2.3%
1.9 - 2.1									0.1%	0.9%	0.0%	0.0%				1.0%
2.1 - 2.3									0.1%	0.4%	0.0%					0.5%
2.3 - 2.5									0.1%	0.0%	0.0%					0.2%
2.5 - 2.7								0.0%	0.1%	0.0%		0.0%				0.1%
2.7 - 2.9									0.1%	0.0%						0.1%
>2.9								0.0%	0.1%	0.0%						0.1%
Total	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	2.9%	25.5%	43.4%	27.4%	0.3%	0.0%	0.0%	99.9%

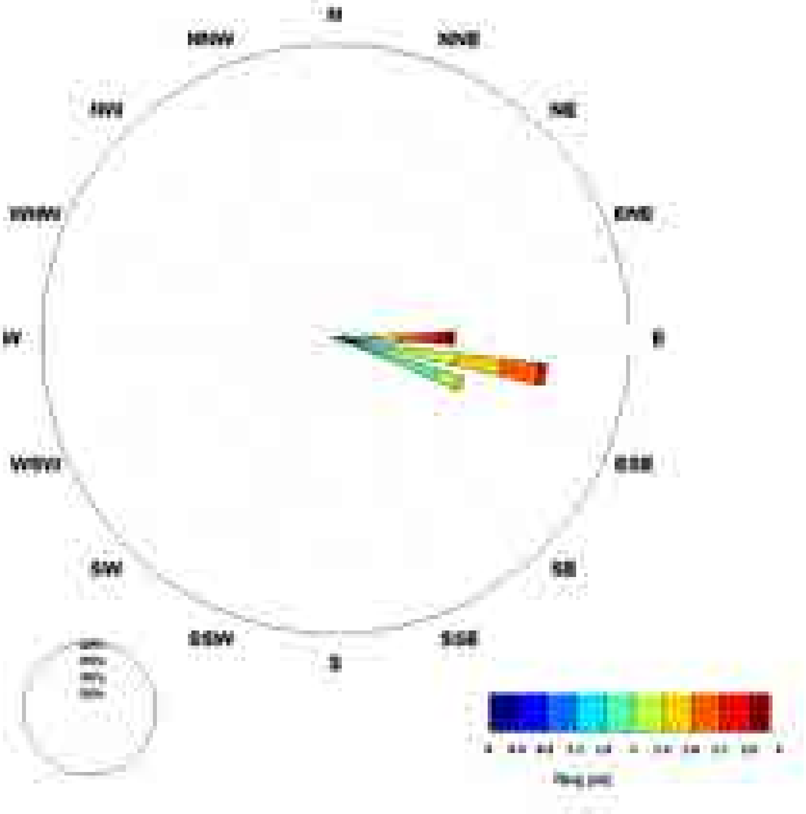


Figure 3-17 Marcoola Wave Rose Plot

Table 3-9 Marcoola Wave Height and Direction Recurrence Frequency (% of time)

	Dir [deg]															
Hs [m]	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**Total**
0.1 - 0.3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%
0.3 - 0.5			0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.1%	0.4%	0.0%	0.0%	0.0%	0.6%
0.5 - 0.7			0.0%	0.0%		0.0%	0.0%	0.1%	0.1%	0.8%	4.8%	5.9%		0.0%		11.7%
0.7 - 0.9						0.1%	0.1%	0.3%	1.0%	4.6%	19.1%	0.9%				26.1%
0.9 - 1.1			0.0%			0.0%	0.0%	0.2%	2.6%	7.6%	10.4%	0.0%				20.8%
1.1 - 1.3							0.0%	0.2%	3.6%	7.4%	2.4%	0.0%				13.6%
1.3 - 1.5						0.0%	0.0%	0.1%	4.2%	8.1%	0.0%	0.0%				12.5%
1.5 - 1.7								0.2%	2.9%	4.0%	0.0%					7.1%
1.7 - 1.9								0.3%	2.2%	0.6%	0.0%					3.1%
1.9 - 2.1								0.1%	1.9%	0.0%						2.0%
2.1 - 2.3							0.0%	0.2%	1.0%	0.0%						1.1%
2.3 - 2.5								0.1%	0.2%	0.0%						0.4%
2.5 - 2.7								0.3%	0.0%	0.0%						0.3%
2.7 - 2.9								0.4%	0.0%							0.4%
2.9 - 3.1							0.0%	0.1%	0.0%							0.1%
>3.1							0.1%	0.0%	0.0%							0.2%
Total	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	2.5%	19.8%	33.1%	36.9%	7.2%	0.0%	0.0%	0.0%	99.9%

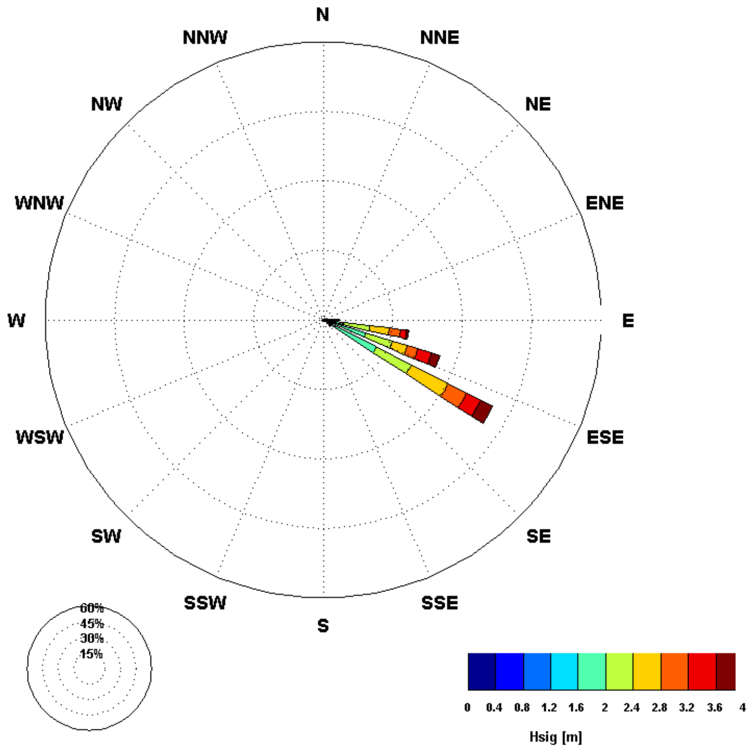


Figure 3-18 Sunshine Beach Wave Rose Plot

Table 3-10 Sunshine Beach Wave Height and Direction Recurrence Frequency (% of time)

	Dir [deg]														
Hs [m]	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**Total**
0.1 - 0.3	0.0%	0.0%	0.0%	0.0%		0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.3 - 0.5				0.0%	0.0%			0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.2%
0.5 - 0.7				0.0%		0.0%	0.0%	0.1%	0.1%	0.2%	0.5%	2.1%	3.0%	0.0%		6.1%
0.7 - 0.9	0.0%					0.0%	0.1%	0.1%	0.3%	1.0%	3.8%	7.4%	9.8%	0.1%	0.0%	22.7%
0.9 - 1.1			0.0%				0.0%	0.0%	0.1%	1.2%	5.8%	6.1%	8.5%	0.1%		21.8%
1.1 - 1.3							0.0%	0.0%	0.0%	0.9%	4.3%	3.4%	8.9%	0.1%		17.6%
1.3 - 1.5								0.0%	0.0%	0.2%	2.5%	2.4%	4.5%	0.3%		9.8%
1.5 - 1.7									0.0%	0.0%	1.3%	3.1%	3.4%	0.7%		8.4%
1.7 - 1.9										0.0%	0.5%	1.9%	2.9%	0.8%		6.0%
1.9 - 2.1											0.1%	1.4%	1.3%	0.3%		3.1%
2.1 - 2.3											0.0%	0.2%	0.8%	0.4%		1.4%
2.3 - 2.5											0.0%	0.2%	0.4%	0.5%		1.1%
2.5 - 2.7												0.0%	0.2%	0.1%		0.4%
2.7 - 2.9												0.0%	0.2%	0.2%		0.4%
2.9 - 3.1												0.0%	0.1%	0.1%		0.3%
3.1 - 3.3													0.1%	0.1%		0.2%
3.3 - 3.5												0.0%	0.0%	0.1%		0.1%
3.5 - 3.7													0.0%	0.0%		0.0%
3.7 - 3.9													0.0%	0.1%		0.1%
>3.9												0.0%	0.0%	0.1%	0.0%	0.1%
Total	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.3%	0.5%	3.6%	18.7%	28.2%	44.3%	4.2%	0.0%	99.9%

3.2.3 Design Wave Conditions

The design wave conditions for the Brisbane Waverider buoy reported by Allen and Callaghan (2001) have been used to estimate the equivalent nearshore design wave conditions for each beach unit. The system of nested wave models was used to transfer the design significant wave heights at the Brisbane Waverider buoy to the study area. For each beach unit wave model output was obtained at an offshore location at a depth of 20m below MSL. The design wave modelling results are used as inputs to the storm erosion potential assessment presented in Section 3.4.

As a conservative approach, a stationary water level of 1.5m above MSL was adopted for all design wave modelling assessments. This elevated water level is representative of design storm surge plus tide conditions (Connell Wagner, 2005).

The results of the design wave assessments are presented below:

- Figure 3-19 showing the 20yr ARI offshore wave height;
- Figure 3-20 showing the 50yr ARI offshore wave height; and
- Figure 3-21 showing the 100yr ARI offshore wave height.

These results are also tabulated in Table 3-11. The offshore design wave height curves for each beach unit are presented with the Brisbane Waverider design wave height curve (Allen and Callaghan, 2001) in Figure 3-22. The wave height design curves for each beach unit are presented in Appendix G.

Rapidly changing wind fields, such as those associated with tropical cyclones, have not been considered in this wave assessment. In their detailed storm tide study, Hardy et al. (2004) simulated a very large population of synthetic tropical cyclones that represented approximately 3000 years. Hardy et al. (2004) report waves at an offshore location at a depth of 35m below MSL. For the Sunshine Coast, the average tropical cyclone induced 100yr ARI wave height is 9.4m.

Title:

20yr Average Recurrence Interval Wave Height (m)

Figure:

3-19

Rev:

A

[illegible]

BMT WBM

www.bmtwbm.com.au

Filepath : [illegible]

Title

50yr Average Recurrence Interval Wave Height (m)

Figure

3-20

Rev

A

N

0 5 10km

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath : [illegible]

Title:

100yr Average Recurrence Interval Wave Height (m)

Figure:

3-21

Rev:

A

[illegible]

N

0 5 10km

Approx. Scale

BMT WBM

www.bmtwbm.com.au

Filepath: [illegible]

Table 3-11 Design Offshore Significant Wave Height

	Offshore Significant Wave Height (m) at 20m Contour		
Location	**20yr ARI**	**50yr ARI**	**100yr ARI**
Brisbane Waverider buoy (deep water)	6.7	7.3	7.8
Dicky Beach	5.3	5.7	6.0
Currimundi	5.1	5.5	5.8
Warana	5.4	5.8	6.1
Buddina	5.1	5.4	5.7
Mooloolaba Bay	5.3	5.6	5.9
Mooloolaba Surf Club	5.3	5.6	5.9
Maroochydore	5.6	6.0	6.3
Marcoola	5.4	5.7	6.0
Coolum	5.5	5.8	6.1
Peregian	5.3	5.6	5.9
Sunshine	5.5	5.9	6.2

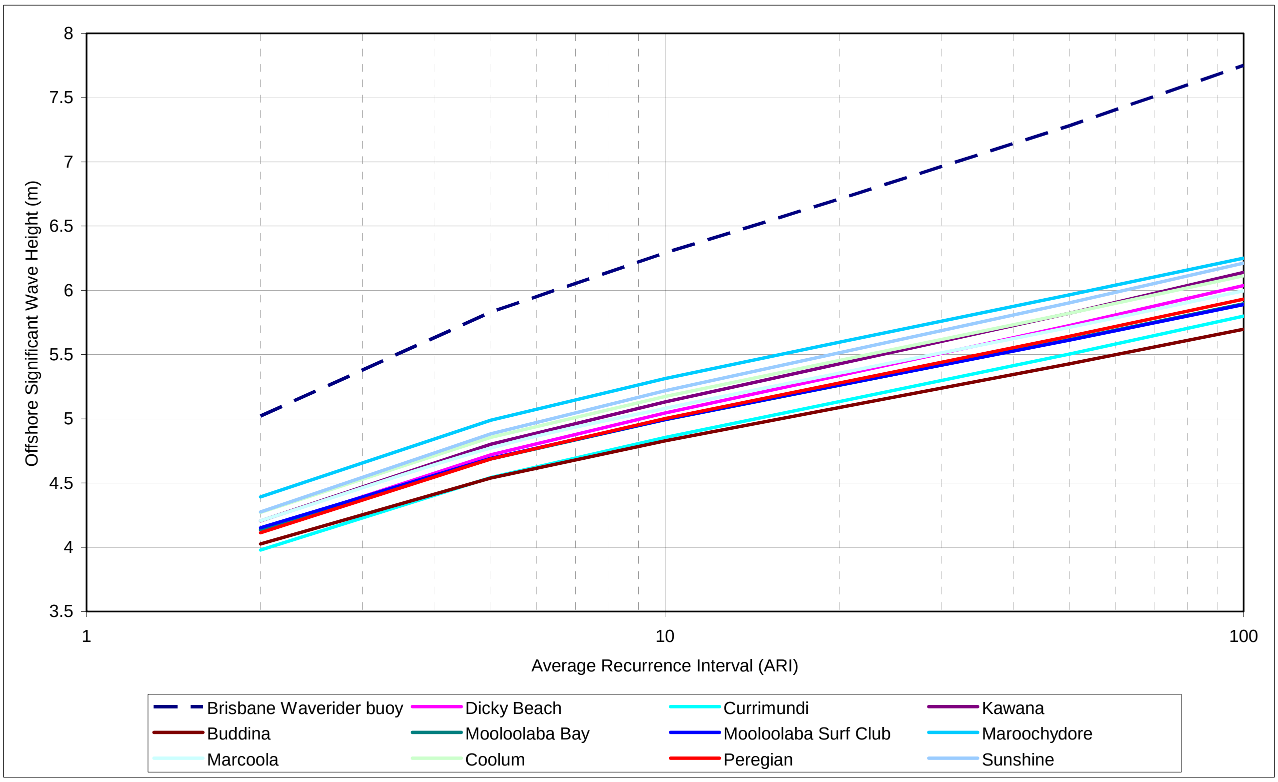


Figure 3-22 Offshore Significant Wave Height Design Curves

3.3 Longshore Sediment Transport Modelling

For the beaches north of Caloundra Headland the rate of longshore sediment transport was estimated using methods originally described in the Shore Protection Manual (CERC, 1984). The so-called "CERC equation" relates the longshore transport to the wave energy flux at the wave breaker location:

$$Q_l = K(EC_n)_b \sin\alpha_b \cos\alpha_b \qquad \text{Equation 1}$$

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

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

The net and gross wave-driven longshore sediment transport along the coast from Currimundi to Sunshine Beach was calculated using the CERC equation and the predicted inshore wave climate. The long term average annual longshore transport rate at selected locations is summarised in Table 3-12. Figure 3-23 shows the cumulative longshore sediment transport volume for the simulation period. It is noted that the reported transport rates represent transport potentials. Actual sand transport rates may be restricted by the availability of sand. For example, at locations where exposed rock exists on the beach or in surf zone from time to time, the actual longshore sand transport rates may be smaller than those predicted.

Results of the longshore sediment transport modelling are summarised below:

- There is a net northerly longshore sand transport potential within the study area that increases progressively from approximately 3,700m^3 per year at Currimundi Beach to approximately 23,300m^3 per year at Sunshine Beach.
- The gradient in average net sand transport varies along the coastline. The predicted average net longshore transport potential rate along Buddina Beach is around 5,600 m^3/yr. Further north, the average net longshore transport along Mooloolaba Beach (Mooloolaba Surf Club) and Maroochydore Beach (Maroochy Surf Club) is approximately 6,100m^3/yr and 7,400m^3/yr respectively. Considering the coffee rock that is frequently exposed at Maroochydore Beach, indicating limited sand supply, the actual average net longshore transport rate along this beach is likely to be smaller than the modelled rates and possibly of the same order as along Buddina Beach.
- The gradient in the average net annual longshore transport potential indicate that a long term trend of shoreline recession may be occurring, albeit at a very slow rate. Considering the longshore sediment transport gradient and the alongshore distance between locations within the study area, the mean net annual loss of sediment due to longshore sediment transport

---

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

processes may be obtained and is presented in Table 3-12. It is noted that the loss of sediment associated with longshore processes may be balanced by an onshore sediment supply (refer Section 2.5) that is not considered as part of this assessment.

- Analysing the gross longshore sand transport rates, it should be noted that the total transport rate at the extended beaches (Currimundi, Buddina, Yaroomba, Marcus and Sunshine Beach) is substantially larger than the transport rates along the sheltered beaches, such as Mooloolaba Beach. The gross longshore transport rate at Buddina Beach is more than 320,000m^3/year, compared to only 32,700m^3/year at Mooloolaba Beach (near the Surf Club). Furthermore, the modelled gross longshore transport rate at the extended beaches show, compared to sheltered beaches, significant variations from year to year, as well as throughout the year.
- Figure 3-23 shows that the longshore sand transport at Buddina Beach has experienced periods of persistent northerly transport (e.g. October 2002 to March 2004 and June 2008 to November 2008), followed by periods of substantial southerly transport (in particular March/April 2004, November 2007 to January 2008 and February 2009 to July 2009). This is in contrast to the longshore sand transport at Mooloolaba Beach and Maroochydore Beach, which shows less fluctuation over time.
- As discussed in Section 2.5, the Sunshine Coast is largely disconnected from the prevailing northerly transport of sand along the Australian east coast. The estimated net annual average longshore sediment transport rates provided in Table 3-12 are significantly smaller that the commonly accepted net annual average rate of 500,000m^3 at the Gold Coast (e.g..Cox and Howe, 2012).

Table 3-12 Annual Longshore Sediment Transport Rate Potentials

Location	Alongshore Distance (km)	Mean Net Longshore Transport Potential (m^3/year)	Mean Gross Longshore Transport Potential (m^3/year)	Sediment loss per metre of shoreline (m^3/m/year)
Currimundi	4.4	3,700 North	276,300	0.64
Buddina	8.7	5,600 North	321,800	0.44
Mooloolaba Surf Club	11.9	6,100 North	32,700	0.16
Maroochydore Surf Club	13.9	7,400 North	154,800	0.18
Mudjimba	16.5	8,300 North	177,700	0.57
Yaroomba	23.5	11,400 North	272,000	0.44
Peregian Beach	33.0	17,900 North	344,600	0.68
Sunshine Beach	40.0	23,300 North	338,300	0.77

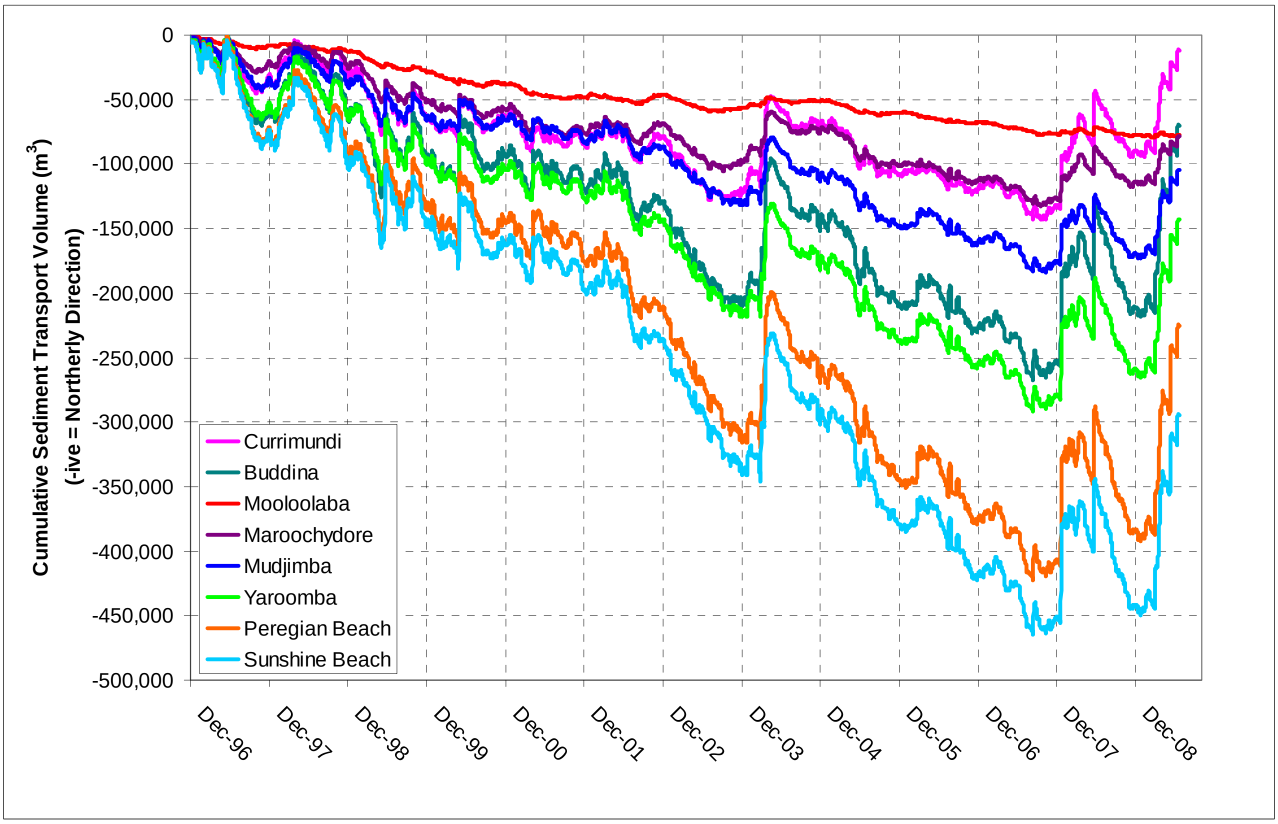


Figure 3-23 Predicted Cumulative Longshore Sediment Transport

LEGEND

🡥 Net Annual Longshore Sediment Transport Potential (m³/year)

Title:

Potential Wave Driven Longshore Sediment Transport

Figure: 3-24

Rev: A

Filepath: [illegible]

3.4 Short Term Storm Erosion Potential

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

The potential for short-term storm erosion due to severe wave and elevated sea water levels (surge conditions) has been predicted using the simple cross-shore equilibrium profile model of Vellinga (1983). This empirical model calculates upper beach and dune erosion associated with storm induced surge and wave conditions. The amount of shoreline recession is determined from the significant wave height, the storm surge plus tide level and the initial beach profile shape. The model assumes the volume of material eroded from the upper beach/dune system and deposited offshore is balanced by a setback of the shoreline.

Storm erosion assessment was performed at locations where sufficient beach profile data was available. In some cases it was necessary to combine recent upper beach profile measurements with historical offshore data in order to extend the profile beyond the active surf zone (a requirement for the Vellinga (1983) model). Initial profile data was obtained from the following sources:

- Extracted from a DEM created using a 2011 bathymetric/topographic survey of the study area north of Currimundi (Queensland Government, 2012);
- Beach profile measurements obtained specifically for this study (specifically at Mooloolaba and Sunshine Beach); and
- Beach profile measurements obtained for another recent study at locations south of Point Cartwright (GHD, 2010).

Design wave conditions for each beach unit were obtained from the wave assessment described in Section 3.2.3. The 50yr ARI offshore design wave heights presented in Table 3-11 were typically adopted for the short term erosion assessment. The offshore (20m depth) design wave height was not considered representative of storm waves within Mooloolaba Bay and therefore additional wave model output at a shallower depth within the Bay was obtained for profiles ETA 521.5, ETA 522 and ETA523.

Design storm surge plus tide levels were obtained from the Maroochy Shire Storm Tide Study summarised in Section 2.1.2 (Connell Wagner, 2005). The contribution of wave setup to the design water level was assumed to be 12.5% of the design wave height. For all storm erosion assessments median sand grain size of 0.2mm was applied.

Table 3-13 lists the storm erosion assessment input parameters and the predicted storm erosion for the available beach profile locations. The storm erosion distance is measured landward from the position where the design water level intersects the beach profile and varies primarily due to the initial beach profile and volume of sand assumed available in the upper beach and dune (the minor differences in design storm conditions also influence the estimated erosion distance). Vellinga (1980) predicts more setback for steeper initial profiles since a greater volume of sand is required to achieve the ultimate storm profile. The initial and estimated storm erosion profile for Maroochydore (ETA 532) is shown in Figure 3-25. The estimated storm profiles for all locations are presented in Appendix H.

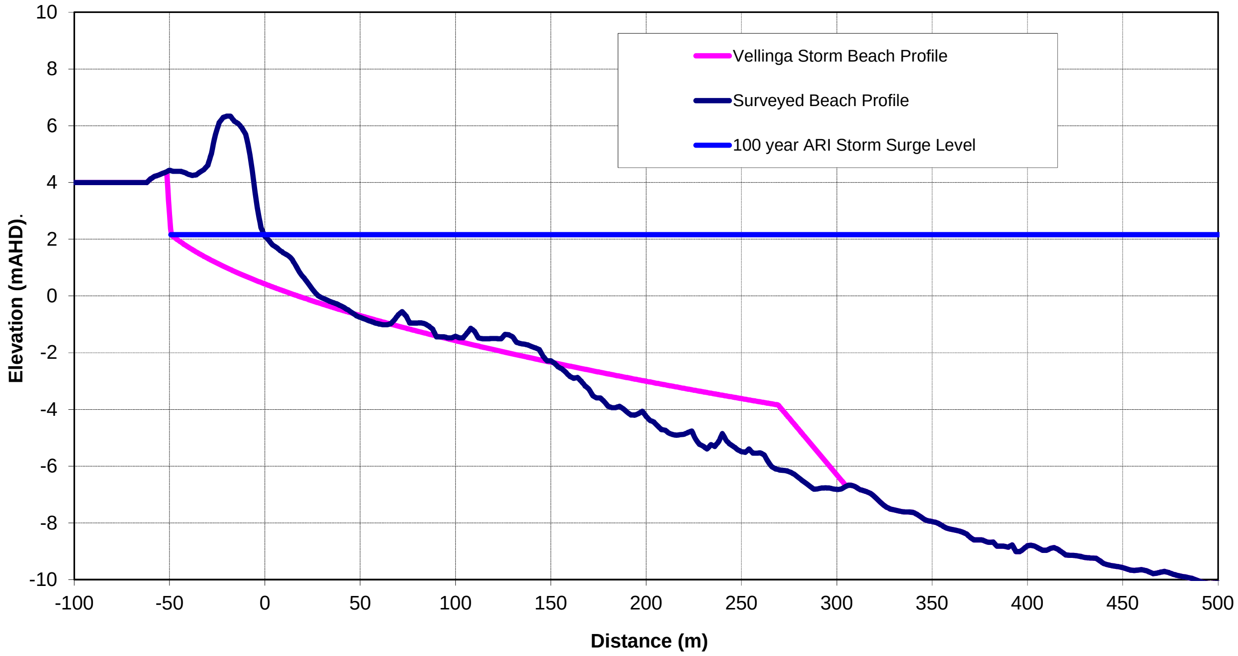


Figure 3-25 Initial Surveyed and Estimated Storm Profiles at Maroochydore Beach (ETA 532)

It is noted that no attempt to verify the Vellinga (1983) model estimates has been undertaken and the assessment is assumed to provide conservative erosion potentials. The calculations consider the upper beach and dune system to consist of sand only and therefore the estimates are likely to be conservative in areas where coffee rock, dense dune vegetation and/or manmade structures exist. The most notable erosion width over-estimates are at locations near Point Cartwright and Point Arkwright (ETA 514, ETA 564 and ETA 566) where significant rocky headlands are present.

The mean storm erosion width estimate for the study area is approximately 37m however it is noted that significantly greater widths are predicted at some locations. The assessment suggests the greatest erosion pressure is experienced between Alexandra Headland and Maroochydore which is consistent with the severely eroded shoreline frequently observed at this location. It is noted that a more detailed storm erosion assessment was recently completed along this section and a mean erosion potential width of 45m was reported (BMT WBM, 2012).

Table 3-13 Storm Erosion Assessment Model Input Parameters and Erosion Widths

Approximate Location	Initial Profile Location	50yr ARI Offshore Design Wave Height (m)	Design Storm Tide Level Including Wave Setup (mAHD)	Vellinga (1980) Design Storm Erosion Width Potential (m)
	ETA488	5.7	2.05	50.3
	ETA490	5.7	2.05	45.5
Currimundi	ETA492	5.5	2.05	28.6
	ETA494	5.5	2.05	27.1
	ETA496	5.5	2.05	13.9
	ETA498	5.8	2.10	53.3
Bokarina	ETA500	5.8	2.10	39.2
	ETA502	5.8	2.10	34.6
	ETA504	5.8	2.10	31.8
	ETA506	5.8	2.10	39.9
	ETA508	5.4	2.12	44.8
Buddina	ETA510	5.4	2.12	40.4
	ETA512	5.4	2.12	36.9
Point Cartwright	ETA514	5.4	2.12	51.4**
Mooloolaba	ETA521.5	2.6*	1.90	24.0
	ETA522	2.6*	1.97	35.2
	ETA523	2.6*	1.97	16.1
	ETA527	3.1*	2.16	32.1
Alexandra Headland	ETA529.8	6.0	2.16	59.9
	ETA530	6.0	2.16	72.4
Maroochydore	ETA532	6.0	2.16	49.3
	ETA538	6.0	2.17	44.7
Mudjimba	ETA540	5.7	2.17	39.9
	ETA542	5.7	2.17	42.5
	ETA544	5.7	2.17	51.4
	ETA546	5.7	2.17	34.7
	ETA548	5.7	2.17	16.3
	ETA550	5.7	2.17	23.9
	ETA554	5.7	2.17	29.0
Mt Coolum	ETA558	5.8	2.17	37.6
	ETA562	5.8	2.17	43.3
Point Arkwright	ETA564	5.8	2.17	35.0**
	ETA566	5.8	2.17	52.9**
Coolum	ETA568	5.8	2.17	16.3
	ETA570	5.8	2.17	19.7
	ETA574	5.6	2.30	28.2
	ETA578	5.6	2.30	24.6
Peregian	ETA582	5.6	2.30	32.8
Sunshine	NA	5.9	2.30	36.2

*Wave model output from within Mooloolaba Bay.

**Rocky headland location, erosion width expected to be significantly over estimated.

3.5 Modelling of Mooloolaba Bay

The tidal currents at Mooloolaba Beach were assessed using TUFLOW-FV, a flexible mesh hydrodynamic model developed by BMT WBM. The assessment also considered the influence of extreme wave and flood events on the currents within Mooloolaba Bay. Such events are expected to increase the sediment transport potential.

The hydrodynamic model domain for the study extends north from Moreton Bay to Double Island Point and offshore to the continental shelf as shown in Figure 3-31. In order to resolve the nearshore processes within Mooloolaba Bay the model mesh was refined for the nearshore locations of the study area and within the Mooloolah River. The mesh detail at Mooloolaba is shown in Figure 3-32.

Tidal (water level) boundary conditions for the model were obtained from the BMT WBM Coral Sea model. Output from the Coral Sea model has been used and verified in a number of recent studies. For this study, the model was verified with astronomical tide prediction at Tangalooma, Caloundra Head, Mooloolaba, and Noosa Head. The verification result for Mooloolaba is shown in Figure 3-26.

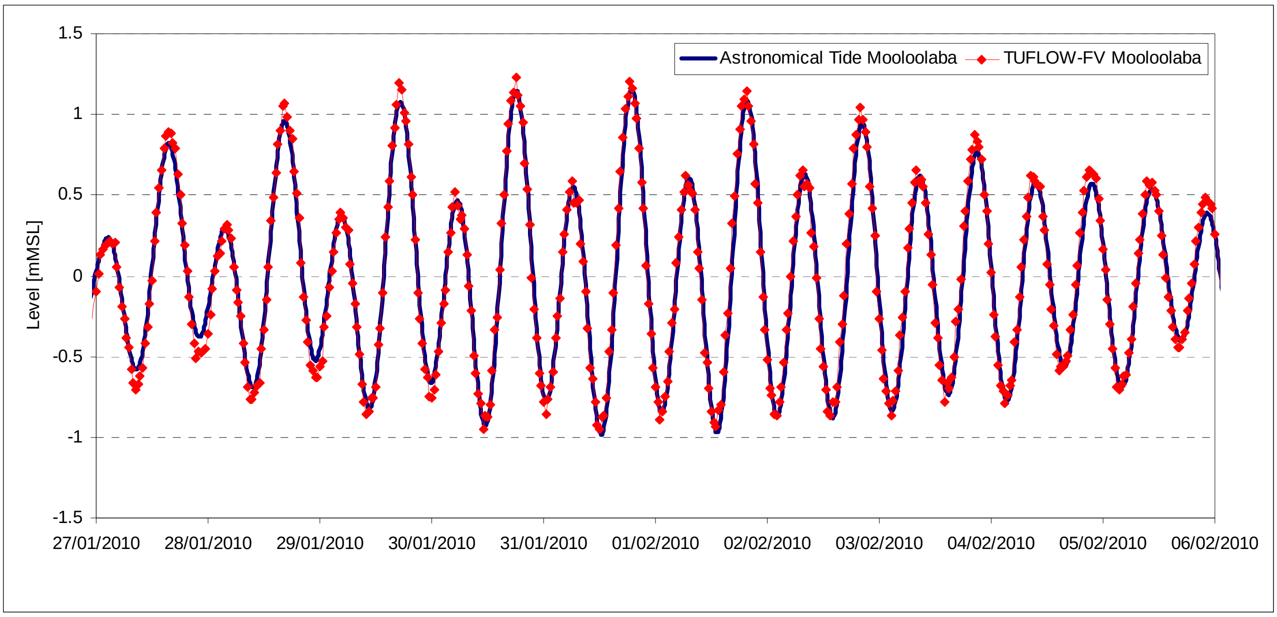


Figure 3-26 TUFLOW-FV Hydrodynamic Model Verification at Mooloolaba

3.5.1 Model Scenarios

Using the developed TUFLOW-FV model, a number of hydrodynamic scenarios at Mooloolaba Beach were assessed. These scenarios included:

- Currents driven by spring tide only (Tide Only scenario).
- Currents driven by spring tide and wave forcing. Three offshore swell wave cases were considered:
    - Hs = 3m, Tp = 12s, Dir = SE (Tide + Wave Case 1 Scenario);
    - Hs = 3m, Tp = 12s, Dir = E. (Tide + Wave Case 2 Scenario); and
    - Hs = 3m, Tp = 12s, Dir = NE (Tide + Wave Case 3 Scenario).

- Currents driven by spring tide and the Mooloolah River in flood for the following design events:
  - 2yr ARI flood event (Tide + Flood 1 Scenario);
  - 10yr ARI flood event (Tide + Flood 2 Scenario); and
  - 100yr ARI flood event (Tide + Flood 3 Scenario).

Additional forcing resulting from a flood event was also assessed. For this scenario the peak flood flow exiting the Mooloolah River was timed to coincide with a spring tide. This flood/tide combination was modelled to simulate peak current conditions.

The scenarios listed above were simulated over a spring tide period. The tidal signal and times of peak flood and peak ebb current at Mooloolaba are indicated in Figure 3-27.

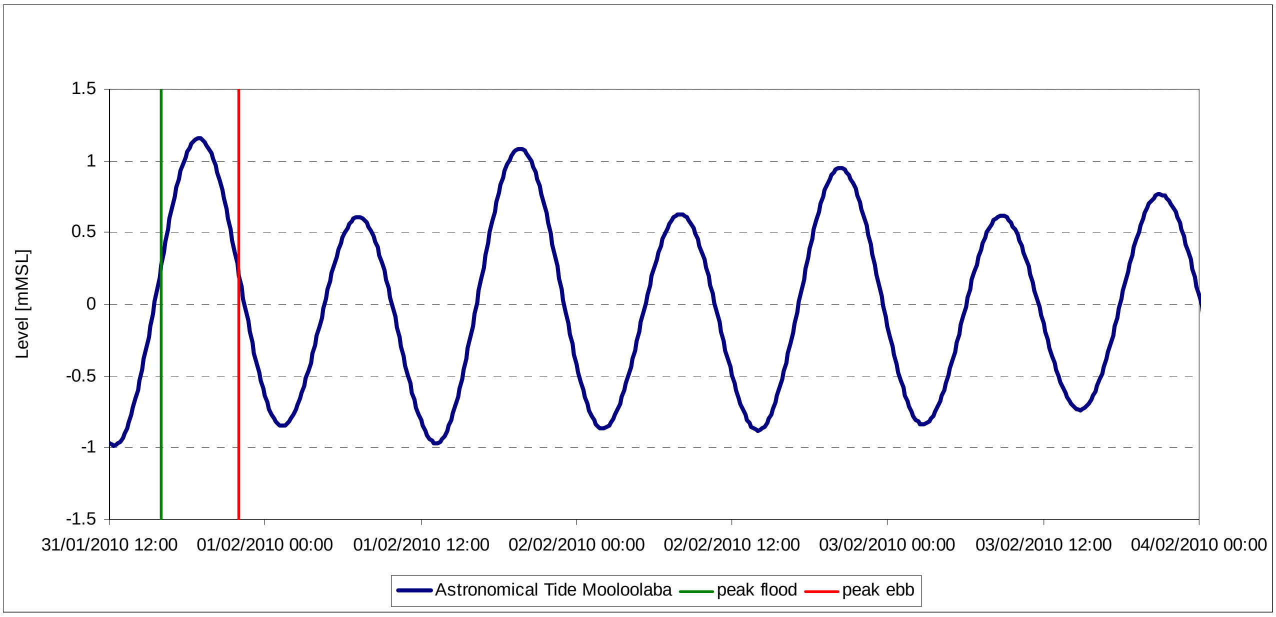


Figure 3-27 Spring Tide Period

3.5.2 Tidal Currents

Figure 3-28 presents the predicted tidal current velocity and direction at Mooloolaba Beach during a spring tide period (model output location is indicated in Figure 3-32). Under spring tidal forcing only, the current velocity peak is less than 0.2m/s. The currents align roughly parallel to the shoreline with the ebb current directed toward the training wall (approximately 40˚N) and the flood current directed away from the training wall (approximately 230˚N). The ebb currents appear to dominate, with the peak ebb current velocity typically twice the peak flood current velocity. Very low sediment transport rates along Mooloolaba Beach would be expected under these conditions.

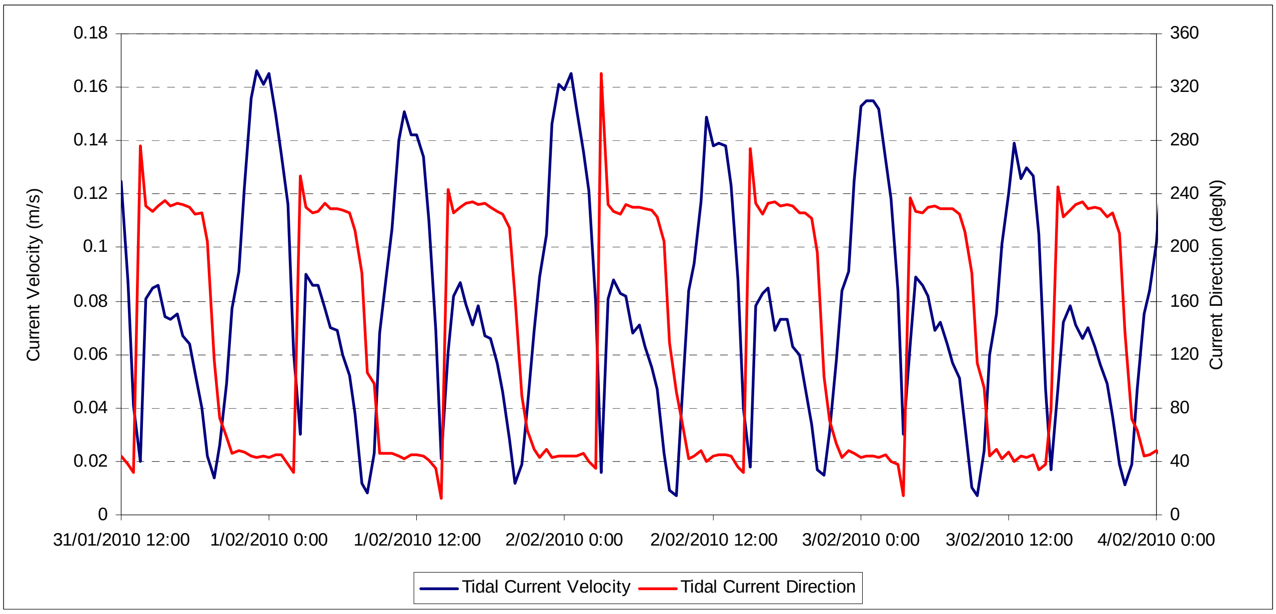


Figure 3-28 Current Velocity and Direction at Mooloolaba Beach – Tidal Only Scenario

3.5.3 Combined Tidal Currents / Wave Forcing

Wave forcing predicted by the SWAN wave model was integrated with the TUFLOW-FV hydrodynamic model. The spring tide period combined with each of the three wave cases was simulated. The additional forcing due to waves significantly altered the local current pattern.

The combined tide and wave conditions increased the peak current velocities at Mooloolaba Beach (Figure 3-29). For the modelled scenarios, the peak current velocity was found to be greatest during north-easterly swell conditions (>0.5m/s). Under the combined wave and current regime, with enhanced bed shear stresses and sediment suspension due to the wave forcing, high sediment transport rates would be expected relative to the Tide Only scenario.

The comparison in Figure 3-30 indicates how the wave driven forces effect the current direction within Mooloolaba Bay. With an easterly or north-easterly swell, the current direction variation reduces and typically remains in a direction favouring northern sediment transport (that is, away from the training wall) for all phases of the tide. For the south-easterly swell case, however, low velocity currents reverse to the direction toward the training wall for a short period. Due to their magnitude, the transport rates associated with these reverse currents are expected to be low. This assessment suggests the wave driven forces, particularly from an easterly or north-easterly direction, act to promote sediment transport away from Mooloolaba Bay.

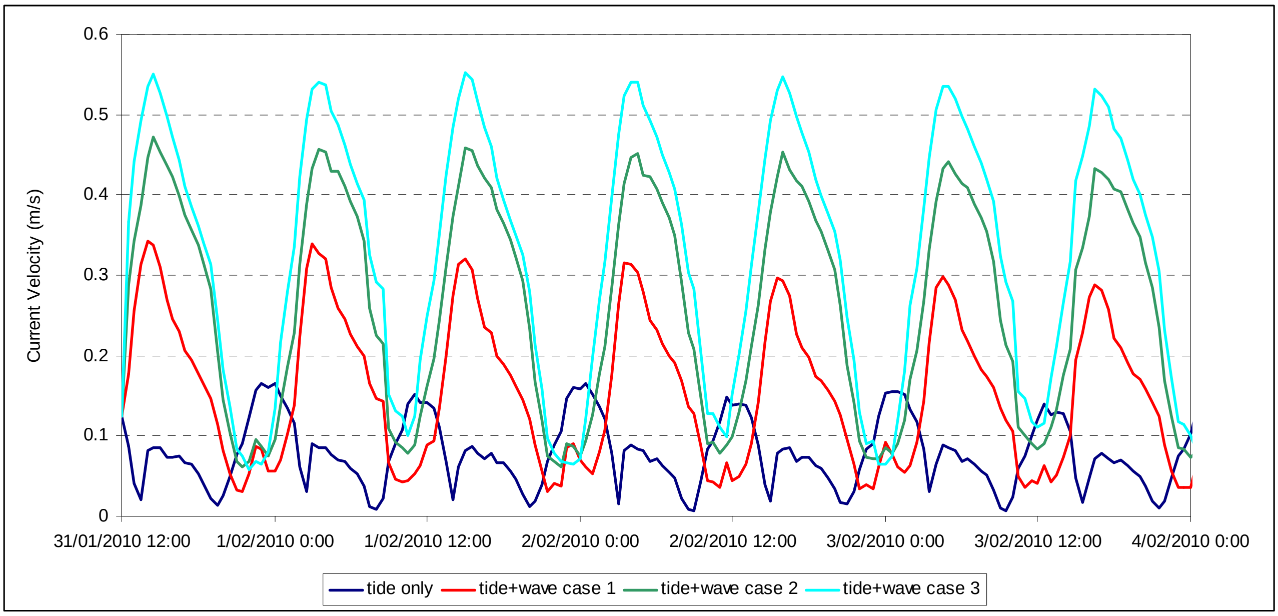


Figure 3-29 Current Velocity at Mooloolaba Beach – Combined Tidal/Wave Forcing

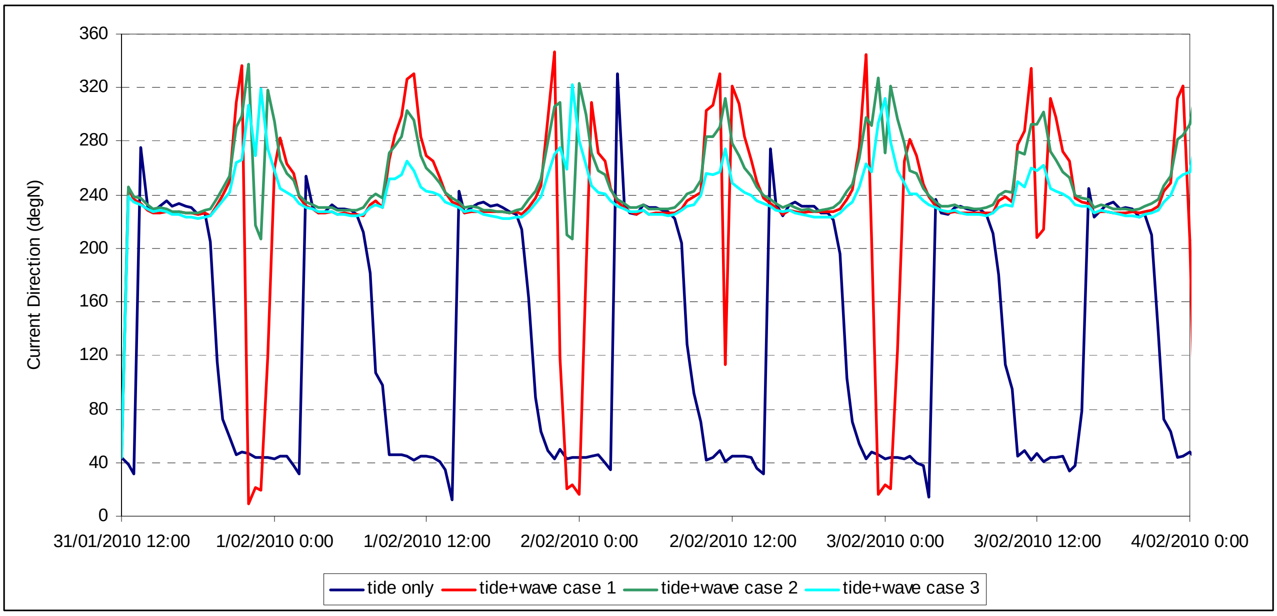


Figure 3-30 Current Direction at Mooloolaba Beach – Combined Tidal/Wave Forcing

Figure 3-33 through Figure 3-40 show contour with vector plots at the times coinciding with the peak flood and ebb currents (indicated in Figure 3-27) for the tide only and tide with wave forcing scenarios. The figures clearly indicate the dominance of wave forcing on the current circulation in the vicinity of Mooloolaba Bay.

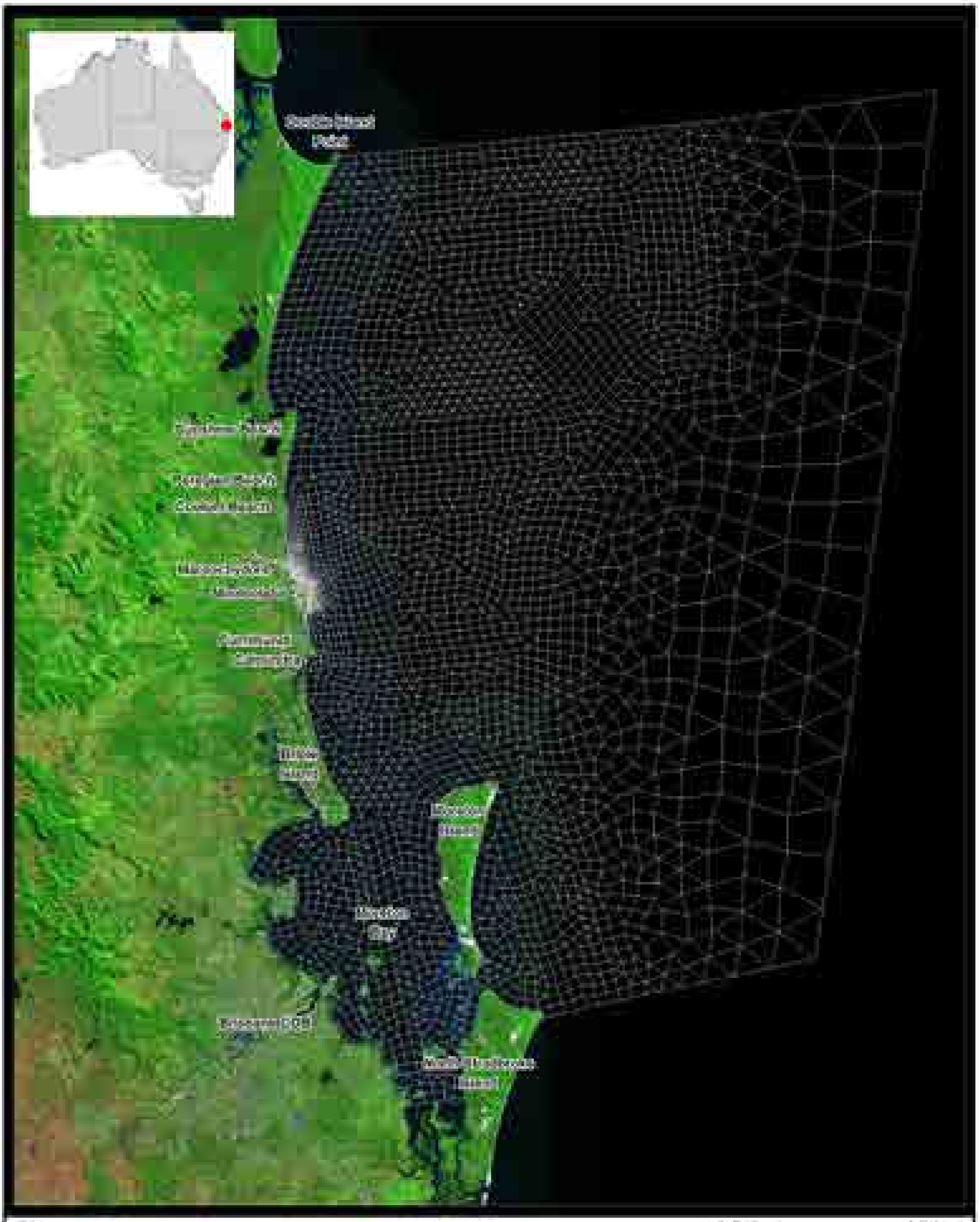
The combined tide and wave forcing generates currents in excess of 1m/s at Point Cartwright. During peak flood tide conditions, the currents are predicted to move into and across the Mooloolah River entrance, setting up a strong longshore current (approximately 0.5m/s) at Mooloolaba Beach.

During peak ebb tide conditions, the currents moving around Point Cartwright reduce to approximately 0.5m/s and combine with the flow exiting the Mooloolah River. For the south-easterly swell case, very low flows within Mooloolaba Bay are predicted at this time. For the easterly and north-easterly swell cases, some current circulation along the beach and toward the training wall is predicted. For persistent swells, the near shore currents and resulting bed shear stresses may be of sufficient strength to entrain and transport material toward the strong flows exiting the river. Under this scenario sediments are likely to be lost from the Mooloolaba Beach system.

3.5.4 Combined Tidal Currents/Flood Forcing

The influence of the 2, 10, and 100 year ARI flood events on the hydrodynamics within Mooloolaba Bay has been assessed. The hydrograph data for the Mooloolah River in flood was extracted from a flood model developed for the Mooloolah River/Currimundi Creek Floodplain Flood Study and Stormwater Management Plan (Sinclair Knight Merz, 2002). Peak flood conditions at the River entrance were timed to coincide with the peak ebb tide currents (indicated in Figure 3-27).

The contour with vector plots for 2, 10, and 100 year ARI flood events are shown in Figure 3-41, Figure 3-42, and Figure 3-43. Summarising the results, with the river in flood, the ebb tide circulation within Mooloolaba River is enhanced. For larger flood events this may promote scouring and erosion adjacent to the training wall and transport sediments to the strong flows exiting the river.



Title:

TUFLOW-FV Model Mesh

Figure:

3-31

Rev:

A

Title

TUFLOW-FV Mesh Detail at Mooloolaba

Figure

3-32

Rev

A

N

0 0.5 1km

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B17814_I_BUA_SunshineCoast_CoastalProcesses\DRG\COA_011_150608 TUFLOW-FV_mesh_Mool.wor

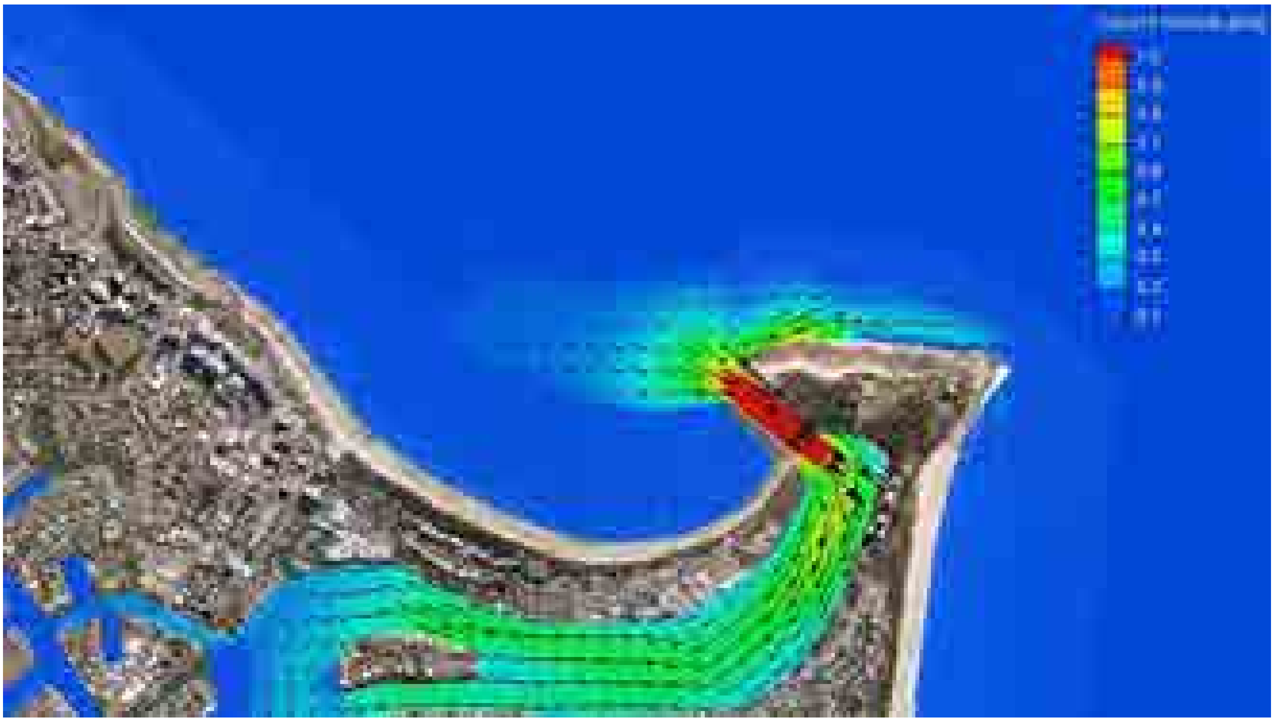


Figure 3-33 Peak Flood Tide Currents without Wave Forcing

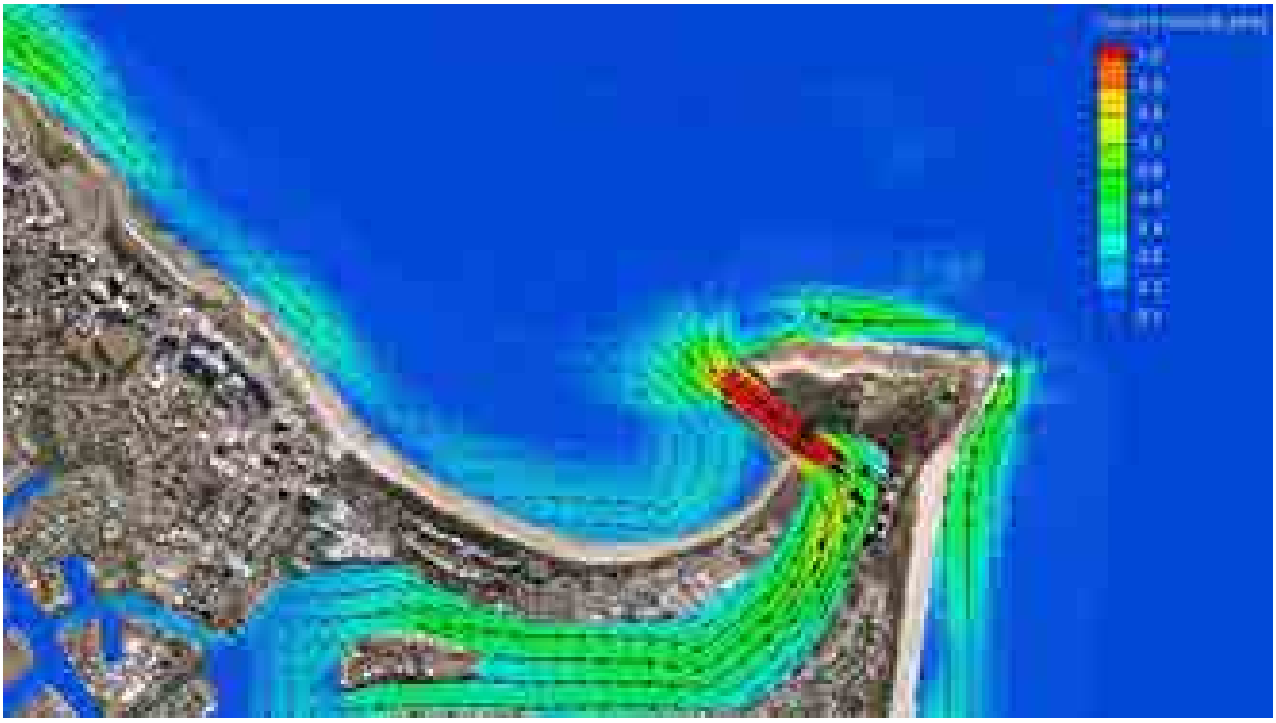


Figure 3-34 Peak Flood Tide Currents with Wave Case 1: Hs = 3m, Tp = 12s, Dir = SE

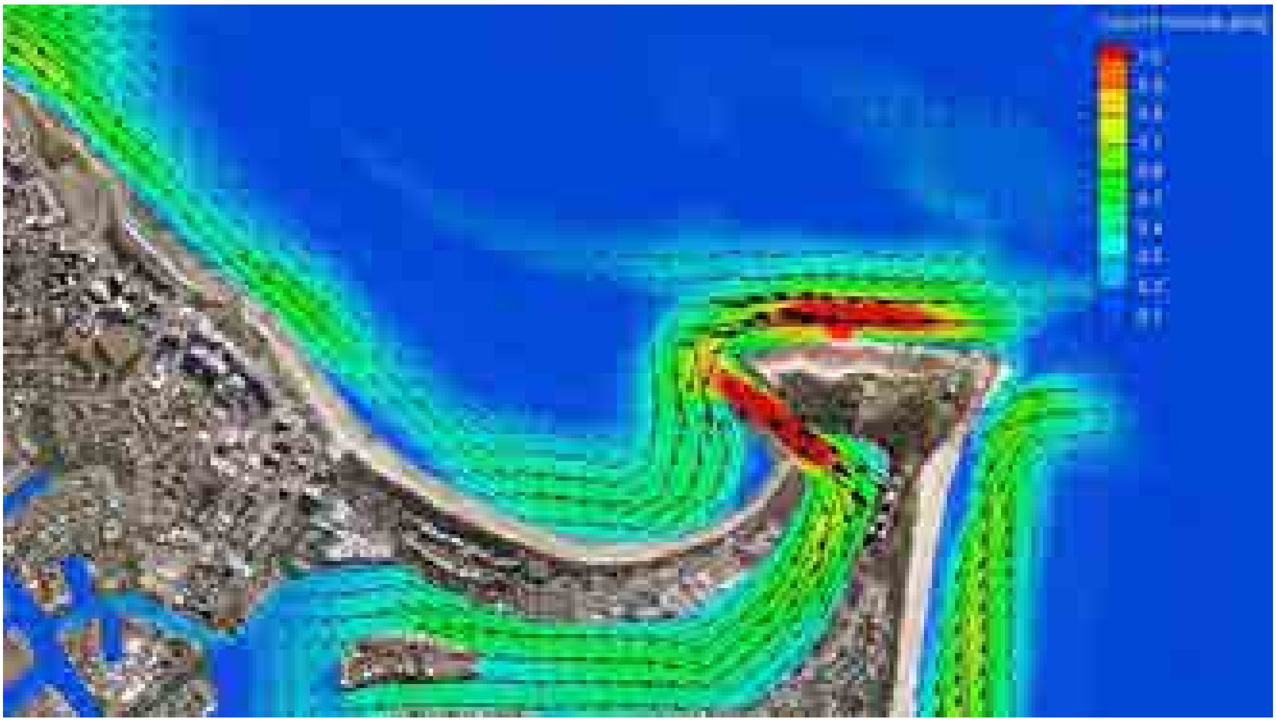


Figure 3-35 Peak Flood Tide Currents with Wave Case 2: Hs = 3m, Tp = 12s, Dir = E

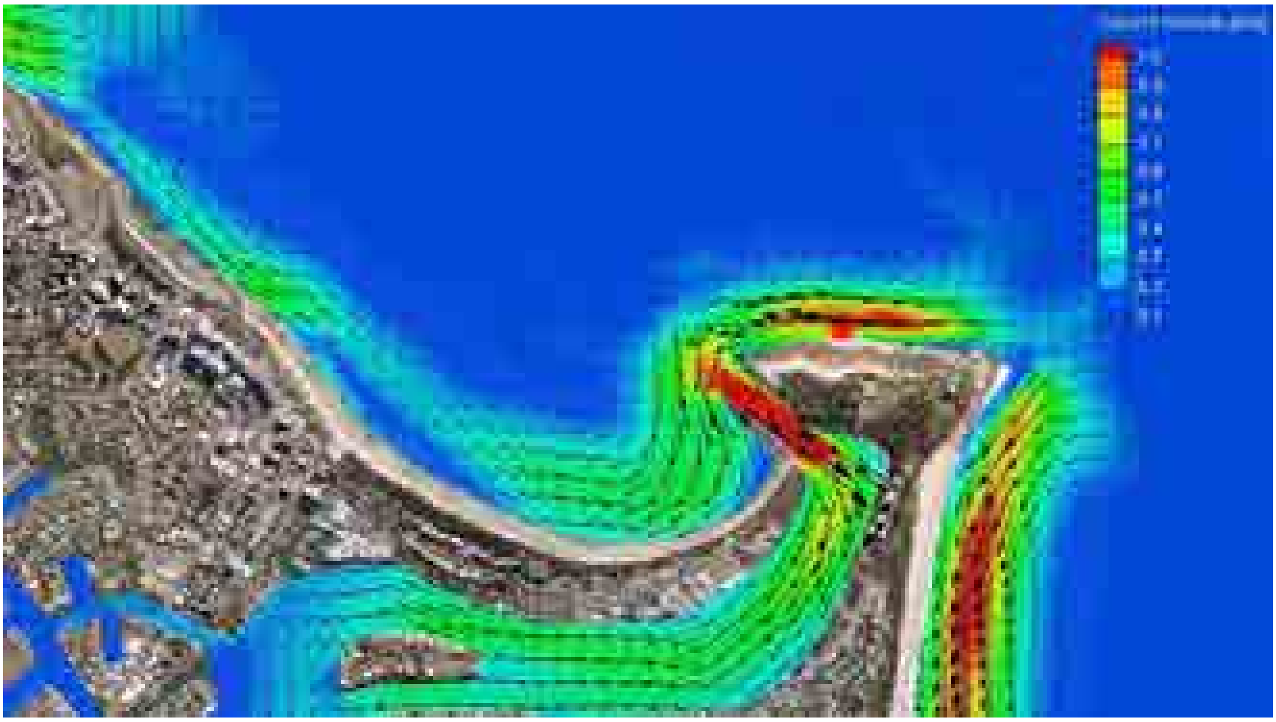


Figure 3-36 Peak Flood Tide Currents with Wave Case 3: Hs = 3m, Tp = 12s, Dir = NE

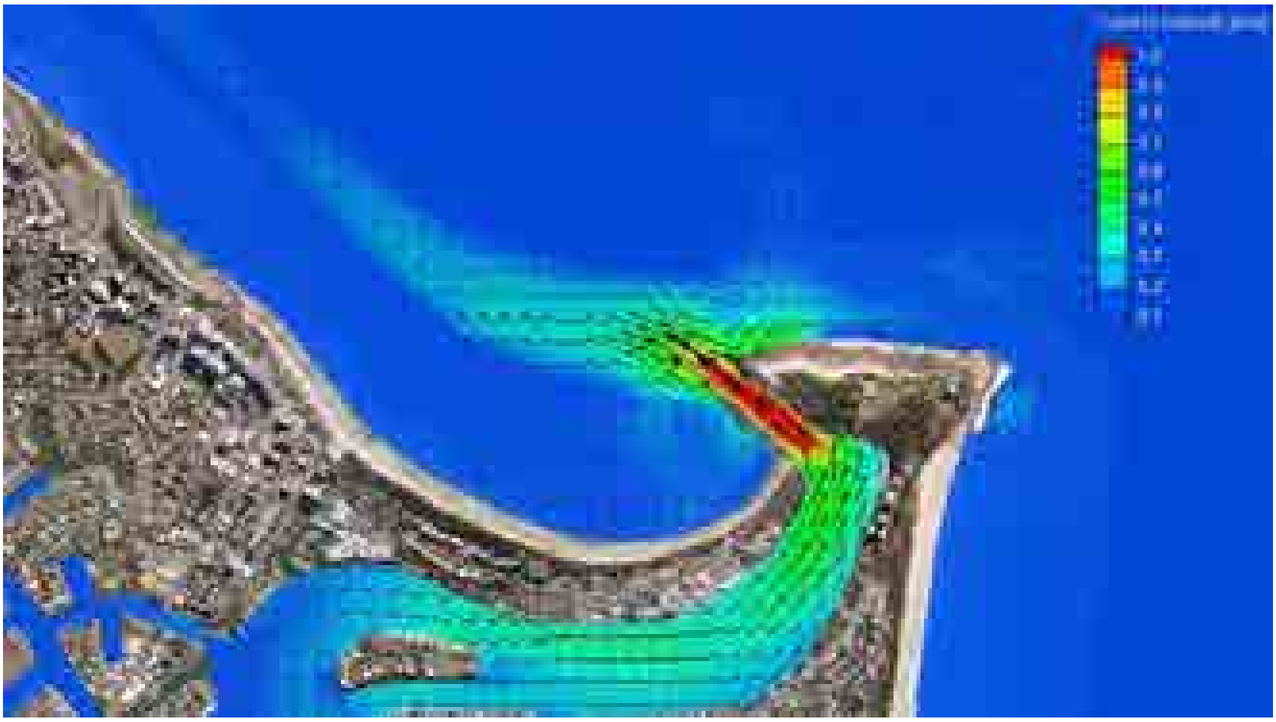


Figure 3-37   Peak Ebb Tide Currents without Wave Forcing

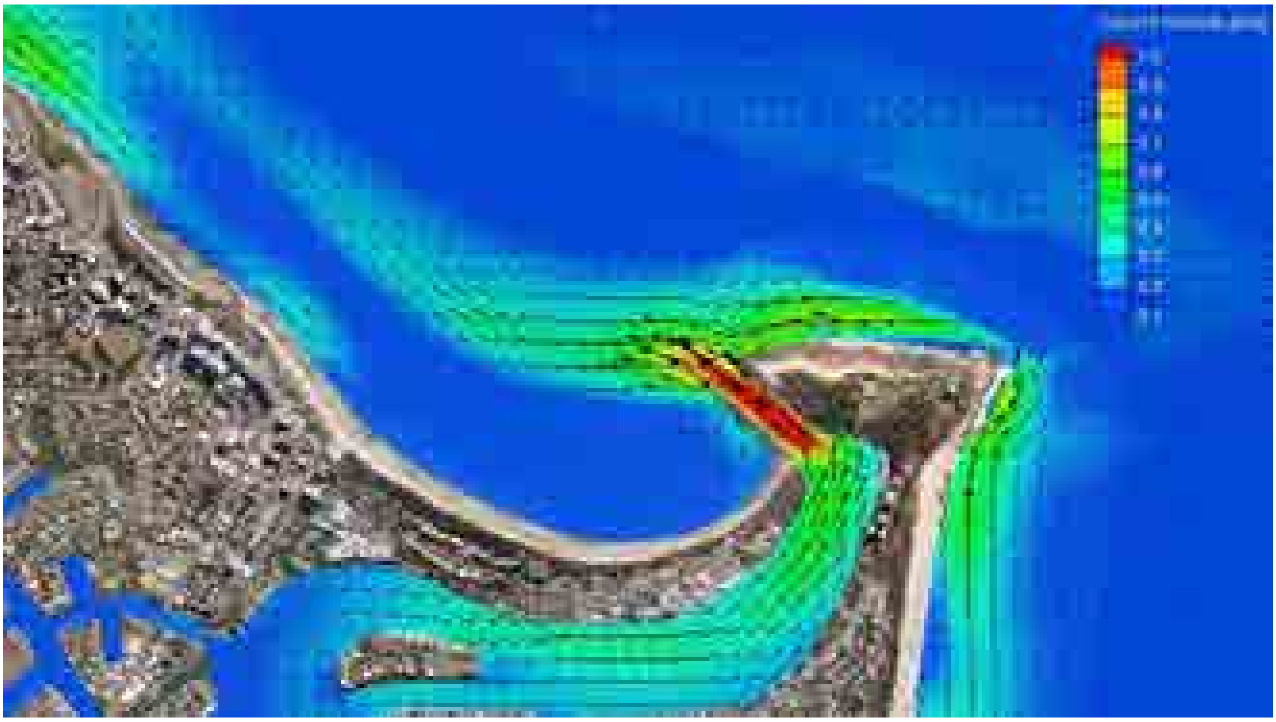


Figure 3-38   Peak Ebb Tide Currents with Wave Case 1: Hs = 3m, Tp = 12s, Dir = SE

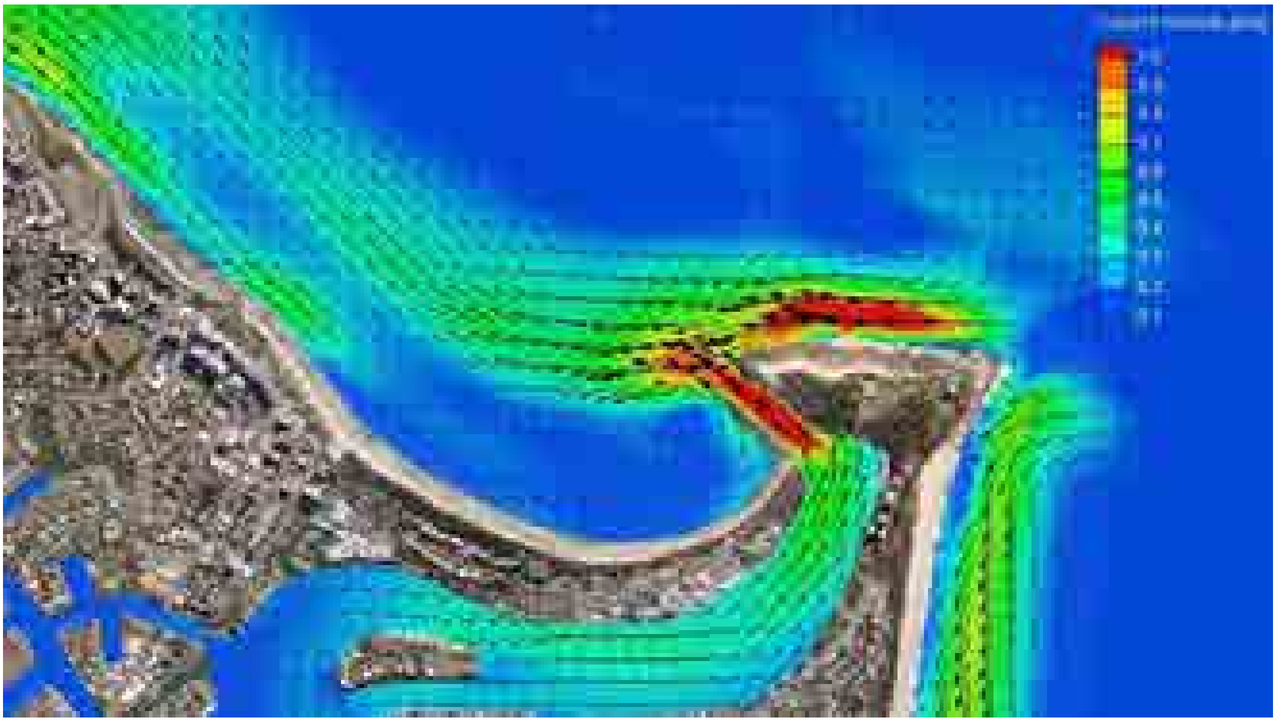


Figure 3-39 Peak Ebb Tide Currents with Wave Case 2: Hs = 3m, Tp = 12s, Dir = E

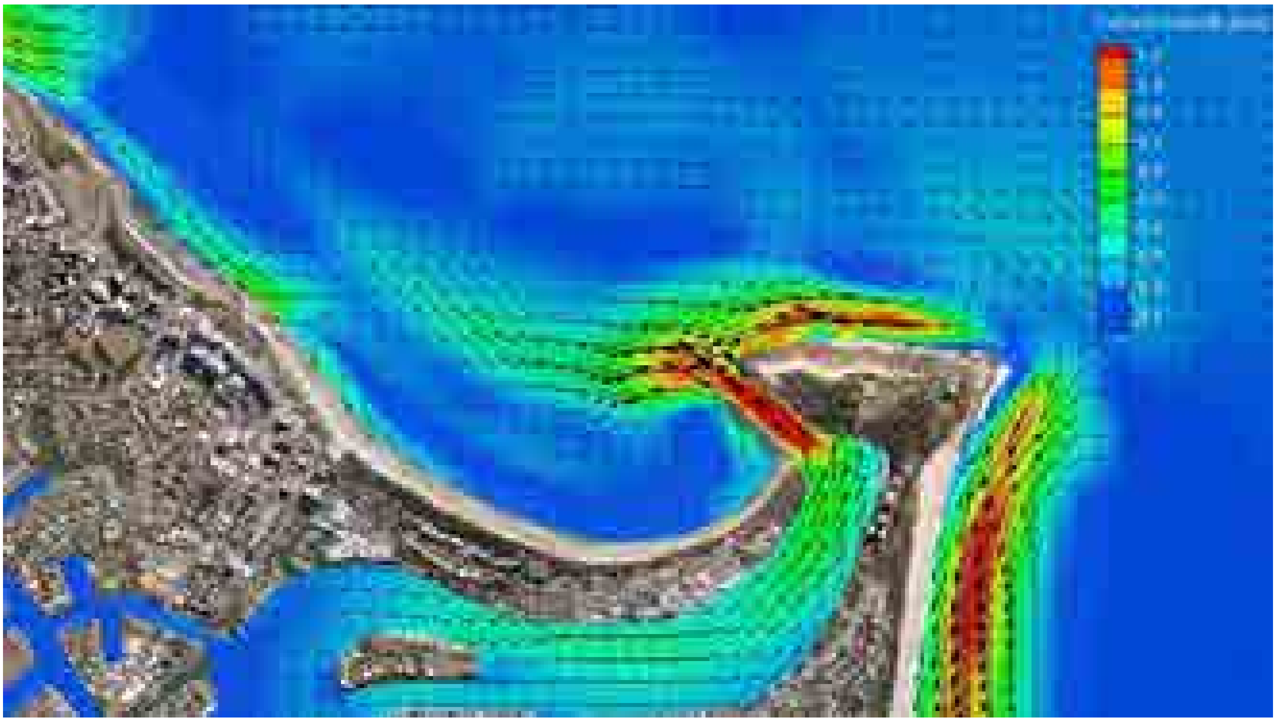


Figure 3-40 Peak Ebb Tide Currents with Wave Case 3: Hs = 3m, Tp = 12s, Dir = NE

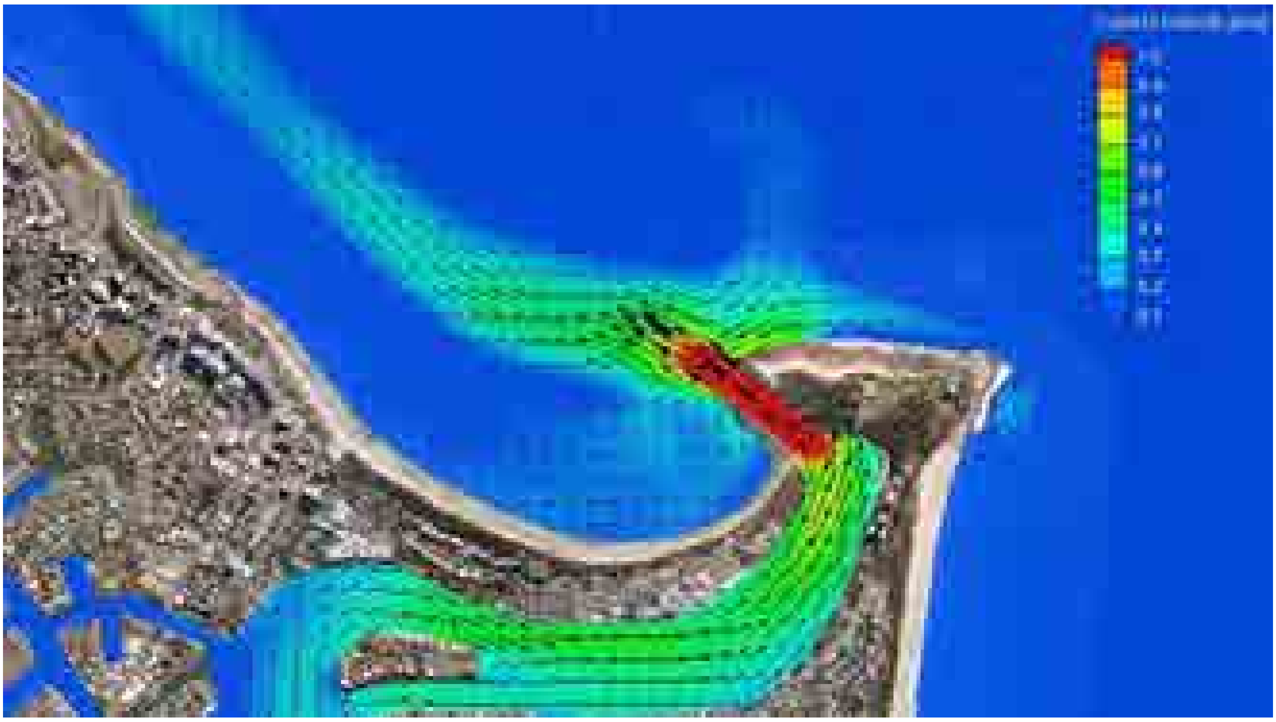


Figure 3-41 Peak Ebb Tide Currents with 2 year ARI Flood Event

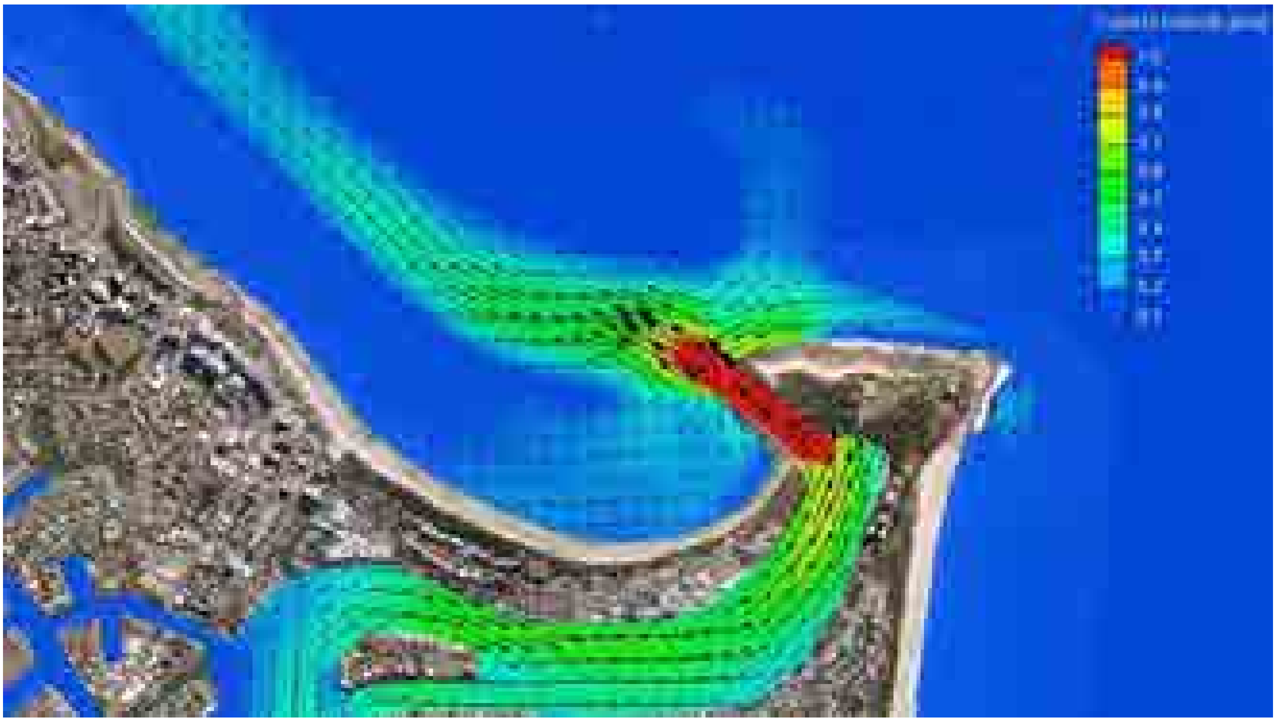


Figure 3-42 Peak Ebb Tide Currents with 10 year ARI Flood Event

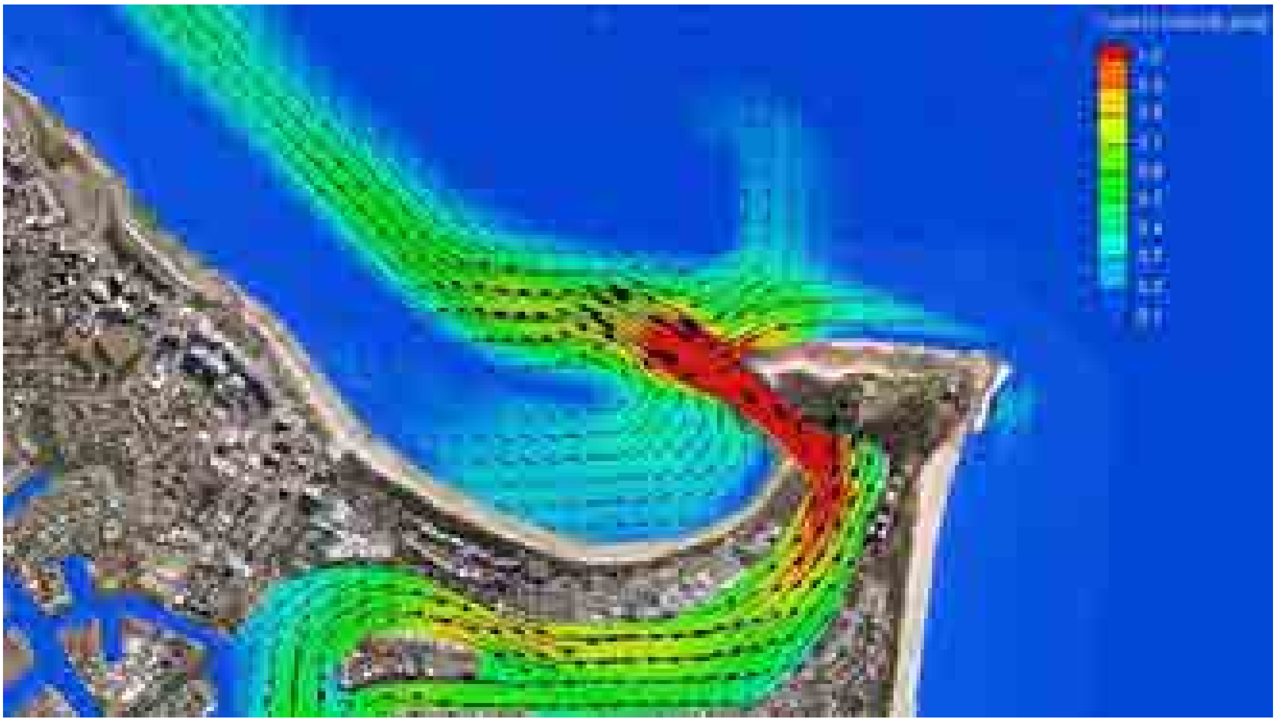


Figure 3-43 Peak Ebb Tide Currents with 100 year ARI Flood Event

3.5.5 Sediment Transport

The sediment transport under combined current and wave conditions at Mooloolaba Bay has been modelled. The transport calculations were performed for a spring tide at the peak of the ebb and flood tide (refer to Figure 3-27) and the wave cases described in Section 3.3. As such, the calculated sediment transport rates are representing peak sediment transport potentials within the Bay.

The bed load and suspended load sediment transport under combined current and wave conditions were calculated using Van Rijn’s TRANSPOR formulations (Van Rijn, 2007a and b). Van Rijn’s model was integrated with the SWAN wave and TUFLOW-FV hydrodynamic models to obtain the depth-integrated sediment transport capacity. The results for the "tide only" and "tide with wave cases" were statistically analysed. The 50% exceedance, or median, sediment transport rate for each case is presented in Figure 3-44 through Figure 3-47. Sediment transport rates less than 0.05 kg/s/m have not been plotted.

Figure 3-44 shows the sediment transport is restricted to the Mooloolah River entrance under tidal currents only. The sediment transport within Mooloolaba Bay and at Point Cartwright is extremely low (median transport is less than 0.05 kg/s/m).

Figure 3-45 shows the median sediment transport for the spring tide period with a south-easterly swell. Under this scenario, transport is predicted at Point Cartwright and inside the Mooloolah River training walls. Moderate, prevailing south-easterly swell conditions are likely to lead to a stockpile of sand off Point Cartwright. The south-easterly wave driven currents drive little transport within Mooloolaba Bay and starve the system of sand supply.

During easterly swell events, the currents are enhanced which in turn generate higher transport rates with diverging transport at Point Cartwright. Figure 3-46 shows high transport rates in the southerly direction toward Buddina Beach and along the exposed head of Point Cartwright. These conditions will promote any stockpiled sand to bypass Point Cartwright. Easterly (and north-easterly) swell events are likely to contribute to shoaling just seaward of Mooloolah River entrance. The shoal occurs as a bar which forms due to the interaction of sand input from the east with tidal flows from the river (Department of Harbours and Marine, 1987). Some sand is predicted to move beyond the river entrance with moderate longshore transport rates predicted at Mooloolaba Beach.

Mooloolaba Bay is more exposed to the north-easterly swell and therefore the highest transport rates are predicted under this condition. Figure 3-47 shows the median transport continuing across the river entrance. Transport rates along Mooloolaba Beach are enhanced. This condition will deliver sand to Mooloolaba Bay when a supply of stockpiled sand is available off Point Cartwright (as described above). When the sand supply is limited, significant beach erosion is likely to be associated with persistent north-easterly swell events.

Figure 3-44 Spring Tide Period Median Sediment Transport without Wave Forcing

Figure 3-45 Spring Tide Period Median Sediment Transport with Wave Case 1: Hs = 3m, Tp = 12s, Dir = SE

Figure 3-46 Spring Tide Period Median Sediment Transport with Wave Case 2: Hs = 3m, Tp = 12s, Dir = E

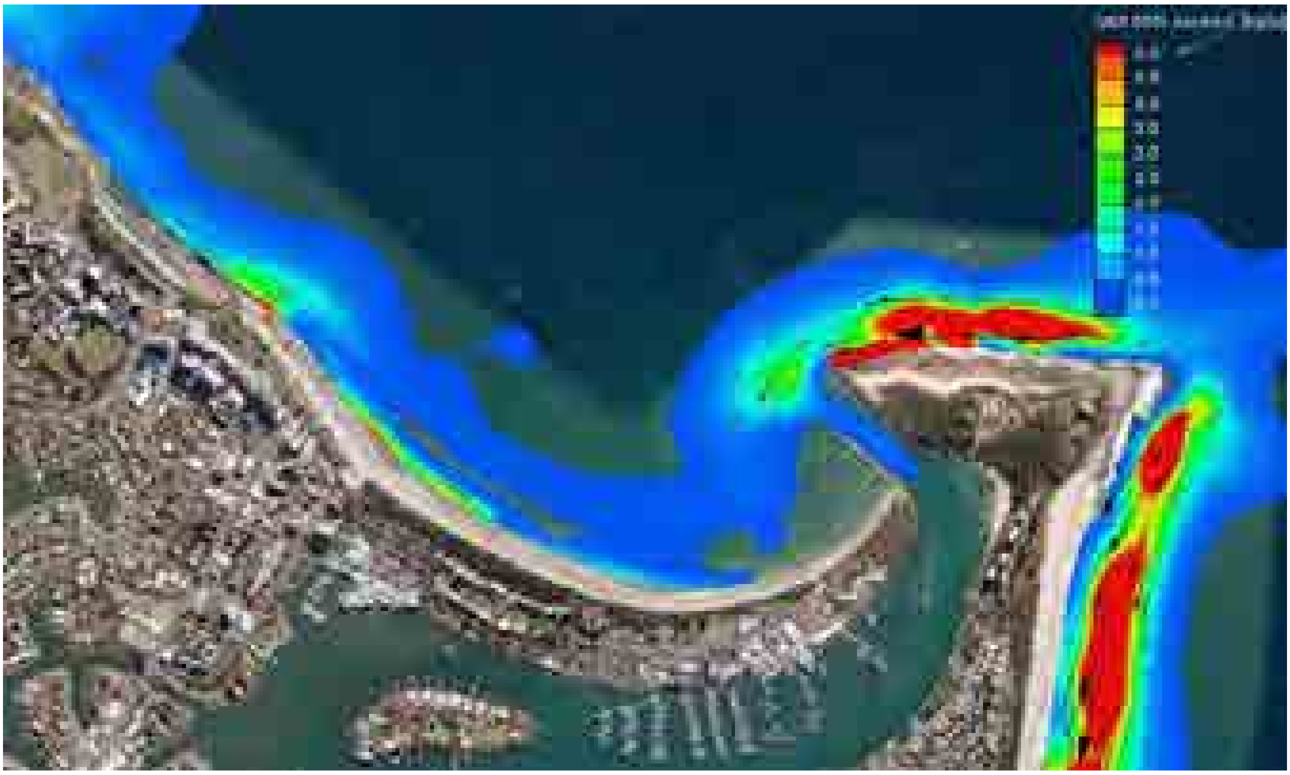


Figure 3-47 Spring Tide Period Median Sediment Transport with Wave Case 3: Hs = 3m, Tp = 12s, Dir = NE

4 PRESENT AND FUTURE SHORELINE EROSION

4.1 Coastal Processes and Erosion Mechanisms

4.1.1 Bells Creek to Lamerough Canal

The Bells Creek community (Pelican Waters) is built on low lying reclaimed land that was once dominated by mangrove habitat.

The shoreline between the Bells Creek boat ramp to just south of Joan Street is generally free of shoreline protection works and characterised by coastal vegetation and sandy beaches. Sediment transport rates in this area are low and the offshore shoal appears relatively stable. A low, unconsolidated rock revetment protects the foreshore area between Joan Street and Roy Street. This structure is deteriorating in some sections. Only a very narrow beach is exposed at low tide.

Beyond Roy Street to Lamerough Canal small beaches are present, partly controlled by the rock and geofabric sand containers used to protect stormwater drains and public boat ramps. A low seawall protects the foreshore facilities between the boat ramps and jetty.

4.1.2 Lamerough Canal to Nelson Street

This beach unit presents a diverse range of shoreline types including an unprotected section vulnerable to erosion, a section with natural storm erosion protection provided by mangrove habitat and a section with inappropriate materials being used in an attempt to limit shoreline erosion.

The Caloundra Power Boat Club is located north of the Lamerough Canal entrance. The Club has been built on low lying land bordered to the north by mangrove habitat. The shoreline at the Club is unprotected and experiencing erosion. An area offshore from the Club was first dredged in the early 1980s to provide an anchorage area. The ongoing maintenance dredge requirements of this area are uncertain.

A mangrove habitat extends for approximately 400m north of the Club. No terminal structures exist along this section with the wide buffer and mangrove vegetation providing suitable protection against shoreline erosion. The TS Onslow Naval Cadet Base is located to the north of the mangrove habitat. The land is leased from the Government and the shoreline is showing severe signs of erosion. An attempt to control the erosion using concrete blocks appears unsuccessful.

4.1.3 Nelson Street to Oxley Street

This beach unit is characterised by a sandy shoreline stabilised by a geofabric sand container groyne field that was established during 1999 and 2000 in response to erosion pressure caused by the migrating flood and ebb channels. At many locations the geofabric containers also provide scour protection to stormwater outfalls that form part of the local drainage infrastructure. The upper beach and foreshore area has been further stabilised by coastal vegetation which is providing a suitable buffer to storm erosion at most locations. The geofabric groynes have a limited lifespan and individual sand containers are replaced as required as part of a regular maintenance program.

4.1.4 Leach Park

Redevelopment of Leach Park is presently underway and forms part of the wider Golden Beach Foreshore Master Plan. Stage one works were completed in December 2010 and included an upgrade of the existing revetment seawall and formalisation of a sandbag groyne (degraded sandbags replaced by rock). The new rock groyne will help relieve the erosion pressure associated with channel migration. A stable beach is only likely to form at Leach Park if/when the main channel migrates offshore, as observed in historical photos of the area.

4.1.5 Bulcock Beach

The foreshore area within this beach unit has undergone considerable redevelopment since 2009. These works are ongoing with the lower picnic and terrace area adjacent to Ontrano Ave scheduled for completion in June/July 2011. In most areas the existing revetment has not been upgraded however, some new seawall and/or seawall realignment works have occurred south of the Ithaca Caloundra City Life Saving Club.

The rocky outcrop at Deepwater Point provides some control and helps to maintain Bulcock Beach. Historically, Bulcock Beach has been observed to widen and extend to the east when the channel entrance migrates toward the south. The amount of sand across the Bulcock Beach tidal flats is expected to be dynamically linked to the movement of Caloundra Bar.

4.1.6 Kings Beach

Kings Beach is sheltered from the prevailing wave climate by Moreton Island and wave refraction across the shallow banks at Caloundra Bar further reduces the wave energy reaching the nearshore area. The shoreline is aligned south-east and extends for 500m between a small groyne at the southern extent (built in the 1960s) and the southern facing rock face of Caloundra Headland. The groyne acts to interrupt the southerly directed longshore sediment transport.

Historically, beach scraping and re-profiling (the transfer of sand from the lower to upper beach) has been applied to maintain the upper beach and dune system in front of the seawall. This regular, ongoing maintenance controls the immediate erosion threat to public assets and enhances the recreational value of the beach. Furthermore, this helps to limit the amount of sand bypassing the groyne in the southerly directed longshore transport.

4.1.7 Shelly Beach

Shelly Beach is small pocket beach aligned north-south and extending for approximately 1km between Caloundra and Moffat Headlands. The rocky outcrops provide control points and stability to the beach. Shelly Beach is noticeably steeper and the sand is coarser (also containing more shell grit) than other beaches in the study area. The mixed beach material is likely to be locally derived from the nearshore zone with only a low supply from adjacent beaches.

Development along Shelly beach is protected by a narrow vegetated dune system. The width of the dune buffer is less than 20m at the central section where a stormwater flow path intersects the beach. Historically, the stormwater runoff has moved laterally along the shoreline and cut through the frontal dune before discharging to the sea. This flow path has severely impacted the dune system however it was noted during a site visit in February 2011 that the stormwater runoff was taking a more direct path to sea.

4.1.8 Moffat and Dicky Beach

Caloundra Headland provides Moffat and Dicky Beach with sheltering from south-easterly swell events. Natural controls provided by rocky outcrops suggest these beaches are subject to localised coastal processes, with Moffat beach somewhat removed from the general longshore and transport affecting beaches to the north. Net transport at these beaches is expected to be weakly northwards, with littoral sand supply limited to transport around the headland from Shelly Beach. An extensive offshore reef suggests onshore sediment supply is also low. Existing development along these beaches is vulnerable to storm erosion.

During 2008, in response to erosion problems at Moffat Beach, Council upgraded the 230m rock seawall between Caloundra Headland and the boat ramp south of Tooway Creek. Following Tropical Cyclone Hamish in 2009, severe beach erosion to the north of Tooway Creek led to the construction of a rock revetment wall (emergency works) to protect private property. The area to the immediate north of the rock revetment also shows signs of erosion pressure.

4.1.9 Currimundi to Buddina

Modelling of longshore sediment transport processes at Currimundi suggests a northern sand transport potential of 3,700m^3 per year. Moving north toward Buddina, the potential for sediment transport gradually increases due to a slight change in the alignment of the coastline and a greater exposure to the prevailing south-easterly swell. The progressive increase in longshore transport potential would be expected to cause shoreline retreat however the relative stability of the shoreline suggests that any erosive processes are balanced by a supply of sediment.

Recent beach profile surveys along this section (GHD, 2010) indicate that the current location of the beach is within the range of movement measured by the BPA between 1973 and 1993. The historical surveys typically show a stable main hind dune. Seaward of the hind dune the profiles display considerable variation and indicate the beach response to the prevailing wave climate. The most eroded profiles can be attributed to periods of high wave energy associated with tropical cyclone activity (e.g. 1974). The beach is observed to recover and accrete following periods of relatively low wave energy. Based on the available historical data and recent surveys, GHD (2010) concluded that the beach is stable in the medium term (25 years) and dynamically stable in the short term.

4.1.10 Buddina to Point Cartwright

The shoreline from Buddina to Point Cartwright is orientated in roughly a north/south direction and represents one of the more exposed sections of coastlines on the Sunshine Coast. The shoreline is exposed to waves from all directions, north through to south, though Moreton Island provides some sheltering from large southerly swells. Beach profiles within section were re-surveyed by GHD (2010) and the comparison with historical profiles suggests a relatively stable beach in the medium term (25 years).

Because of its exposure and orientation, this section of shoreline predominantly experiences larger waves than the beaches to the south and immediate north (Mooloolaba Bay). As a result, the gross sand transport rate along this section is greater with periods of both northerly and southerly transport. No long-term erosion is evident, and therefore any sand losses associated with the predicted longshore sand transport differentials along this beach are potentially balanced by an offshore supply of sand.

4.1.11 Mooloolaba Bay

Modelling of longshore sediment transport processes indicate there is a net sand movement along the coast of the Mooloolaba Bay system towards the north. The natural sand supply to Mooloolaba Bay is transported around Point Cartwright from Buddina Beach. The calculated average rate of the incoming longshore sand transport is approximately 5,600m^3 per year. The calculated rate of the average outgoing longshore transport (at the northern end of the beach) is similar and approximately 6,100m^3 per year. This indicates only a weakly erosive pattern and that there is no significant loss of sand due to longshore processes.

Sand from Buddina Beach will only travel around Point Cartwright when significant quantities of sand accumulate at the northern end of Buddina Beach and favourable wave conditions occur. In general terms, the mechanisms that deliver sand to Mooloolaba Beach are as follows:

- Longshore transport from Buddina Beach moves sand to a deposition area immediately north of Point Cartwright.
- When significant quantities of sand build up at the northern end of Buddina Beach and favourable wave conditions occur, waves and currents move the stored sand along the rocky north shore of Point Cartwright to the river entrance where the capacity to move the sand is reduced and deposition occurs near the training walls.
- Over time most of the sand reaching the river entrance area drifts past the entrance into Mooloolaba Bay under prevailing current and wave action. However, some sand which enters the river entrance is diverted into the harbour under tidal conditions and become deposited on the flood tide delta sand bar within the boat harbour. Based on (BMT WBM, 2010), the average volume of marine sand that becomes deposited within the boat harbour is estimated to be around 2,500m^3 per year. At times of strong and persistent sand transport to the entrance, significant bar formation occurs, which may affect vessels entering the harbour.
- Sand that naturally drifts past the entrance disperses slowly onshore to the active beach system of Mooloolaba Beach where it becomes subject to a net drift towards the north along the beach.

With respect to the sand deposition within Mooloolah River entrance, it is noted that episodic dredging of flood delta sand bar is undertaken by Queensland Department of Transport and Main Roads to maintain a navigable harbour entrance. The sand removed has typically been placed near the western side of the western training wall or used as sand for beach nourishment at various locations along Mooloolaba Beach. Council has recently installed a buried pipeline to redistribute the sand that is periodically dredged from the entrance.

Both nearshore and onshore dredge disposal locations are successful in returning sand to the active beach system. As such, the boat harbour is not considered to be a sediment sink and contributing to the long term loss of sand supply to the Mooloolaba Bay beach system. However, the ebb tide flow exiting the river is likely be stronger compared to the pre-development ebb flow. This may be transporting sand north at a higher rate than occurred naturally and therefore change the timing at which the sand is delivered to Mooloolaba Beach.

Historical aerial photography suggests no long-term trends of recession at Mooloolaba Bay. There is no clear evidence that the coastal system has experienced a persistent loss of sand, however periods of erosion and recovery can be identified. As such, the shoreline of Mooloolaba Bay is considered to be dynamically stable.

4.1.12 Alexandra Headland to Maroochy River

Generally this area is more exposed to open ocean conditions than the beaches to the south within Mooloolaba Bay, though less exposed than Buddina, during southerly swell events due to sheltering from Moreton Island and Point Cartwright. The nearshore zone is steeper than that at Mooloolaba, but milder than beaches fully exposed to the open ocean. Coffee rock is frequently exposed along this section and may be evident of a slowly receding shoreline (e.g. Jones, 1992).

A narrow beach is located between Alexandra Headland, the road and the Alexandra Headland Surf Club. At the southern extent of this section the road alignment is close to the beach and a retaining wall has been built to prevent infrastructure loss due to erosion.

The Alexandra Headland Surf Club is located behind coffee rock. A significant retaining wall exists in front of the Surf Club and the foreshore picnic and recreational facilities.

There is a relatively narrow vegetated buffer between the road and the beach south of the Surf Club. The western part of this buffer zone is grassed with a pedestrian/bike track. Seaward of the path, natural vegetation exists. Coffee rock is present in the beach face for most of the time and can limit beach access when erosion occurs.

Adjacent to Sea Breeze Caravan Park (where Alexandra Parade becomes Aerodrome Road) there is approximately 20 metres of natural buffer between the boundary of the Caravan Park and the beach, and coffee rock is often exposed in the beach face. Moving north, this buffer zone increases in width to 40 metres prior to reaching Maroochydore Surf Club. The beach in front of the Surf Club is generally sandy, however, during erosive periods coffee rock is exposed. Figure 4-1 shows an historical photo with extensive erosion and sandbagging in front of the Maroochydore Surf Club.

Figure 4-1 Erosion and Sandbagging: Maroochy Surf Club

The Maroochy River entrance is north of the Maroochydore Surf Club and is presently (2010) located between the Pincushion Caravan Park and Pincushion Island. Four geotextile groynes and a seawall have been built in this area since 2001 to protect the existing infrastructure and maintain beach amenity.

Prior to 1999, the beach was connected to Pincushion Island and the river entrance was located north of Pincushion Island. At that time a significant buffer existed between the beach and the Caravan Park. As part of the process of the entrance relocating to the south of Pincushion Island, a large quantity of sand, which was the beach and dune connecting to Pincushion Island, moved into the entrance. This caused substantial shoaling in the lower part of the estuary, downstream of Goat and Channel Islands.

4.1.13 Maroochy River Entrance to Mudjimba

This area is again more exposed to open ocean conditions than the Mooloolaba Bay and Alexandra Headland to Maroochy River beach unit. The nearshore zone is typically steeper than at Maroochydore.

Pincushion Island is currently connected to the beach to the north by a wide sand spit. During high tide a small portion of the sand spit is inundated allowing minor flows to the north of the island (observed during 2010).

North of the sand spit, a significant naturally vegetated buffer exists between the North Shore Road and the beach up to and north of the village of Mudjimba. The beach in this area has a reasonably stable alignment because of the sheltering effect of Mudjimba Island, with isolated patches of coffee rock often exposed in the beach face.

4.1.14 Mudjimba to Point Arkwright

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

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

4.1.15 Coolum to Sunshine Beach

Point Arkwright provides Coolum Beach with some sheltering from south-easterly swell. The Coolum Beach Surf Life Saving Club has no vegetation or dune buffer and is protected by a low seawall. The Surf Club is also protected by a wide beach and rocky outcrop and does not appear vulnerable to erosion.

Further north, the beaches are more exposed and experience larger waves with the northerly sand transport rates estimated to reach up to 25,000m^3 per year. A well established dune and vegetation buffer allow the beach to respond naturally to erosion events. At present, the erosion threat to development is considered low.

4.2 Climate Change Impacts

Climate change research indicates that two fundamental impacts may affect the shoreline, namely:

- Changes to storm occurrences and storm winds together with their effects on storm surges; and
- Sea level rise.

The simple tool used for climate change vulnerability assessment developed by BMT WBM (Fisk and Kay, 2010) is presented in the Legislation and Generic Shoreline Management Options report. Climate change assumptions, in particular sea level rise projections, adopted for the purpose of coastal processes assessment are described below.

4.2.1 Future Sea Level Rise

Since 1900, global-average temperatures have increased by about 0.7°C and the global-average sea-level has risen at a rate of 1.7mm/year (Church and White, 2006). Due to anthropogenic greenhouse gas emissions the rates of both temperature increase and Sea Level Rise (SLR) are likely to be presently increasing and are expected to further accelerate in the future (IPCC, 2001; IPCC, 2007).

There are uncertainties as to the actual magnitude and rate of future sea level rise. This has lead to various scenarios being adopted by the Intergovernmental Panel on Climate Change (IPCC), based on the range of model results available and dependent upon the amount of future emissions assumed.

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) reports that global sea level rise is projected to be 18–59 cm by year 2100 relative to 1990 levels. These projections do not include a contribution from ice flow rates, however if these were to continue to grow linearly with global warming, then the upper ranges of sea level rise would increase by a further 10 to 20 cm (by year 2100 relative to 1990) (IPCC, 2007). There is an acknowledged risk that the contribution of ice sheets to sea level rise this century may be substantially higher than this.

The climate models predict that there will be some regional variation in future sea level rise, predominantly due to spatial variations in the contribution made by ocean thermal expansion. Predictions reported by the CSIRO (2007) indicate that future sea level rise along the eastern Australian coastline may be up to 7 cm greater than the global average due to the greater efficiency in South Pacific Ocean currents (such as the East Australian Current) to disperse thermal energy.

In summary the total mean sea level rise along the eastern Australian coastline is estimated to be in the range 28–86 cm to the year 2100. This will occur gradually at first as we continue to accelerate from the historic rate of 1.7 mm per year and then more rapidly as the year 2100 is approached.

The Queensland Coastal Plan (2011) has adopted a sea level rise projection of 0.8m by 2100 (relative to the1990 mean sea level). This value is based on the upper range of projections published by the IPCC (2007) and may be revised following the release of future IPCC reports.

4.2.2 Changes to Storm Occurrences

There is uncertainty regarding changes to prevailing winds or extreme storm behaviour associated with climate change, although it is likely that cyclones would extend further south under warmer sea temperatures. The effect of changed storm occurrences on storm surges has been investigated by James Cook University as part of the Oceans Hazard Assessment Stage 3 Report (JCU, 2004).

The JCU study assessed the likely impact of a 10% increase in cyclone intensity and frequency including a poleward shift in cyclone track by 1.3 degrees. The predictions by JCU indicate that these potential changes to cyclone intensity, frequency and path may increase the 1% AEP storm tide levels in the study area by 0.30m. This would be in addition to mean sea level rise.

Changes in storm conditions and sea level rise may impact on the severity of storm erosion due to more intense or more frequent storms or long term changes in wind directions may cause a re-alignment of the shoreline resulting in accretion at one end of the beach and erosion at the other. A recent report summarising existing theory and high-resolution dynamical climate model output indicates that greenhouse warming will cause the globally averaged intensity of tropical cyclones to increase by 2-11% by 2100. These studies also project decreases in the globally averaged frequency of tropical cyclones by 6-34% (Knutson et al., 2010).

With regard to beach erosion it is expected that future sea level rise and any change in wind climate (speed and direction) or storminess will exacerbate the existing problem.

4.2.3 Beach Profile Response due to Climate Change

Both mean sea level rise and intensification of the storm occurrences are likely to have an impact on the maintenance requirements of Sunshine Coast shoreline. For the development of this study, as a minimum, recognition is therefore required that this may affect the shoreline and any shoreline management action will need to cater for these potential changes.

As water levels change, the beach profile will respond toward a new equilibrium, which causes a redistribution of sand over the active beach profile with erosion of the foreshore and deposition of sand offshore. With mean sea level rise likely to accelerate due to climate change, the shoreline erosion is likely to increase in the future.

In addition to shoreline erosion due to beach profile alterations, increased sea level rise has also the potential to affect the longshore sediment supply to beaches in the study area as the various headlands to the south of the study area will tend to interrupt the longshore sand transport more on a receding shoreline.

5 ASSESSMENT OF COASTAL EROSION RISK

5.1 Introduction

The coastal erosion risks within the study area arise from a combination of:

- The physical processes that are causing or leading to the erosion;
- The assets potentially affected by the erosion; and
- The timeframe over which the threat may act upon the asset.

In order to assess the erosion risks for the open coast beaches within the study area (north of Caloundra Headland), it is necessary to understand which areas are presently subject to coastal erosion threats and which areas may become subject to erosion threats in the future. Erosion is a naturally occurring process that is affected by a number of climatic factors. Therefore, potential effects of climate change will need to be considered in such assessment.

To effectively assess the coastal erosion risks, an erosion vulnerability zone is to be determined for a number of planning horizons. The erosion vulnerability zone should include the following components, consistent with the Queensland Coastal Plan (2011):

- Short term storm erosion buffer;
- Continuation of the past and present shoreline recession trend, if there is one;
- Additional future effects of climate change; and
- Any factors that related to the suitable location of buildings on the dune crest.

5.2 Basic Considerations

Erosion prone area widths are determined to cater for potential erosion of the dune system over a specified planning period. Both short term (storm related) and longer term (gradual) trends are included in the assessment together with an allowance for potential sea level rise associated with the Greenhouse Effect. Provision is also to be included for a factor of safety on the estimates and an allowance made for slumping of the dune scarp following erosion. The following relationship was used by the BPA for determination of the erosion prone area widths. This formula continues to be recognised by DEHP as a reasonable method of assessing shoreline recession risk.

$$E = [(NR) + C + G] \times (1 + F) + D \qquad \text{Equation 2}$$

Where E = Erosion Prone Area Width (metres)

N = Planning Period (years)

R = Rate of Long-term Erosion (metres/year)

C = Short-term Erosion from the design cyclone (metres)

G = Erosion due to Greenhouse Effect (metres)

F = Factor of Safety

D = Dune Scarp Component

The various components in the above relationship are determined on the basis of the characteristics of the individual beaches together with presently accepted practices as discussed in the following sections below.

It should be noted that Equation 2 provides a conservative value of the individual components used to assess the erosion potential and involves a safety factor. The calculated erosion widths are therefore expected to be at the upper limit of the erosion that may occur during the planning period. It is most likely that these erosion widths will not be realised within the planning period but serve as a reasonable yardstick to assess shoreline risk.

At this stage it has been considered that the coffee rock (indurated sand) that becomes exposed on beaches in Maroochy Shire during storms will not resist erosion in the long term. This is based on limited testing that suggests the cohesiveness of the coffee rock breaks down after extended exposure to the elements. The assessment has been undertaken across a wide study area and local features that may resist shoreline erosion (such as dense vegetation, rocky headlands and/or manmade structures) have not been considered.

5.2.1 Planning Period (N)

The duration of the planning period influences the erosion prone area width calculations by affecting:

- The total extent of gradual long-term erosion;
- The extent of possible sea level rise due to the Greenhouse Effect; and
- The selection of design cyclone conditions which are based on an accepted risk level.

In accordance with current policies, a planning period of 50 years has been adopted.

5.2.2 Rate of Long Term Erosion (R)

The rate of long term erosion can be estimated by extrapolating past trends (through analysis of historical survey data) and/or determining any deficit in the local sediment budget (typically via longshore sediment transport modelling). Consideration is also given to local features and/or characteristics that may indicate long-term erosion over geological timescales (e.g. exposed coffee rock).

Beach profile surveys carried out by the BPA between 1973 and 1993 have been analysed (refer Appendix A and Appendix B) and there is no strong indication of shoreline recession during this period. However, it should be noted that this is a relatively short period of record and it begins at a time when the beaches were known to be recovering from severe cyclonic erosion in the early 1970's. The exposure of coffee rock at many locations is considered anecdotal evidence of a receding shoreline on geological timescales.

For this study the rate of long term erosion has been estimated from the longshore sediment transport results described in Section 3.3. An estimate of the long term erosion rate was obtained by dividing the annual sediment loss per metre of shoreline (averaged over the study area and taken to be 0.55m^3/m/year, refer Table 3-12) by an estimate of the active profile height at each location. The active profile is defined as the vertical distance from the dune crest to the depth of the closure. The dune crest was obtained from the measured beach profile data and the depth of closure was estimated to be twice the 100yr ARI wave height for each location.

The annual rate of long-term erosion (R) and the long-term erosion for the 2030 and 2060 planning periods (N × R) are presented in Table 5-1. These results suggest the long term erosion rate is low with the 2060 long term erosion is less than 2m.

Table 5-1 Rate of Long-Term Erosion

Approximate Location	Initial Profile Location	Dune Crest Height (m)	Depth of Closure (m)	2030 Long Term Erosion (m)	2060 Long Term Erosion (m)
	ETA488	5.7	12.0	0.7	1.6
	ETA490	5.6	12.0	0.7	1.6
Currimundi	ETA492	10.3	12.0	0.5	1.3
	ETA494	7.4	12.0	0.6	1.5
	ETA496	12.0	12.0	0.5	1.2
	ETA498	9.0	11.6	0.6	1.4
Bokarina	ETA500	6.1	11.6	0.7	1.8
	ETA502	9.6	11.6	0.7	1.7
	ETA504	7.4	12.2	0.6	1.6
	ETA506	7.8	12.2	0.6	1.6
	ETA508	6.4	11.4	0.6	1.4
Buddina	ETA510	7.3	11.4	0.6	1.5
	ETA512	9.6	11.4	0.5	1.3
Point Cartwright	ETA514	16.2	11.8	0.6	1.5
Mooloolaba	ETA521.5	4.3	11.8	0.7	1.7
	ETA522	3.9	11.8	0.7	1.8
	ETA523	6.3	11.8	0.6	1.5
	ETA527	5.2	11.8	0.6	1.6
Alexandra Headland	ETA529.8	4.5	12.6	0.6	1.6
	ETA530	4.8	12.6	0.6	1.6
Maroochydore	ETA532	6.0	12.6	0.6	1.5
	ETA538	5.1	12.6	0.6	1.6
Mudjimba	ETA540	5.7	12.0	0.6	1.6
	ETA542	8.9	12.0	0.5	1.3
	ETA544	6.3	12.0	0.6	1.5
	ETA546	6.5	12.0	0.6	1.5
	ETA548	7.2	12.0	0.6	1.4
	ETA550	7.5	12.0	0.6	1.4
	ETA554	9.1	12.0	0.5	1.3
Mt Coolum	ETA558	8.8	12.2	0.5	1.3
	ETA562	12.8	12.2	0.4	1.1
Point Arkwright	ETA564	12.8	12.2	0.4	1.1
	ETA566	12.8	12.2	0.4	1.1
Coolum	ETA568	6.7	12.2	0.6	1.5
	ETA570	7.4	12.2	0.6	1.4
	ETA574	7.5	11.8	0.6	1.4
	ETA578	6.7	11.8	0.6	1.5
Peregian	ETA582	6.3	11.8	0.6	1.5
Sunshine	NA	4.4	12.4	0.7	1.6

5.2.3 Short-term Erosion (C)

Short-term erosion of the upper beach and dune can occur from time to time, associated with tropical cyclone or severe storm events. Such events usually involve co-existing storm surges and high waves.

Storm erosion involves the movement of sand from the upper beach and dune in the offshore direction. This sand would be returned gradually to the upper beach by wave and wind action over a relatively longer period of time. In cases where the dune is low and overtopped, sand may also be carried landwards.

Where appropriate, the erosion distance can be calculated on the basis that a characterised equilibrium beach profile is developed during the storm-induced extreme water level and wave conditions and that this profile provides a volume balance between the material eroded from the upper beach/dune and that deposited on the lower zone of the beach slope. The empirical method described by Vellinga (1983) has been used for this assessment and is described in Section 3.4. The potential storm erosion width at numerous locations within the study area is listed in Table 3-13 and the estimated storm profiles for all locations are presented in Appendix H.

5.2.4 Erosion Due to Greenhouse Effect (G)

Provision is required for coastal recession associated with an expected sea level rise due to the Greenhouse Effect. At the time of writing, the Sunshine Coast Regional Council had adopted a sea level rise value of 0.7m by 2070 and 1.1m by 2100. For this assessment, sea level rise values of 0.2m by 2030 and 0.5m by 2060 have been applied.

In assessing the coastal recession associated with an increase in mean sea level, consideration has been given to the geography of the area, existing beach profiles and sediment characteristics. It is considered that beach ridges are likely to be predominantly wave formed with the coarser particles being moved onshore to the upper beach face/dune and the finer particles remaining in the nearshore zone. This could result in beach profiles with two distinct slopes; a steep upper beach face with coarse sand and a flat nearshore zone with fine sand.

The standard method of Per Bruun (Bruun, 1962) has been used to predict the beach response to sea level rise:

$$G = -S\frac{W}{d_c + B} \qquad \text{Equation 3}$$

Where G = Erosion due to sea level rise

S = Sea level rise projection

W = Width of the beach profile

d_c = Depth of closure

B = Dune height

An initial beach profile and design wave height is typically used to estimate *W* and d_c. For this assessment, a profile width of 900m has been adopted for all locations and the depth of closure is estimated to be twice the 100yr ARI wave height for each location (dune height and depth of closure estimates are provided in Table 5-1). The so-called "Bruun Rule" is based on the upper beach/dune sand eroding and depositing in the nearshore zone to maintain the same depths below mean sea level and is illustrated in Figure 5-1.

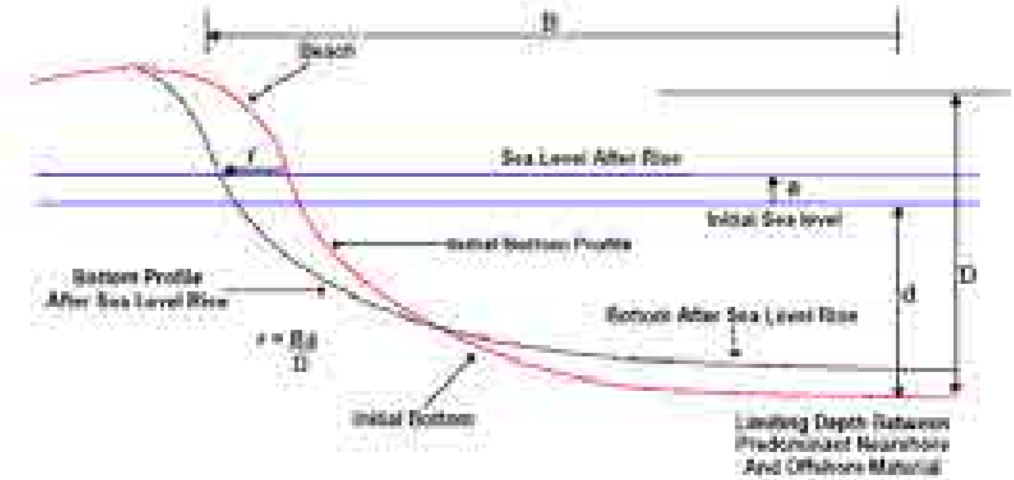


Figure 5-1 Bruun Rule for Shoreline Response to Rising Sea Level

The estimated shoreline recession associated with the adopted sea level rise projections for the 2030 and 2060 planning periods are presented in Table 5-2.

Table 5-2 Erosion due to Sea Level Rise

Location	Initial Profile Location	2030 Erosion due to Sea Level Rise (m)	2060 Erosion due to Sea Level Rise (m)
	ETA488	10.7	26.9
	ETA490	10.7	27.0
Currimundi	ETA492	8.4	21.1
	ETA494	9.7	24.4
	ETA496	7.8	19.6
	ETA498	9.1	22.8
Bokarina	ETA500	11.5	28.9
	ETA502	10.9	27.4
	ETA504	10.3	25.9
	ETA506	10.4	26.2
	ETA508	9.4	23.7
Buddina	ETA510	9.9	24.9
	ETA512	8.7	21.8
Point Cartwright	ETA514	9.8	24.7
Mooloolaba	ETA521.5	11.2	28.1
	ETA522	11.5	28.8
	ETA523	9.9	25.0
	ETA527	10.6	26.6
Alexandra Headland	ETA529.8	10.5	26.5
	ETA530	10.3	26.0
Maroochydore	ETA532	9.7	24.4
	ETA538	10.2	25.6
Mudjimba	ETA540	10.2	25.6
	ETA542	8.6	21.7
	ETA544	9.8	24.7
	ETA546	9.8	24.5
	ETA548	9.4	23.6
	ETA550	9.2	23.2
	ETA554	8.5	21.5
Mt Coolum	ETA558	8.6	21.6
	ETA562	7.2	18.1
Point Arkwright	ETA564	7.2	18.1
	ETA566	7.2	18.1
Coolum	ETA568	9.5	24.0
	ETA570	9.2	23.1
	ETA574	9.3	23.5
	ETA578	9.7	24.5
Peregian	ETA582	9.9	25.0
Sunshine	NA	10.7	27.0

5.2.5 Factor of Safety (F)

A factor of safety is included in the assessments of the short-term, long-term and Greenhouse Effect erosion components to provide for uncertainties and error margins in the calculation procedures. DERM recommend a 40% factor of safety however considering the relatively detailed assessment of coastal processes in this study, and other conservative assumptions (including sea level rise projections), the factor of safety has been reduced to 20%.

5.2.6 Dune Scarp Component (D)

The erosion prone areas are specified as measured from the toe of the frontal dune. The short and long-term erosion components provide a measure of the recession of the dune toe. The dune scarp component provides for the horizontal distance between the toe and the crest after slumping to a pre-determined stable slope (stability threshold slope of 1:3 has been assumed).

For the 2030 and 2060 planning horizons the horizontal erosion due to dune slumping is typically between 10m and 20m and is presented in Table 5-3. Note that at some locations the dune scarp component may be over-estimated due to the presence of natural rock or terminal structure.

Table 5-3 Erosion due to Dune Slumping

Location	Initial Profile Location	2030 Erosion due to Dune Slumping (m)	2060 Erosion due to Dune Slumping (m)
	ETA488	11.4	12.3
	ETA490	11.3	12.2
Currimundi	ETA492	25.4	26.3
	ETA494	16.6	17.5
	ETA496	30.4	31.3
	ETA498	21.3	22.2
Bokarina	ETA500	8.6	9.5
	ETA502	11.3	12.2
	ETA504	12.8	13.7
	ETA506	12.2	13.1
	ETA508	19.4	20.3
Buddina	ETA510	14.5	15.4
	ETA512	22.3	23.2
Point Cartwright	ETA514	13.9	14.8
Mooloolaba	ETA521.5	7.8	8.7
	ETA522	6.4	7.3
	ETA523	13.7	14.6
	ETA527	9.7	10.6
Alexandra Headland	ETA529.8	7.6	8.5
	ETA530	8.5	9.4
Maroochydore	ETA532	12.1	13.0
	ETA538	9.4	10.3
Mudjimba	ETA540	11.2	12.1
	ETA542	20.8	21.7
	ETA544	13.1	14.0
	ETA546	13.4	14.3
	ETA548	15.6	16.5
	ETA550	16.6	17.5
	ETA554	21.4	22.3
Mt Coolum	ETA558	20.3	21.2
	ETA562	32.5	33.4
Point Arkwright	ETA564	32.5	33.4
	ETA566	32.5	33.4
Coolum	ETA568	14.1	15.0
	ETA570	16.3	17.2
	ETA574	16.1	17.0
	ETA578	13.8	14.7
Peregian	ETA582	12.6	13.5
Sunshine	NA	6.8	7.7

5.3 Summary of Calculated Erosion Prone Area Widths

The erosion prone area width has been calculated following the methodology described in Section 5.2 for locations where sufficient data is available. The calculated widths for the 2030 and 2060 planning horizons are presented in Table 5-4. The widths have been measured landward of the frontal dune position defined using 2009 aerial photography.

Table 5-4 Calculated Erosion Prone Area Widths

Location	Initial Profile Location	2030 Planning Horizon (m)	2060 Planning Horizon (m)
	ETA488	85	107
	ETA490	80	101
Currimundi	ETA492	70	87
	ETA494	61	81
	ETA496	57	73
	ETA498	97	115
Bokarina	ETA500	70	93
	ETA502	67	89
	ETA504	64	85
	ETA506	73	94
	ETA508	85	104
Buddina	ETA510	76	96
	ETA512.9	78	95
Point Cartwright	ETA516	88	108
Mooloolaba	ETA521.5	51	73
	ETA522	63	86
	ETA523	46	66
	ETA527	62	83
Alexandra Headland	ETA529.8	93	114
	ETA530	109	129
Maroochydore	ETA532	84	103
	ETA538	76	96
Mudjimba	ETA540	72	93
	ETA542	83	100
	ETA544	87	107
	ETA546	68	87
	ETA548	47	66
	ETA550	57	76
	ETA554	67	84
Mt Coolum	ETA558	76	94
	ETA562	94	108
Point Arkwright	ETA564	84	98
	ETA566	105	120
Coolum	ETA568	46	65
	ETA570	52	70
	ETA574	62	81
	ETA578	56	75
Peregian	ETA582	65	85
Sunshine	NA	64	86

6 REFERENCES

Allen, M. and Callaghan, J. (2001). Extreme Wave Conditions for the South Queensland Coastal Region, Environmental Technical Report 32, Queensland Environmental Protection Agency.

Aurecon (2009). Bribie Island Tidal Breakthrough Risk Assessment, prepared for Sunshine Coast Regional Council.

Aurecon (2010). Shoreline Erosion Management Plan Caloundra Bar to Bells Creek, prepared for Sunshine Coast Regional Council.

BMT WBM (2010). Long Term Dredging Strategy Mooloolaba Boat Harbour – Final Report, prepared for Department of Transport and Main Roads.

BMT WBM (2010). Maroochydore Beach Nourishment Feasibility Report, prepared for Sunshine Coast Regional Council.

Bruun, P. (1962). Sea Level Rise as a Cause of Shore Erosion, Journal Waterways and Harbours Division, 88(1-3), 117-130.

CERC (1984). Shore Protection Manual, Vol 2, Coastal Engineering Research Center, US Corps of Engineers, Department of the Army, Waterway Experiment Station.

Connell Wagner (2005). Maroochy Shire Storm Tide Study, prepared for Maroochy Shire Council.

Cowell P., Stive, M., Roy, P., Kaminsky, C., Buijsman, M., Thom, B. and Wright, L. (2001). Shoreface sand supply to beaches, Proceedings of the 27th International Conference on Coastal Engineering, Sydney, July 2000.

Cox, R. and Howe D. (2012). Tweed River Entrance and Bypass Sediment Dynamics, Proceedings of the 33th International Conference on Coastal Engineering, Santander, July 2012.

Department of Harbours and Marine (1987). Mooloolah River Entrance Shoaling.

Fisk, G. and Kay, R. (2010). Dealing with uncertainty in climate change adaptation planning and developing triggers for future action, Practical Responses to Climate Change Conference 2010, Melbourne, September 2010.

GHD (2010). Report for Beach Surveys and Data Assessment, Sunshine Coast Region, prepared for Sunshine Coast Regional Council.

Goodwin, I., Stables, M. and Olley, J. (2005). Wave Climate, Sand Budget and Shoreline Alinement Evolution of the Iluka-Woody Bay Sand Barrier, Northern NSW, Australia, Since 3000 Yr BP. Marine Geology, 226 (no. 1-2): 127-144.

Hallermeier, RJ (1981). A Profile Zonation for Seasonal Sand Beaches from Wave Climate. Coastal Engineering, Volume 4, 253-277

Hardy, T., Mason, L., Astorquia, A. and Harper, B. (2004). Tropical Cyclone Induced Water Levels and Waves: Hervey Bay and Sunshine Coast, Marine Modelling Unit James Cook University, prepared for Queensland Environmental Protection Agency.

IPCC (2001). The IPCC Third Assessment Report, Climate Change 2001, Intergovernmental Panel on Climate Change.

IPCC (2007). The IPCC Forth Assessment Report, Climate Change 2007, Intergovernmental Panel on Climate Change.

Jones, M.R. (1992). Quaternary Evolution of the Woorim-Point Cartwright Coastline, Volumes 1 & 2, Department of Minerals and Energy, Marine and Coastal Investigations Project Report MA49/2.

Knutson T. R., McBride J. L., Chan J., Emanuel K., Holland G., Landsea C., Held I., Kossin J. P., Srivastava A. K. and Sugi M. (2010). Tropical cyclones and climate change, Nature Geoscience, 3(3), 157-163.

Patterson, D.C. (2009). Modelling the Shoreline Impacts of Richmond River Training Walls, Proc 18th NSW Coastal Conference, Ballina, November 2009.

Masselink, G. and Hughes M. G. (2003). Introduction to Coastal Processes and Geomorphology, Oxford University Press, London, 354 pp.

Queensland Government (2012). Queensland coastal risk and bathymetric LiDAR: a pilot study for collecting near-shore bathymetry. Queensland Department of Science, Information Technology, Innovation and the Arts, Brisbane, Australia.

Riedel and Byrne (1979). Estuarine and tidal study proposed canal development Caloundra, Queensland, prepared for Cardno and Davies Pty Ltd.

Roy, P. (2001). Sand deposits on the NSW inner continental shelf. Geoscience Surveys report.

Sinclair Knight Merz (2002). Mooloolah River/Currimundi Creek Floodplain Flood Study and Stormwater Management Plan, prepared for Maroochy Shire Council.

Tomlinson, R., Williams, P., Richards, R., Weigand, A., Schlacher, T., Butterworth, V. and Graffet, N. (2010). Lake Currimundi dynamics study, Final Report, Griffith Centre for Coastal Management Research Report No. 75.

Van Rijn, L.C. (2007a). A unified view of sediment transport by current and waves, Part I: Suspended transport. Journal of Hydraulic Engineering, ASCE, vol. 133, no. 6, 649-667.

Van Rijn, L.C. (2007b). A unified view of sediment transport by current and waves, Part II: Initiation of motion, bed roughness and bed load transport. Journal of Hydraulic Engineering, ASCE, vol. 133, no. 6, 668-689.

Vellinga, P. (1983). Predictive computation model for beach and dune erosion during storm surges. Delft Hydraulics Laboratory, Publication No. 294.

WBM (1996). Erosion Prone Area - Mudjimba to Coolum, prepared for Maunsell Pty Ltd.

WBM (2002). Mooloolaba to Mudjimba Coastal Management Plan, prepared for Maroochy Shire Council.

WBM (2006). Mooloolah River Entrance Shoal Development Indicator, prepared for Department of Transport and Main Roads.

WBM (2007). Maroochy Shire Shoreline Erosion Management Plan, prepared for Maroochy Shire Council.

Willmott, W. (2007). Rock and Landscapes of the Sunshine Coast, Revised second edition, Geological Society of Australia, Queensland Division, Brisbane.

APPENDIX A: COPE BEACH PROFILE SURVEYS

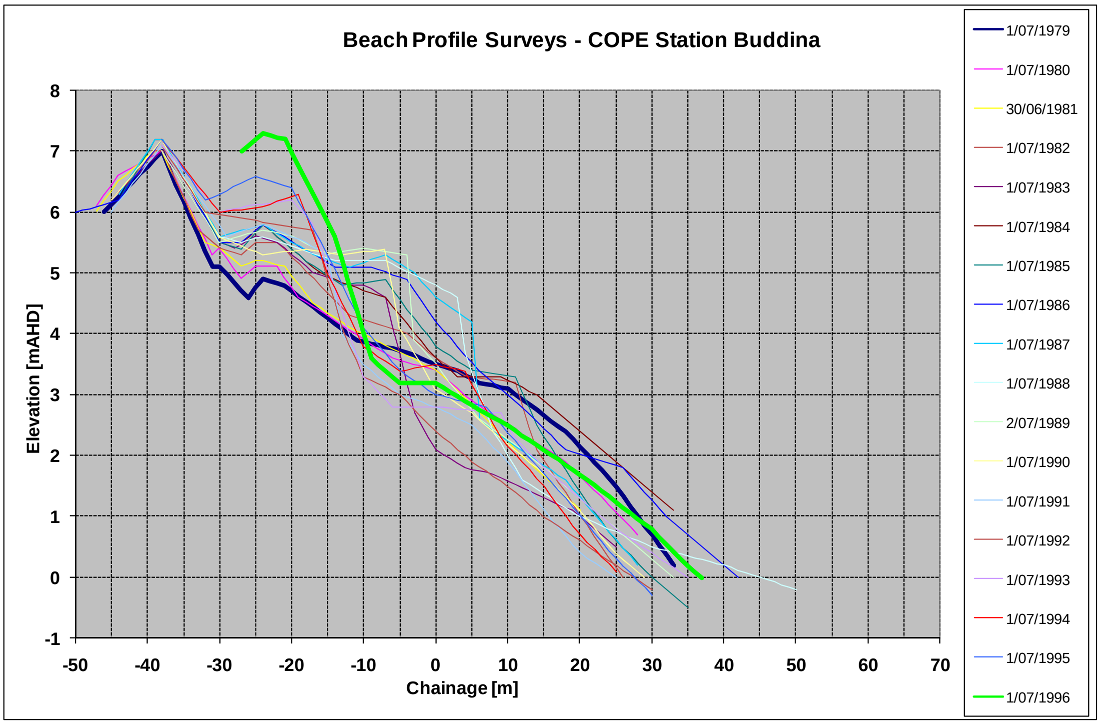


Figure A- 1 Beach Profile Survey Data - COPE Station Buddina

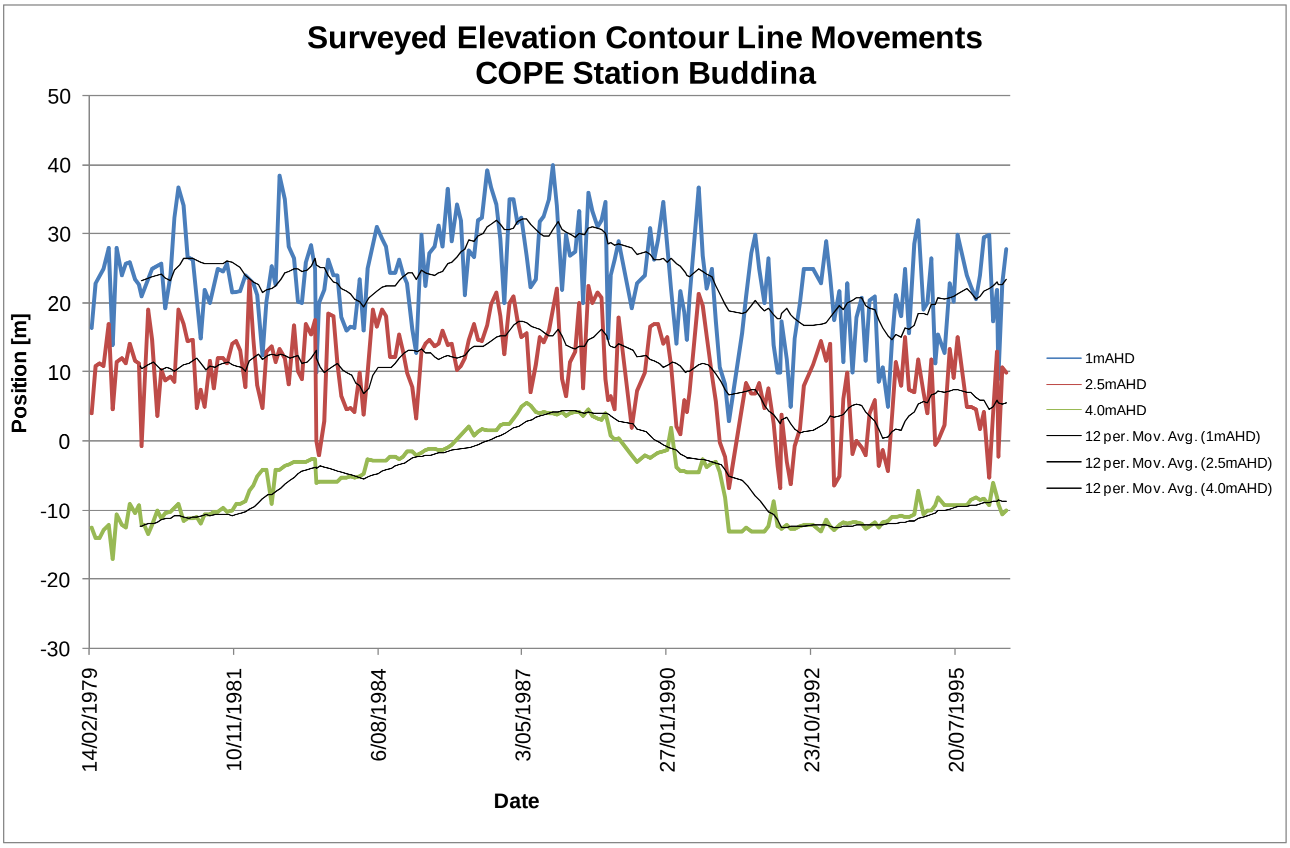


Figure A- 2 Buddina Beach Shoreline Movement

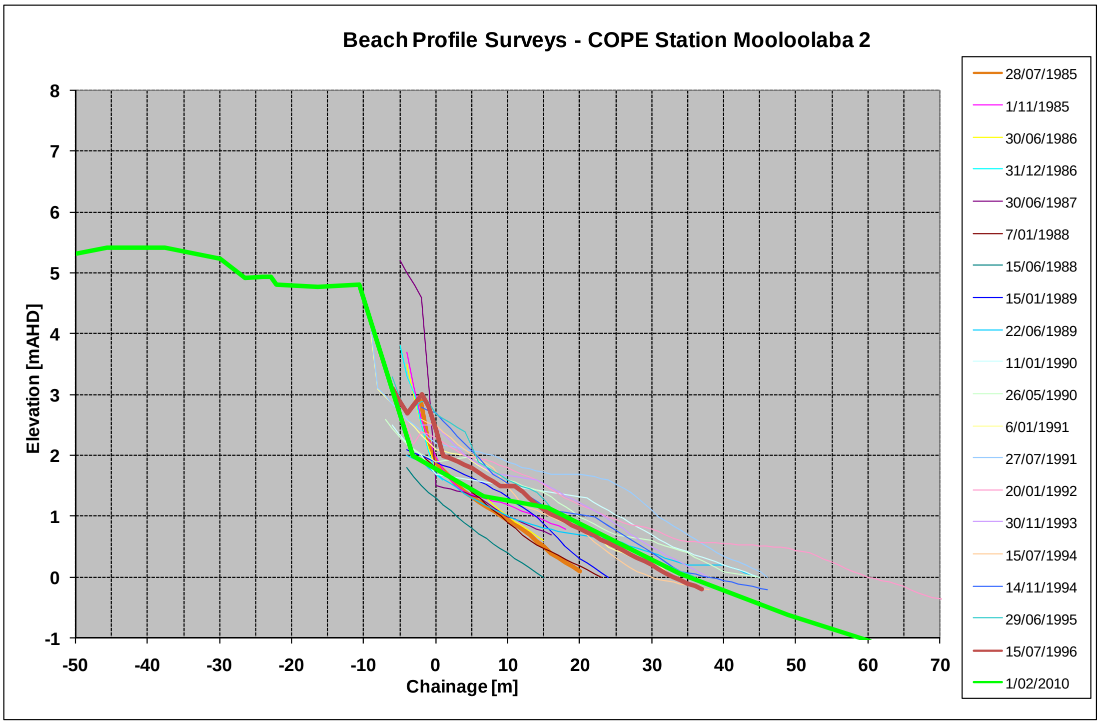


Figure A- 3 Mooloolaba Beach Profile Survey Data (COPE Station 2)

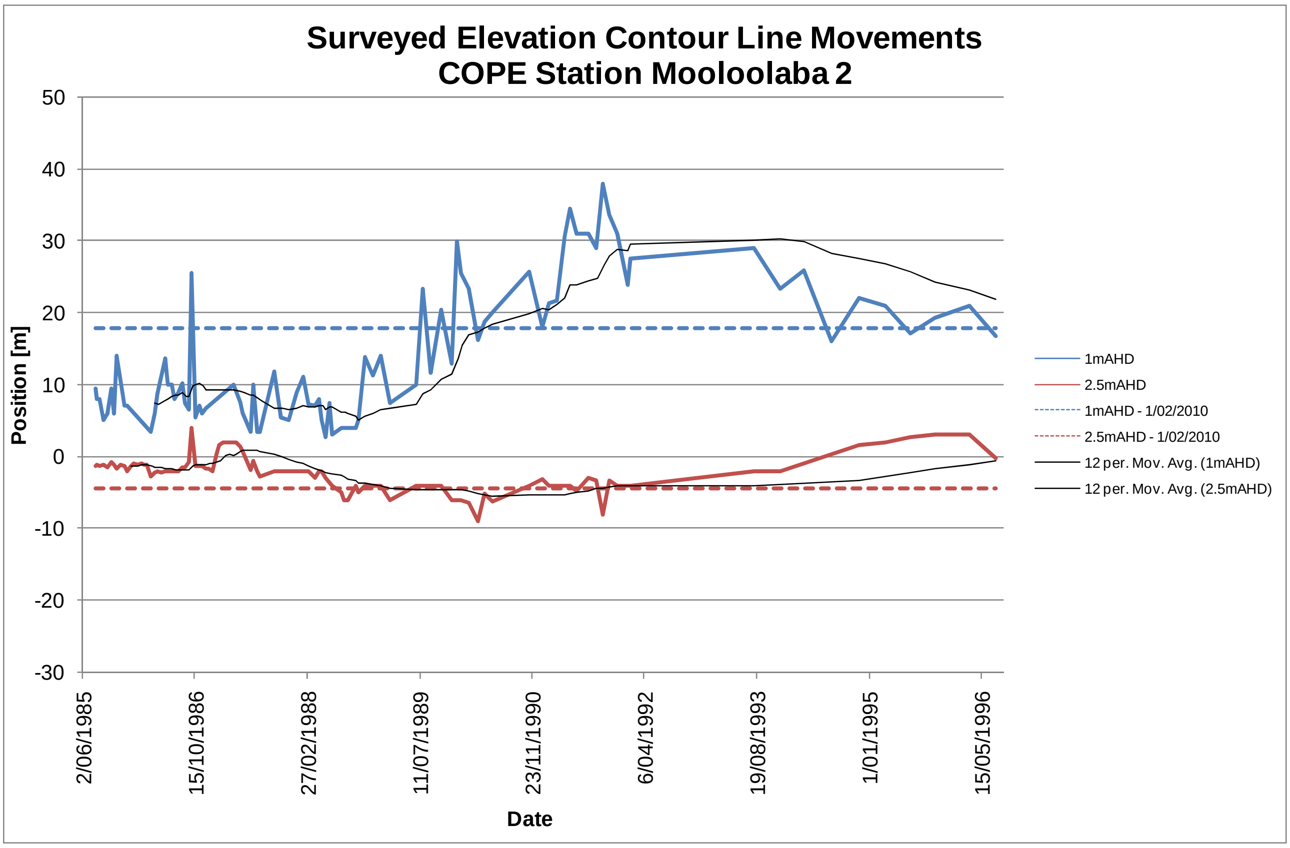


Figure A- 4 Mooloolaba Beach Shoreline Movement (COPE Station 2)

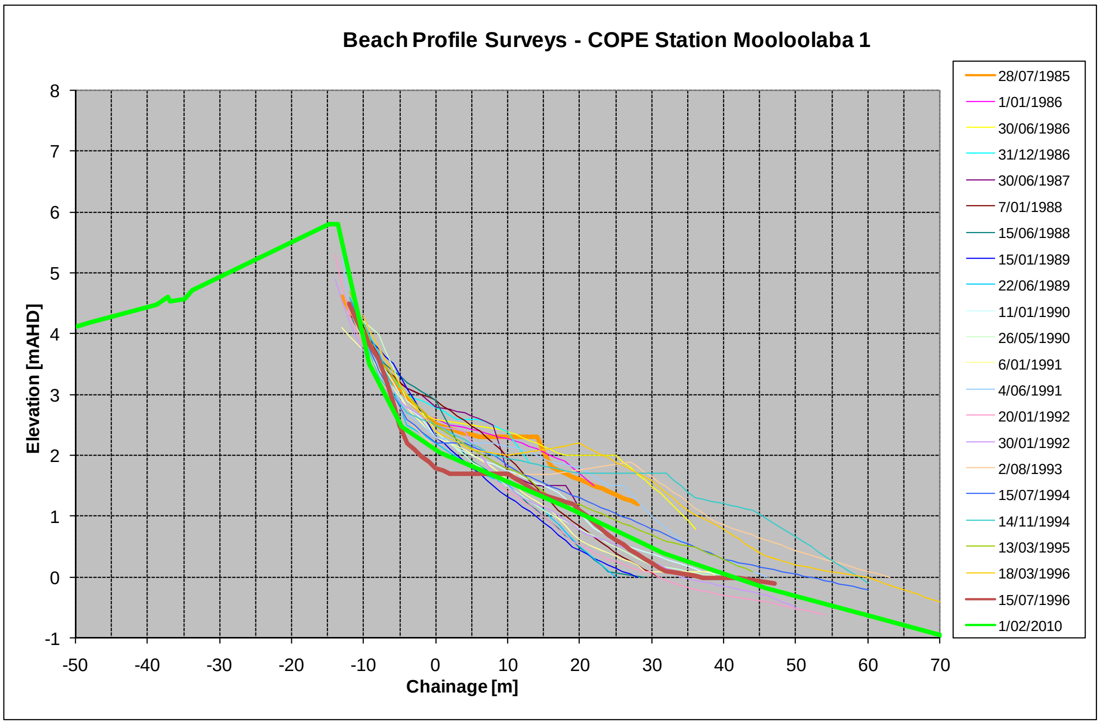


Figure A- 5 Mooloolaba Beach Profile Survey Data (COPE Station 1)

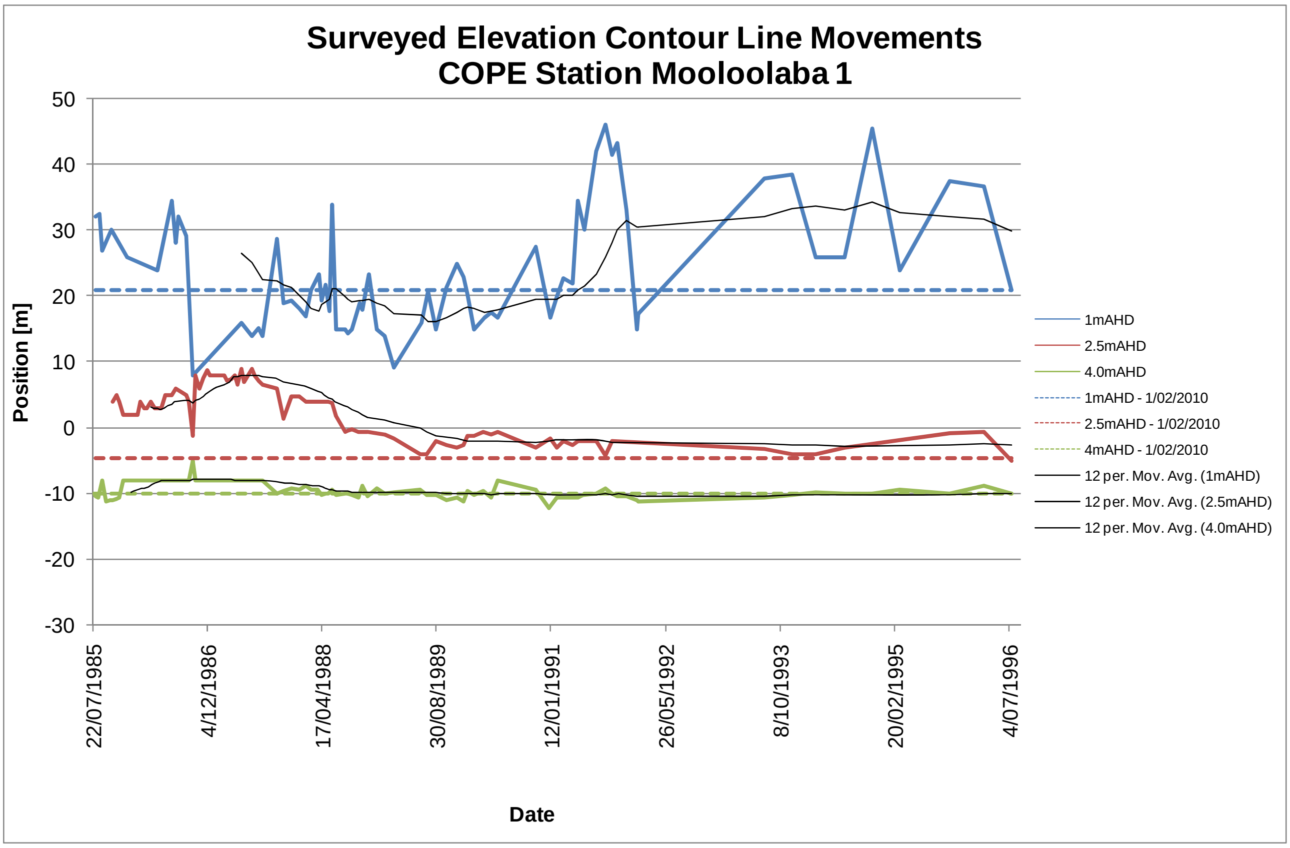


Figure A- 6 Mooloolaba Beach Shoreline Movement (COPE Station 1)

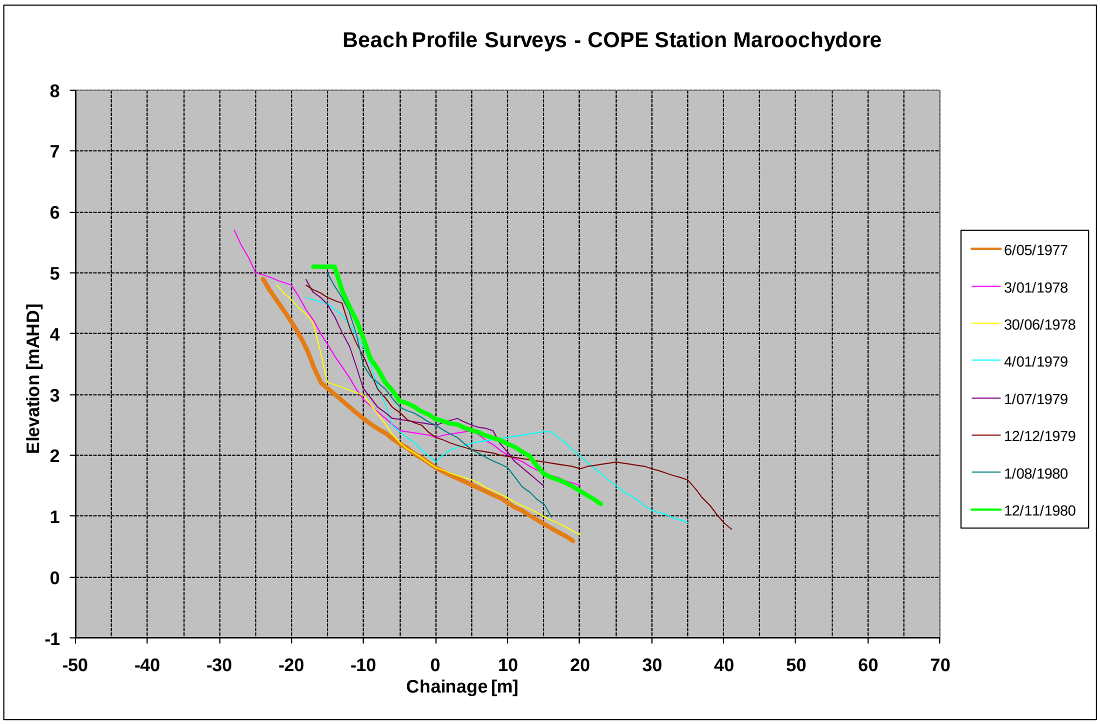


Figure A- 7 Maroochydore Beach Profile Survey Data

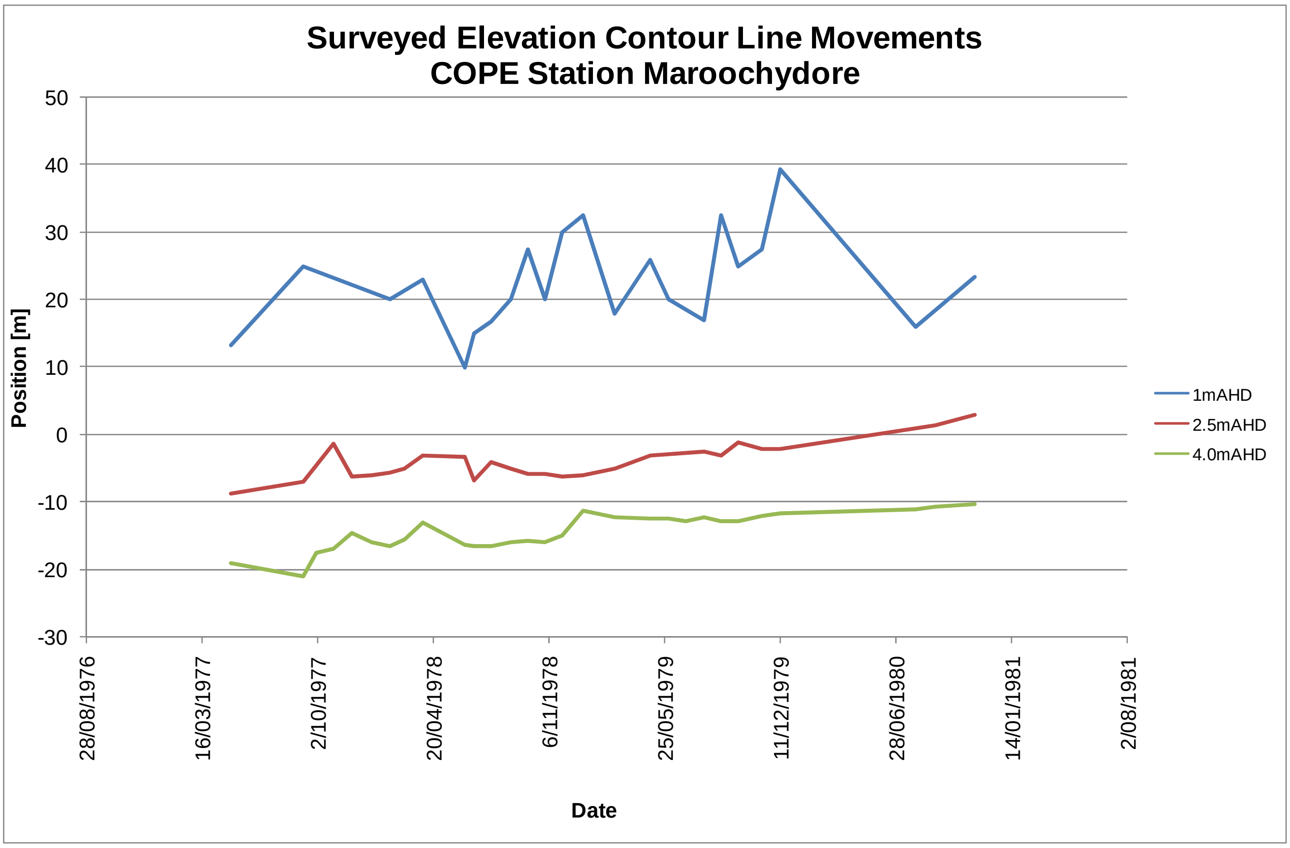


Figure A- 8 Maroochydore Beach Shoreline Movement

APPENDIX B: HISTORICAL ETA PROFILES AT SELECTED LOCATIONS

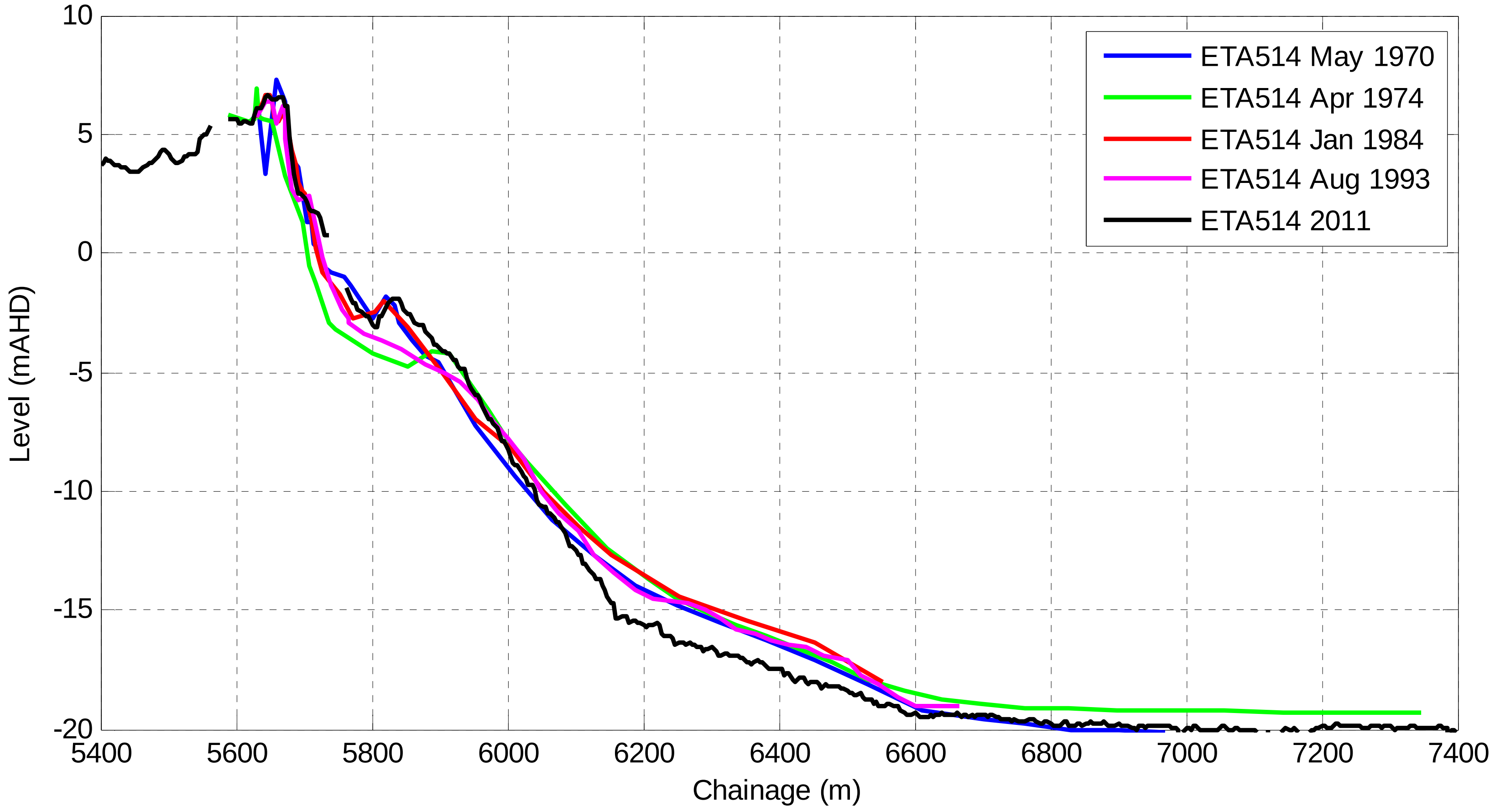


Figure B- 1 ETA 514 (Buddina) Historical ETA Profiles

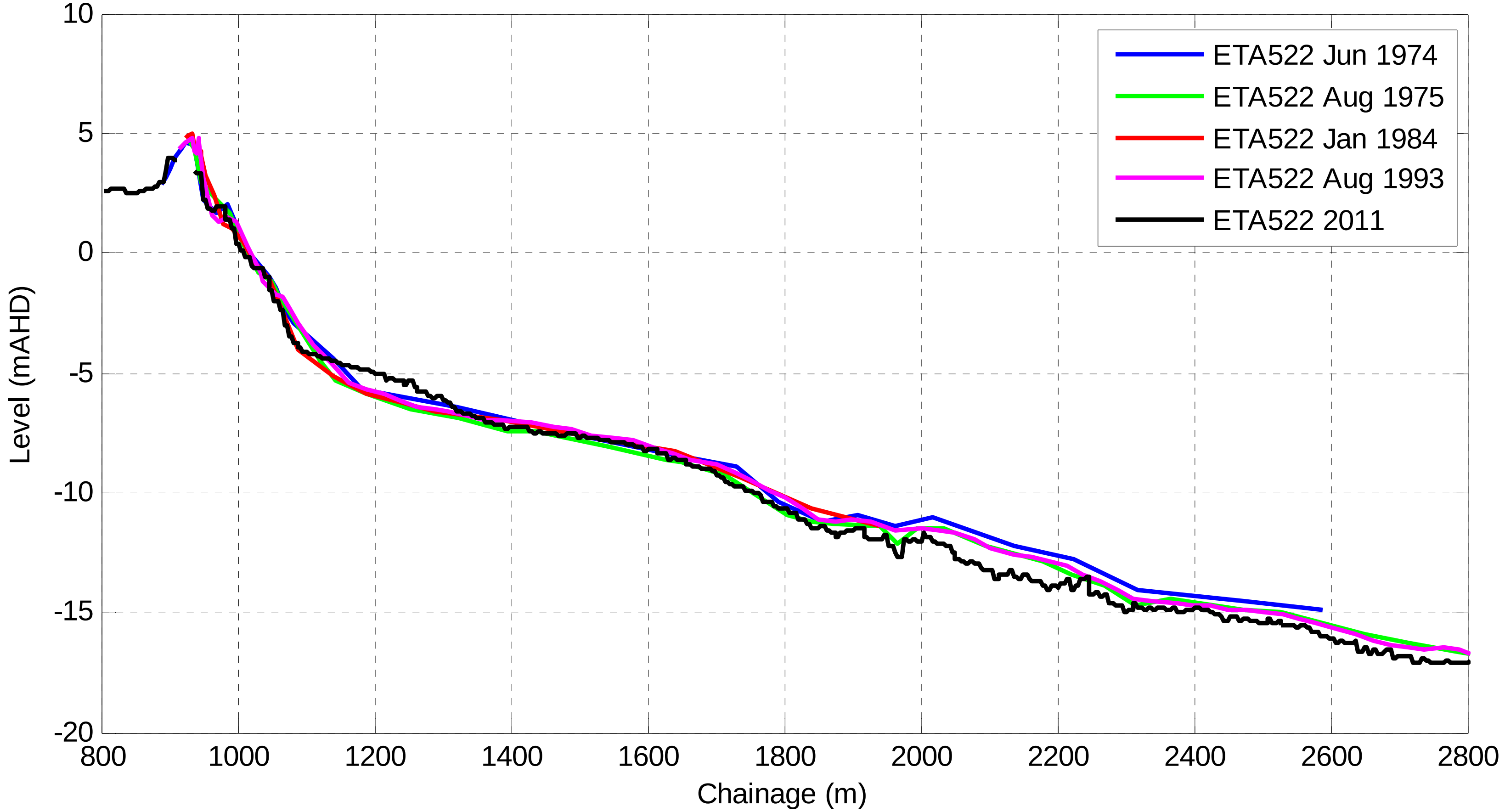


Figure B- 2 ETA 522 (Mooloolaba) Historical ETA Profiles

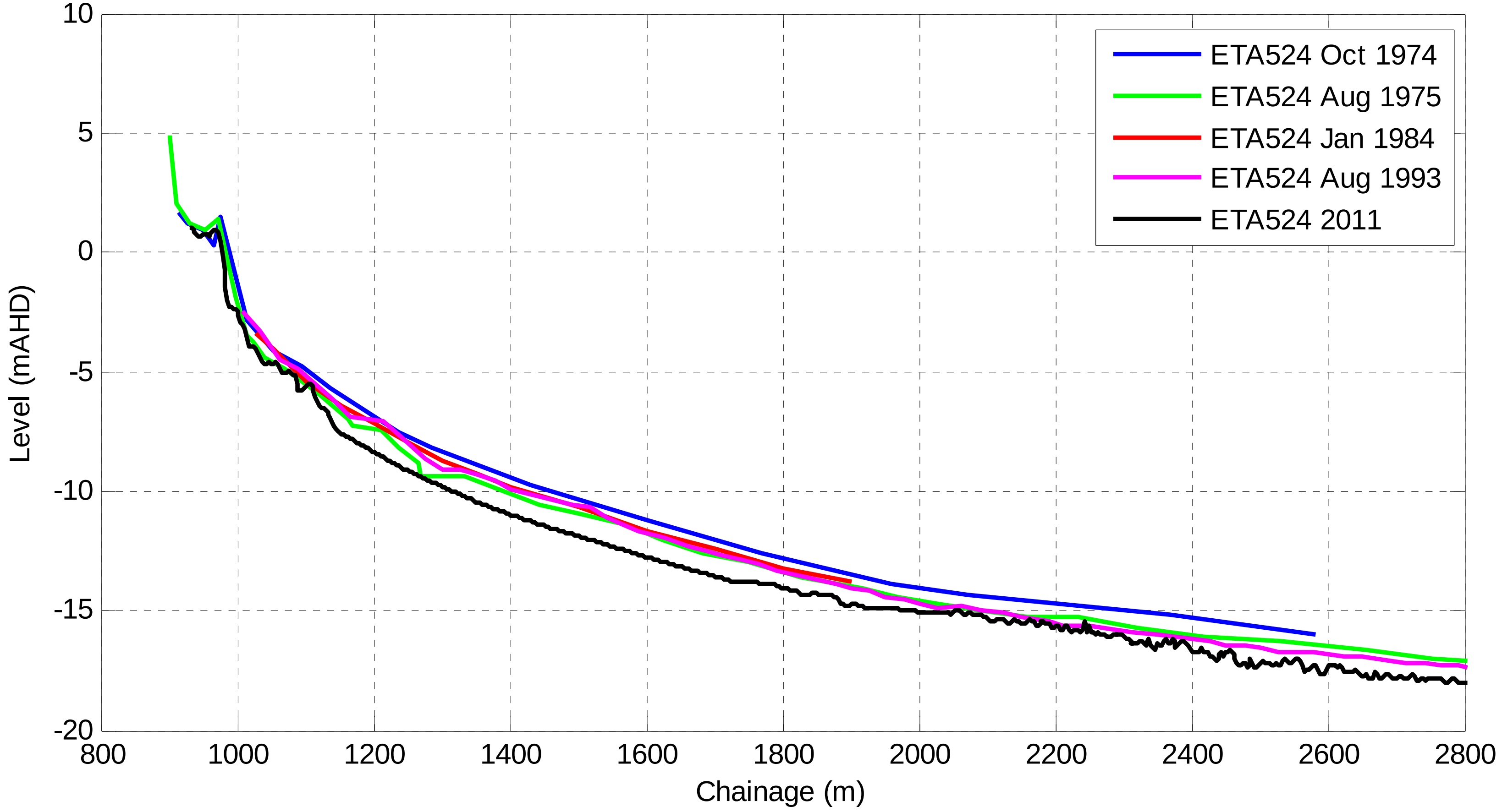


Figure B- 3 ETA 524 (Mooloolaba) Historical ETA Profiles

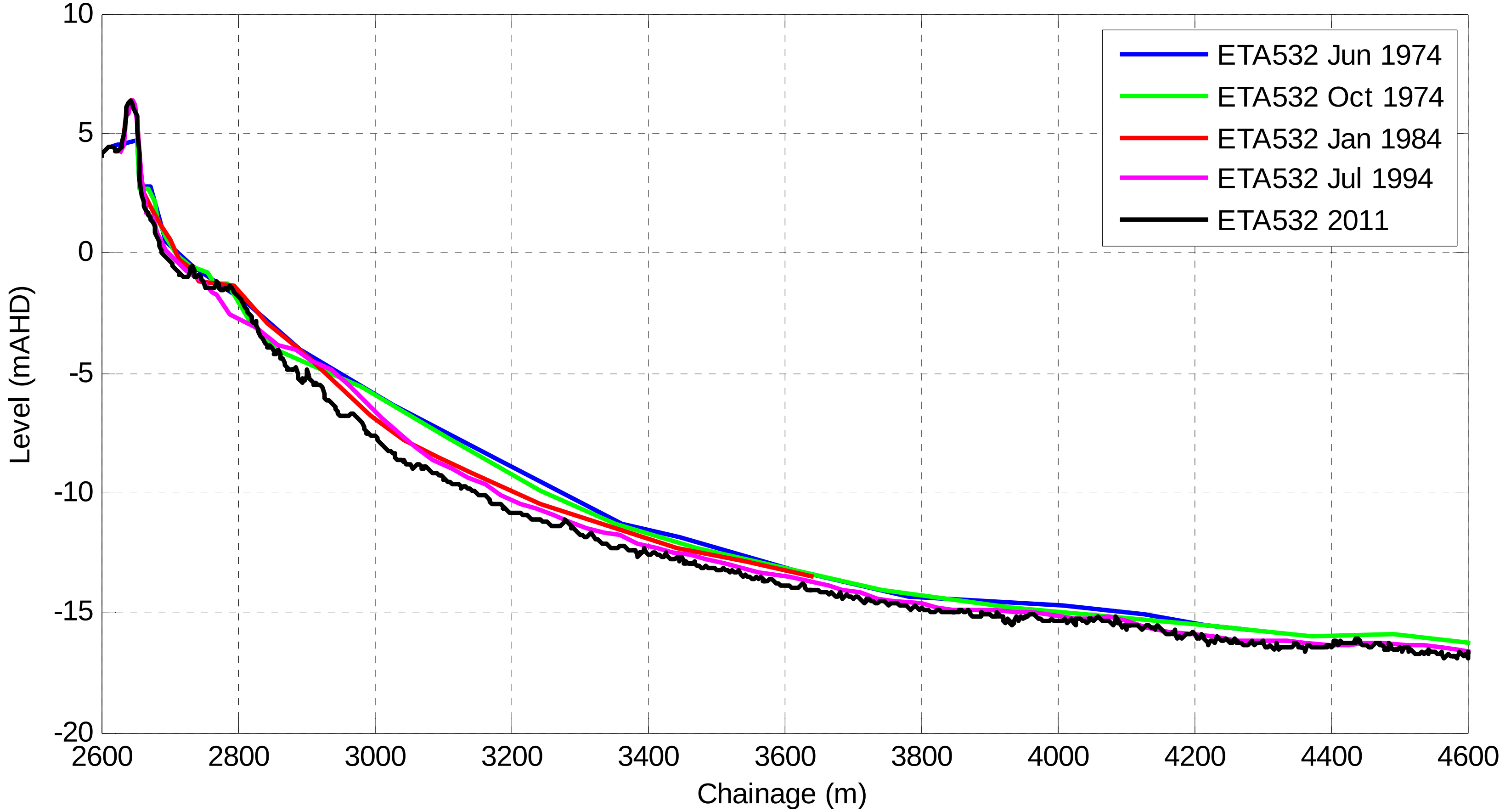


Figure B- 4 ETA 524 (Maroochydore) Historical ETA Profiles

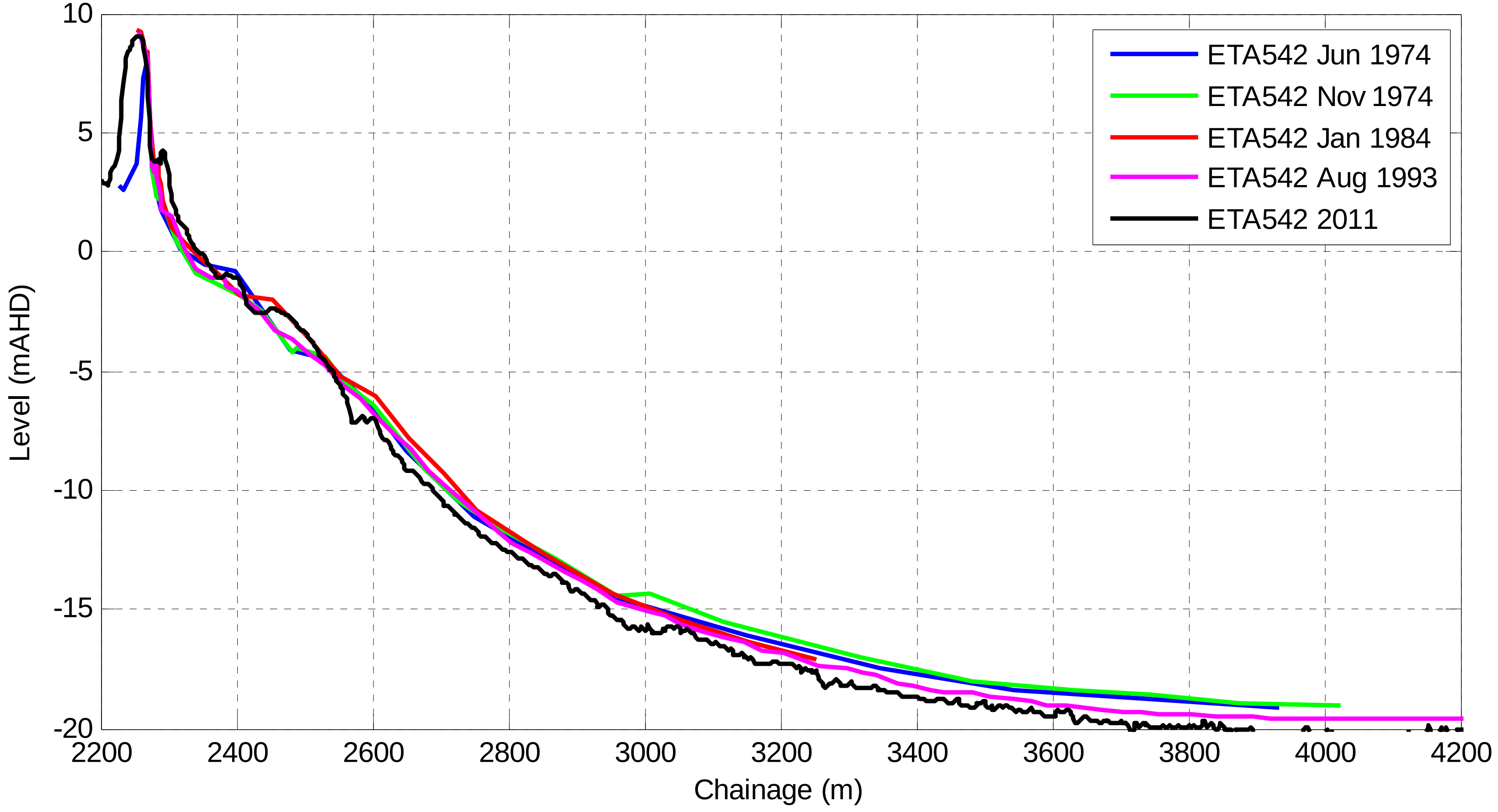


Figure B- 5 ETA 524 (Between North Shore and Mudjimba) Historical ETA Profiles

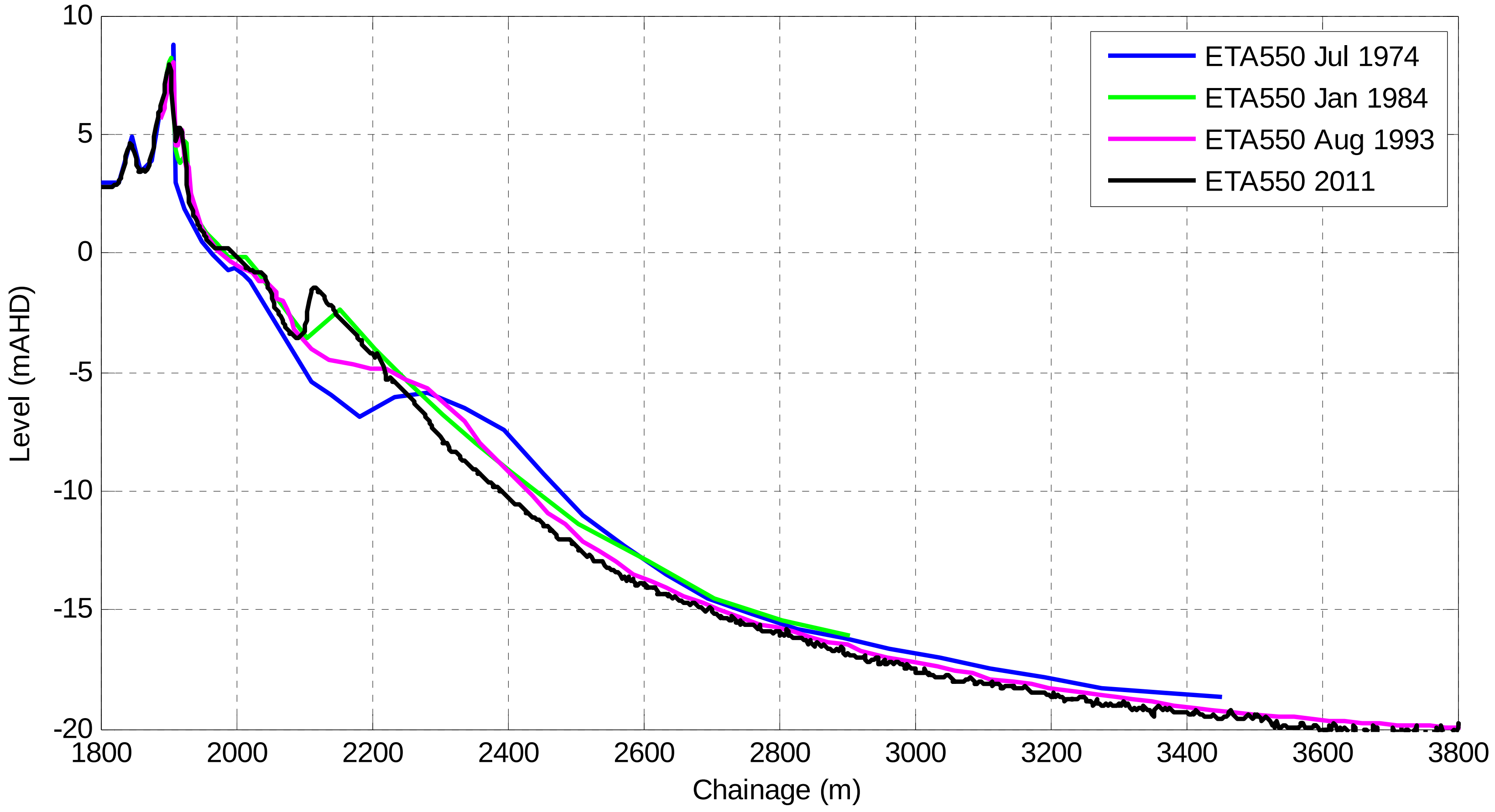


Figure B- 6 ETA 550 (Marcoola) Historical ETA Profiles

APPENDIX C: BELLS CREEK TO CALOUNDRA BAR HISTORICAL PHOTOGRAPHY

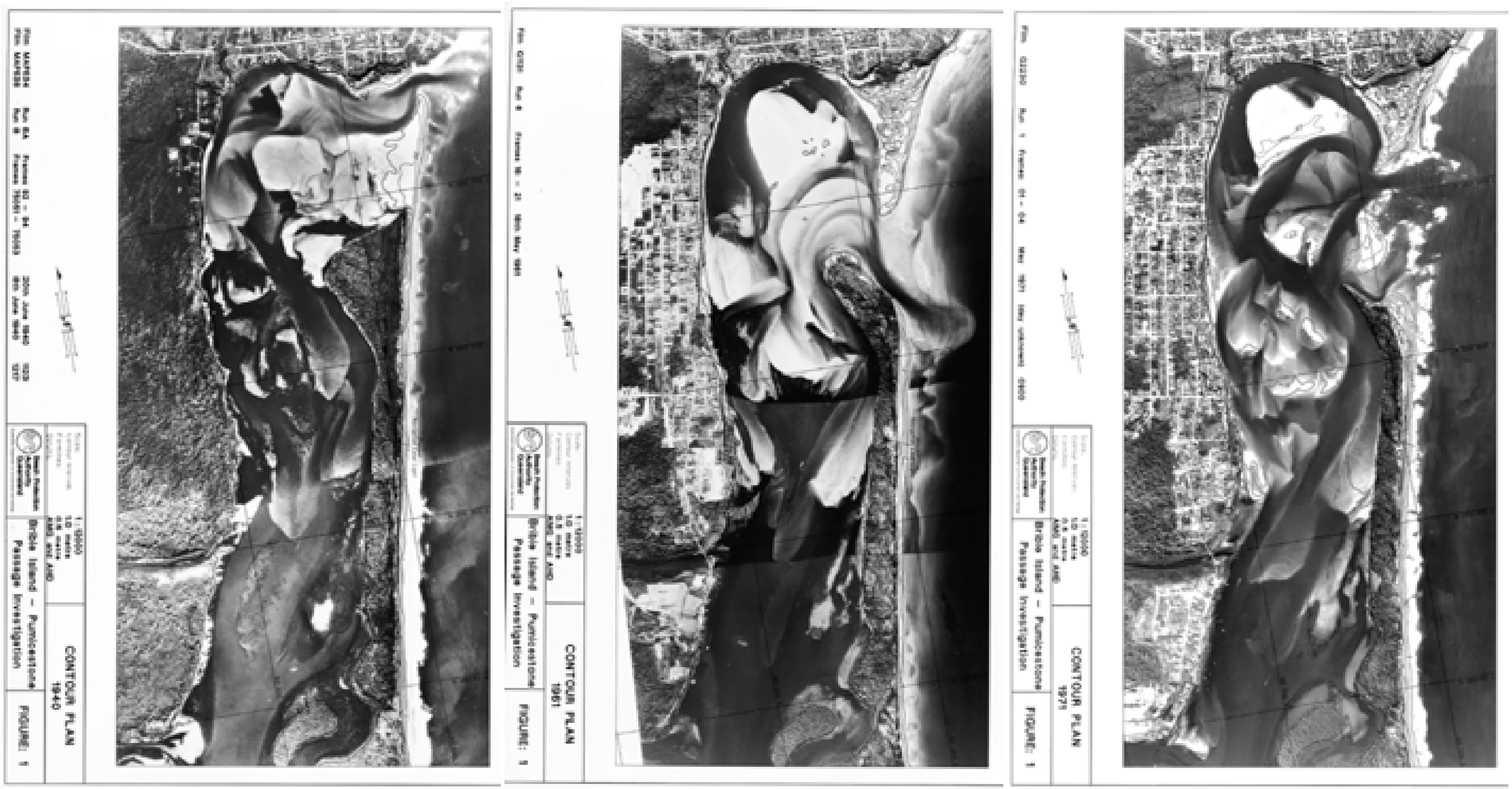


Figure C- 1 Bells Creek to Caloundra Bar Aerial Photography (1940, 1961 and 1971)

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

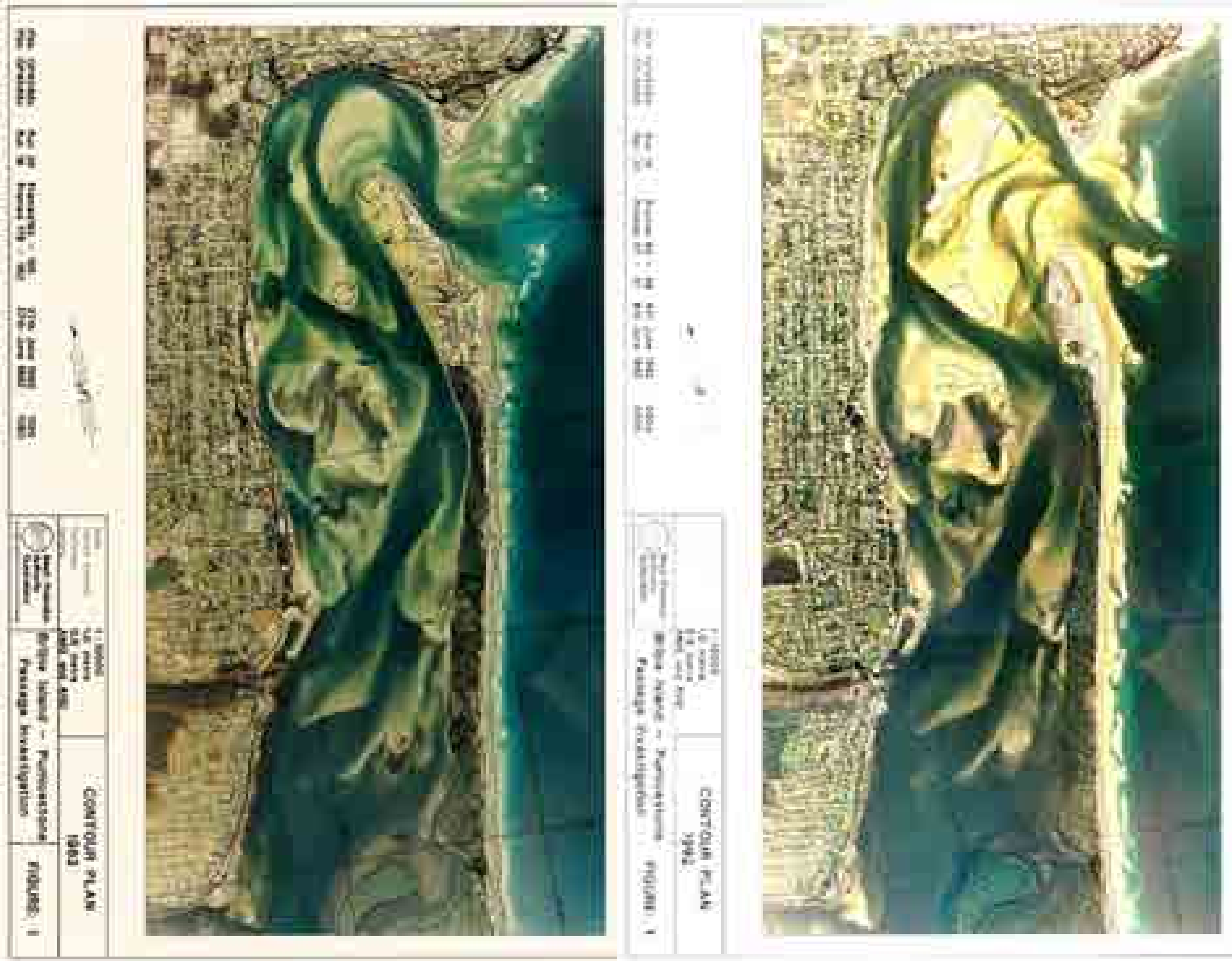


Figure C- 3 Bells Creek to Caloundra Bar Aerial Photography (1982 and 1992)

APPENDIX D: BUDDINA BEACH TO POINT CARTWRIGHT HISTORICAL PHOTOGRAPHY

Figure D- 1 Buddina Beach to Point Cartwright Aerial Photography (1961 – 1979)

Figure D- 2 Buddina Beach to Point Cartwright Aerial Photography (1984 – 1987)

Figure D- 3 Buddina Beach to Point Cartwright Aerial Photography (1994 – 2004)

APPENDIX E: MOOLOOLABA BAY HISTORICAL AERIAL PHOTOGRAPHY

Figure E- 1 Mooloolaba Bay Aerial Photography (1961 – 1974)

Figure E- 2 Mooloolaba Bay Aerial Photography (1979 – 1984)

Figure E- 3 Mooloolaba Bay Aerial Photography (1987 – 1994)

Figure E- 4 Mooloolaba Bay Aerial Photography (1999 – 2004)

APPENDIX F: MAROOCHY RIVER MOUTH HISTORICAL AERIAL PHOTOGRAPHY

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

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

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

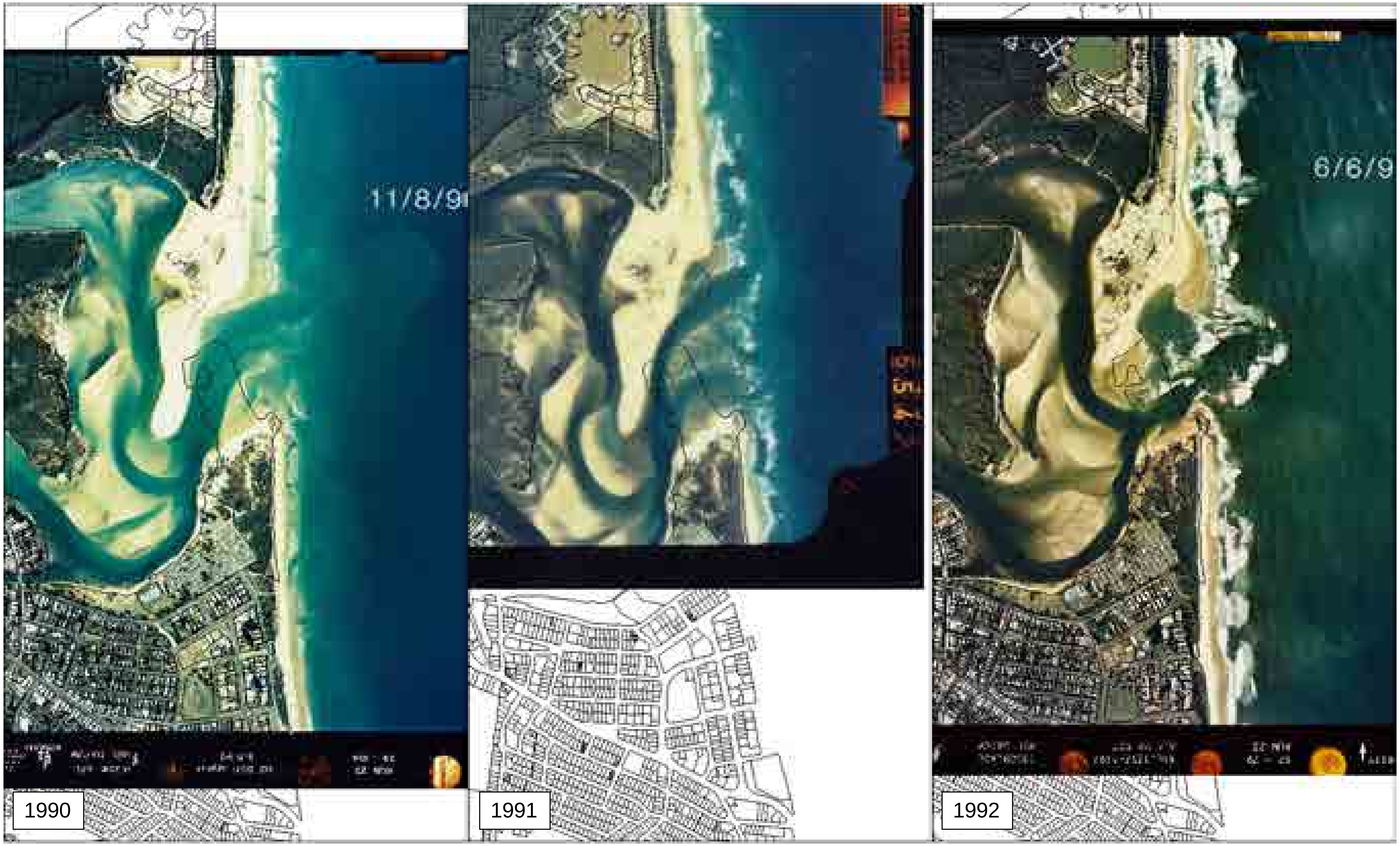
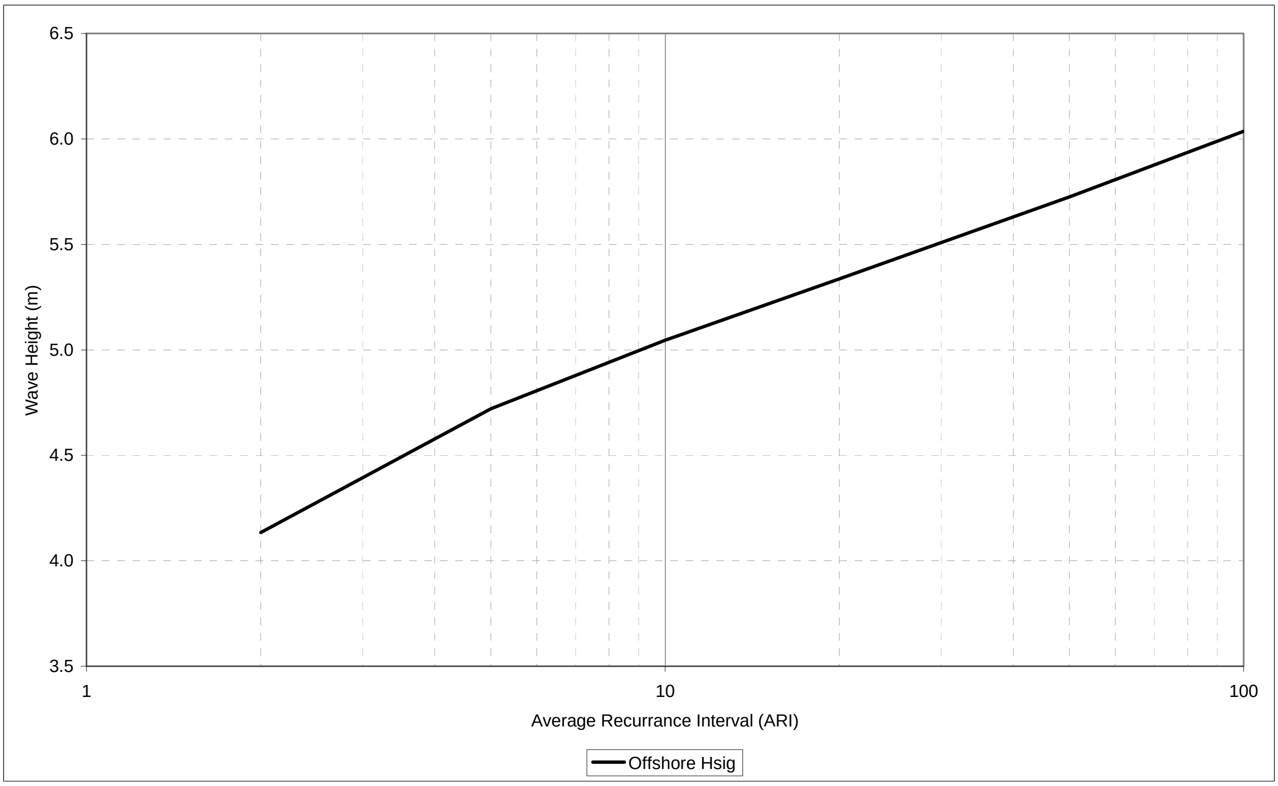


Figure F- 4 Maroochy River Mouth Aerial Photography (1990 – 1992)

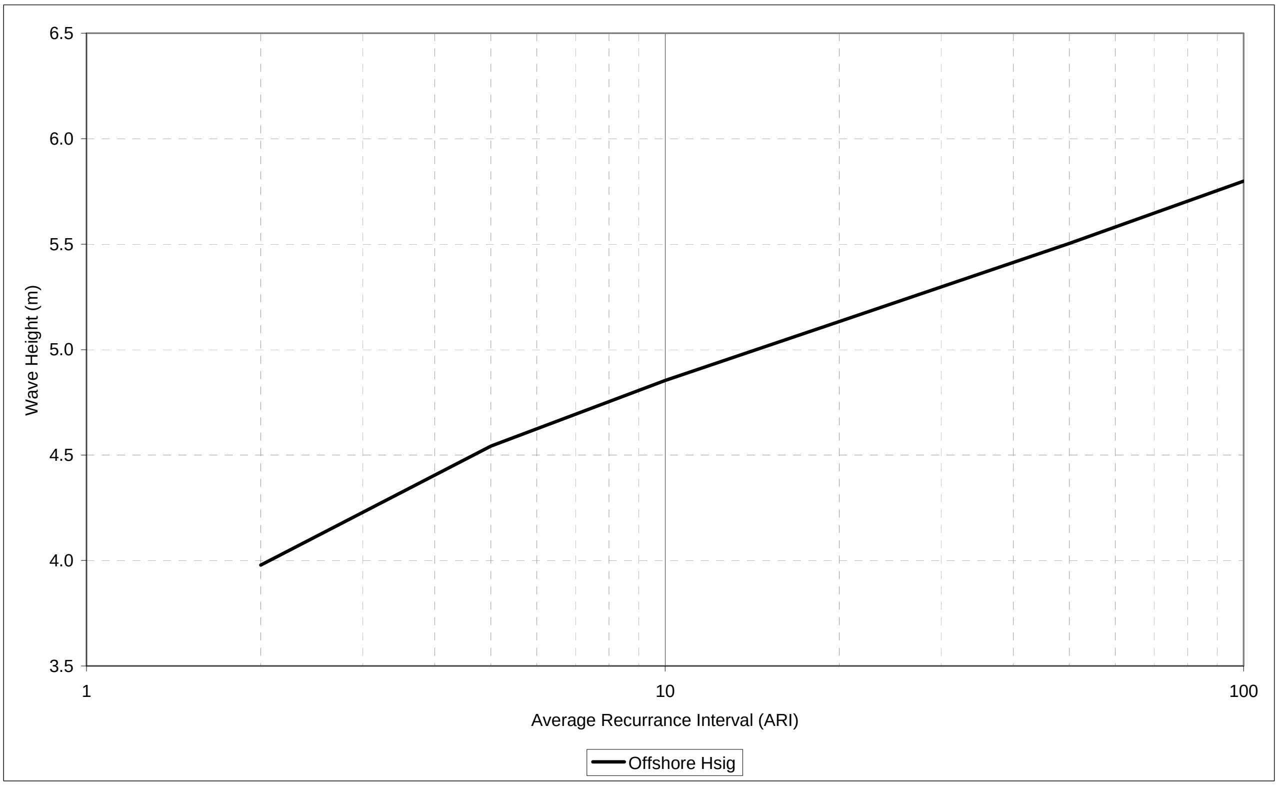
Figure F- 5 Maroochy River Mouth Aerial Photography (1994 – 1999)

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

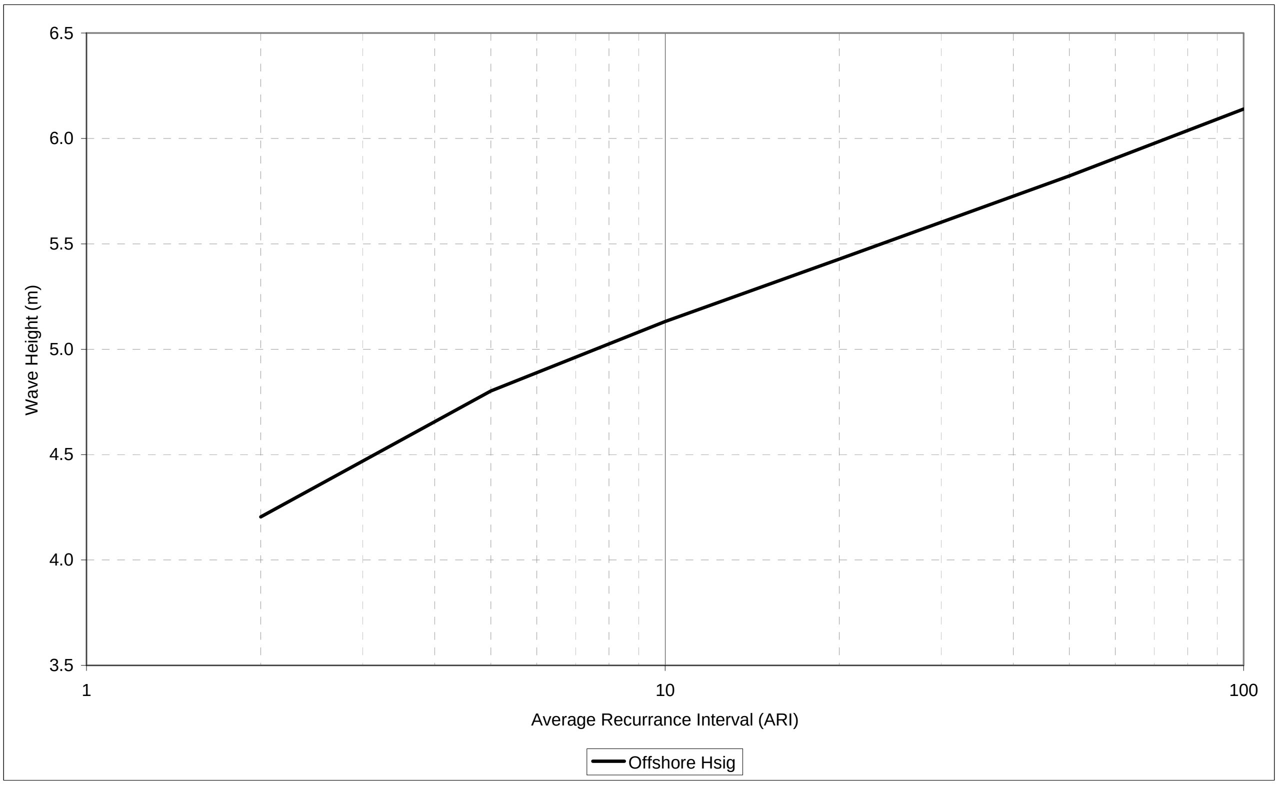
APPENDIX G: DESIGN WAVE CURVES



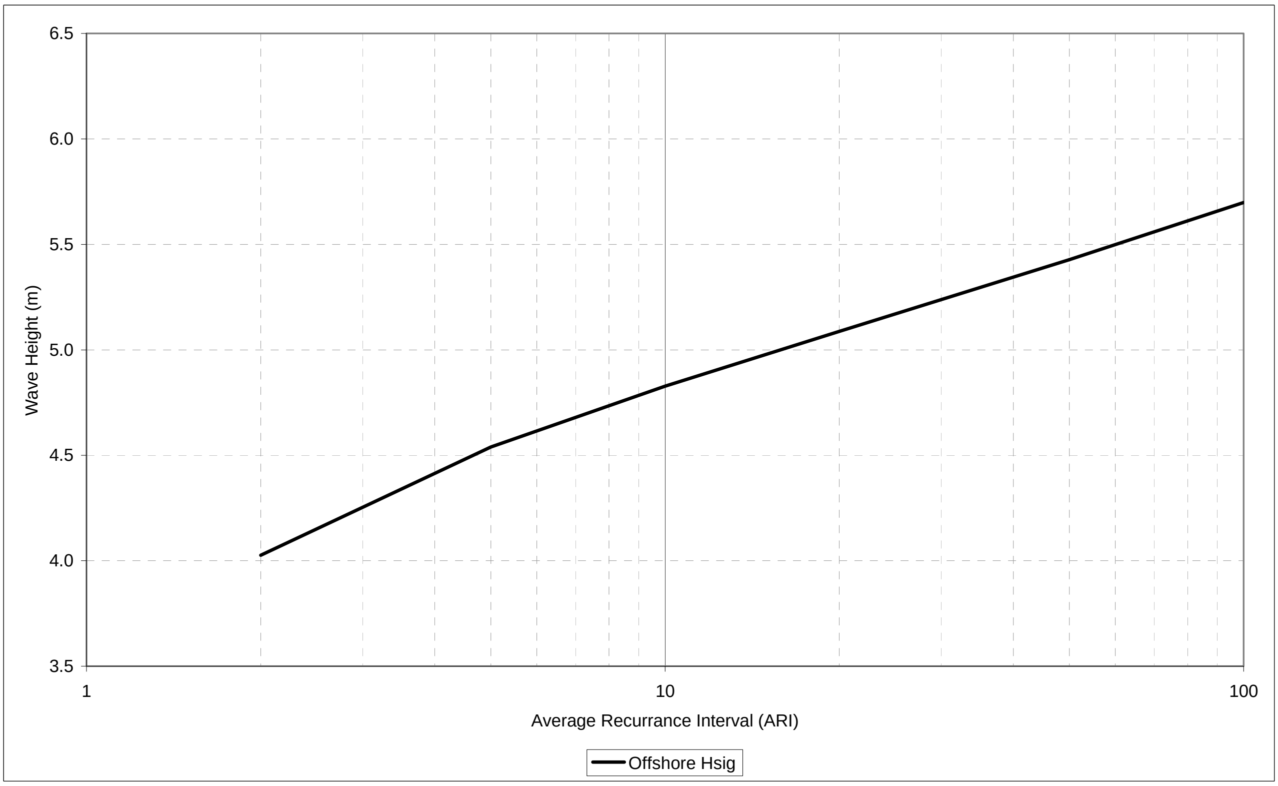
Dicky



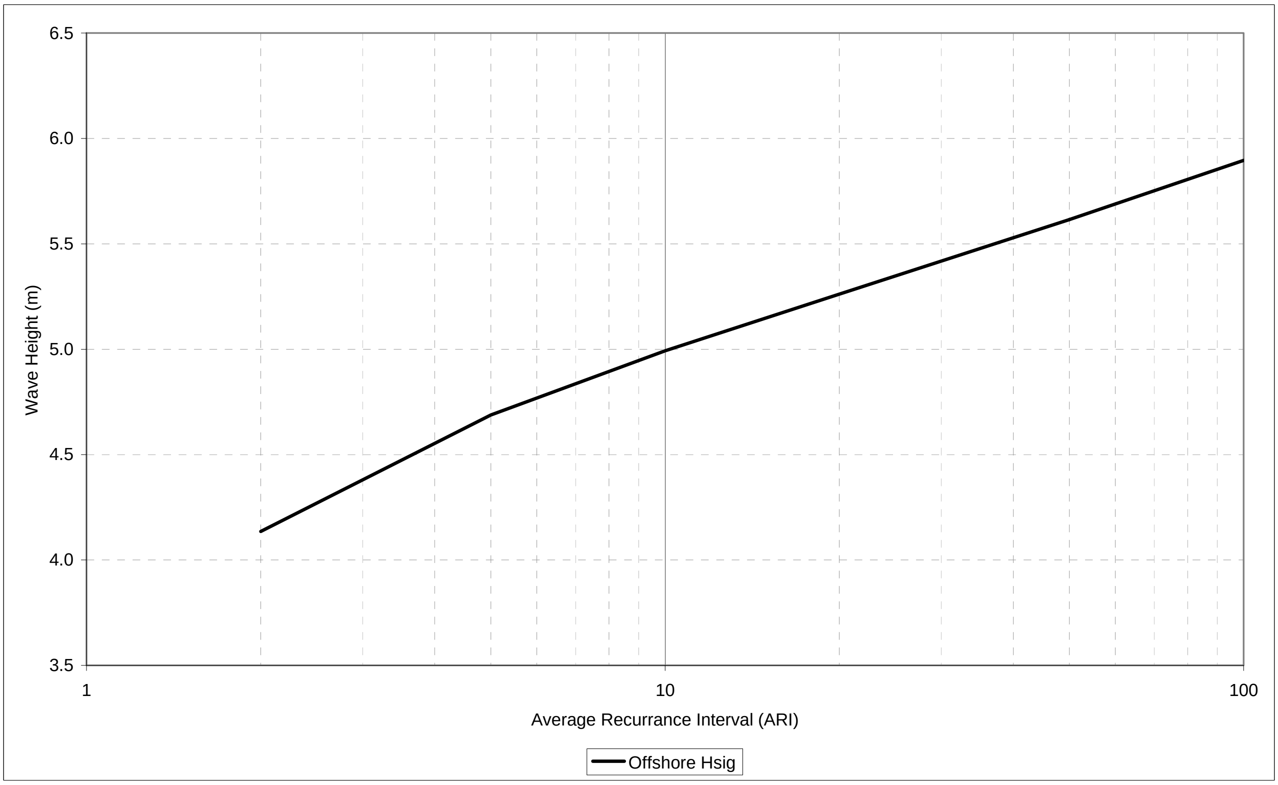
Currimundi



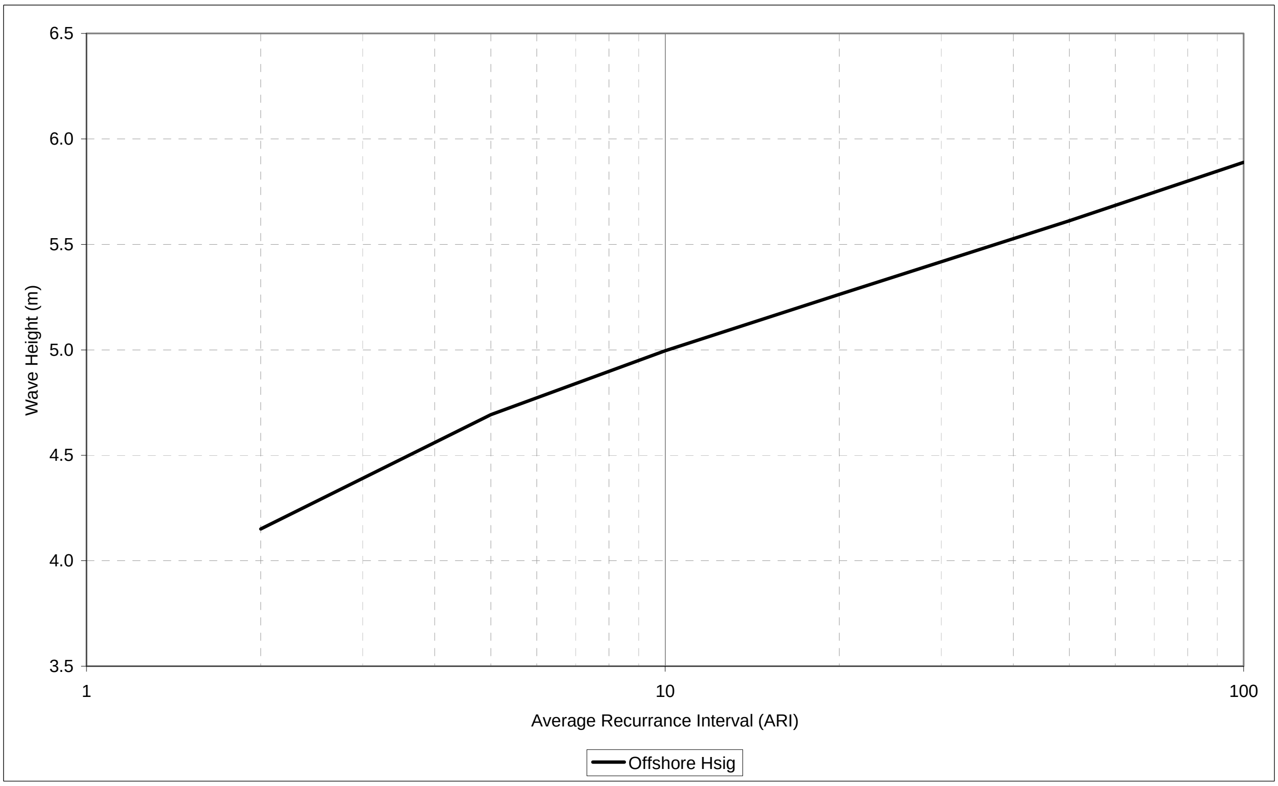
Warana



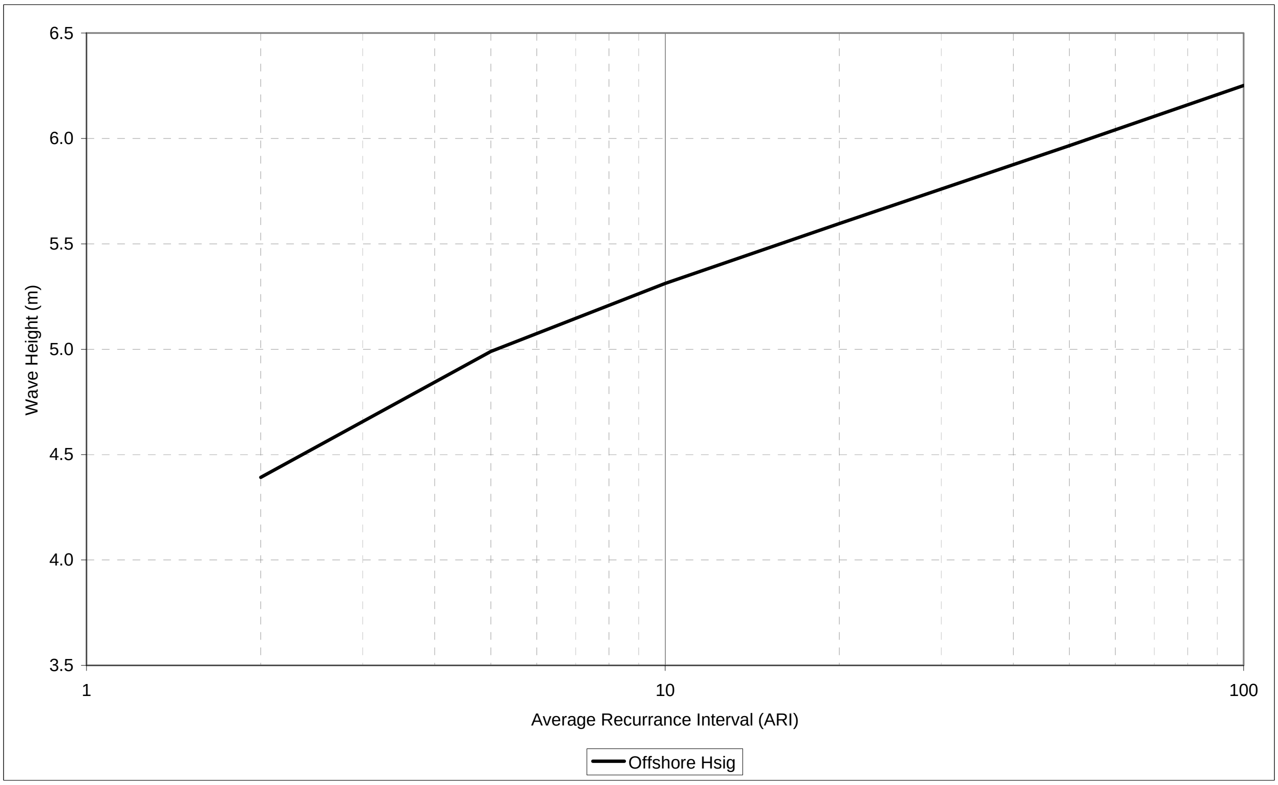
Buddina



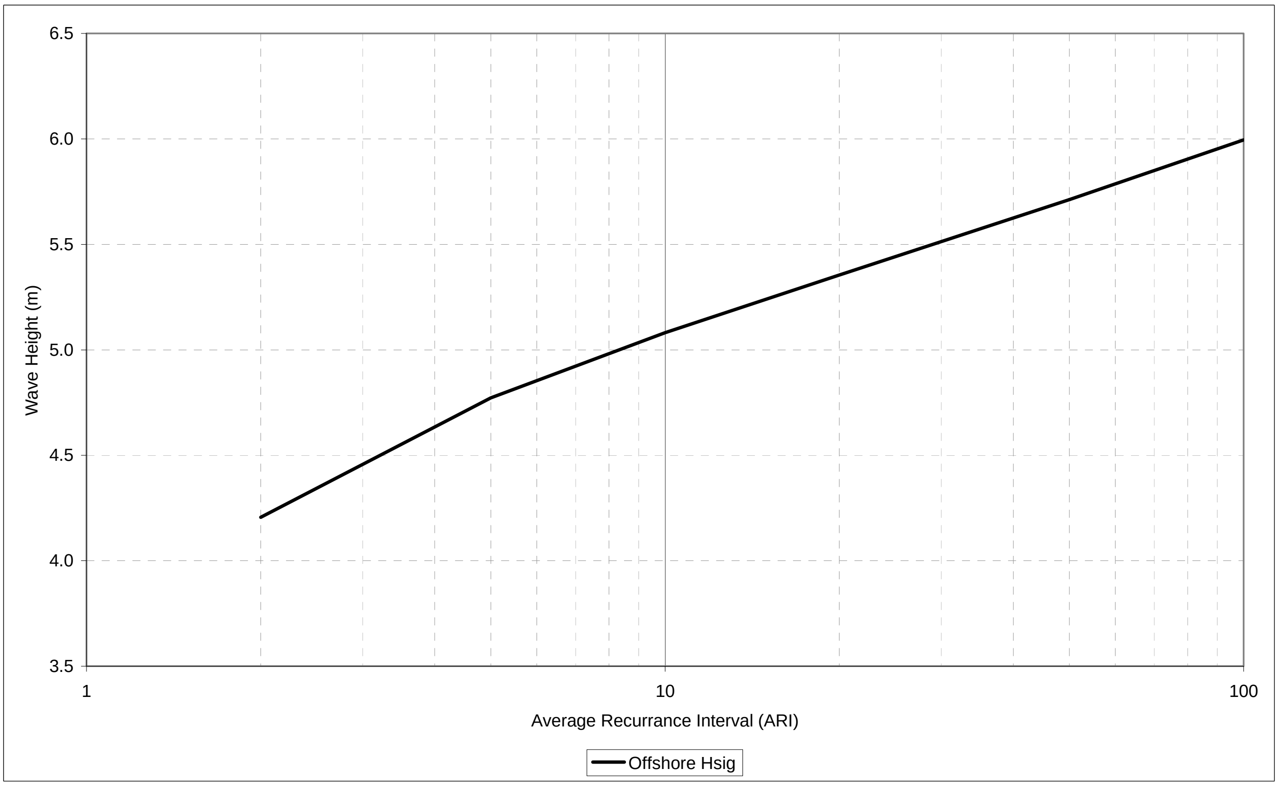
Mooloolaba Bay



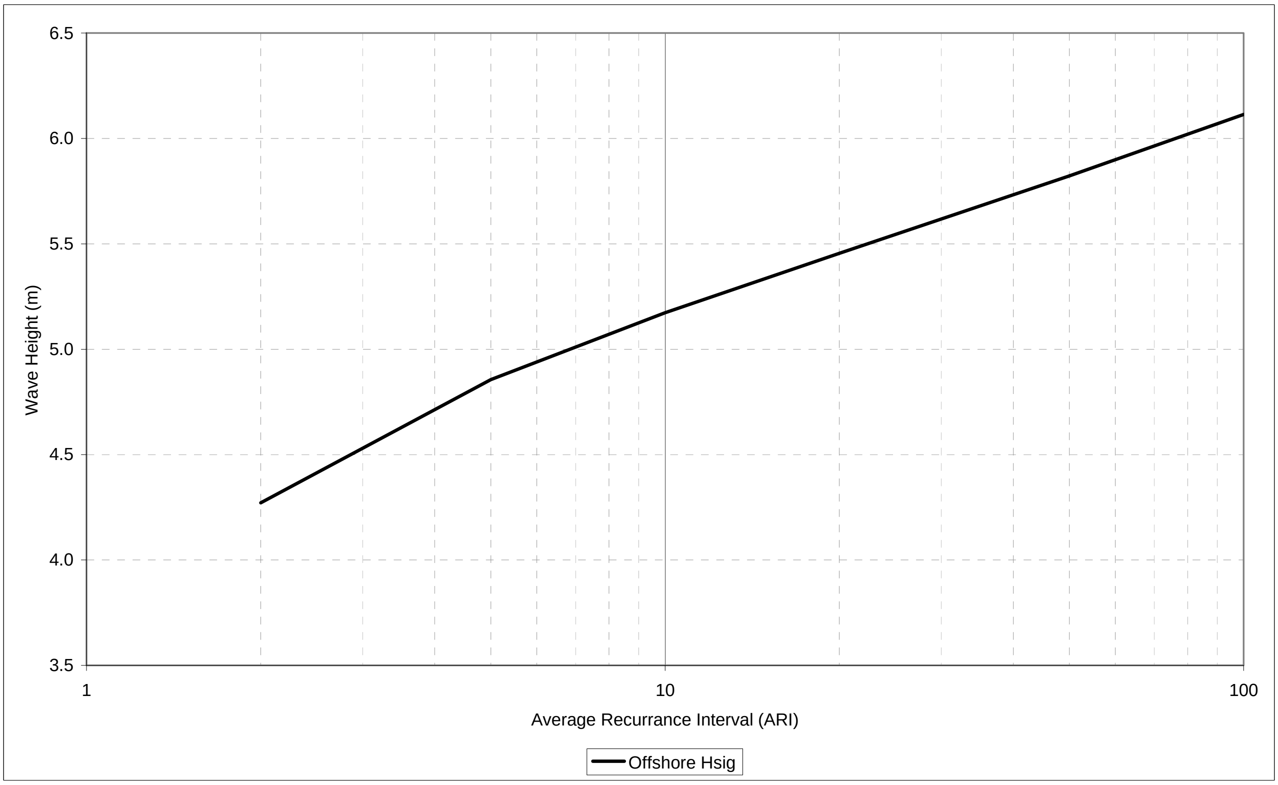
Mooloolaba Surf Club



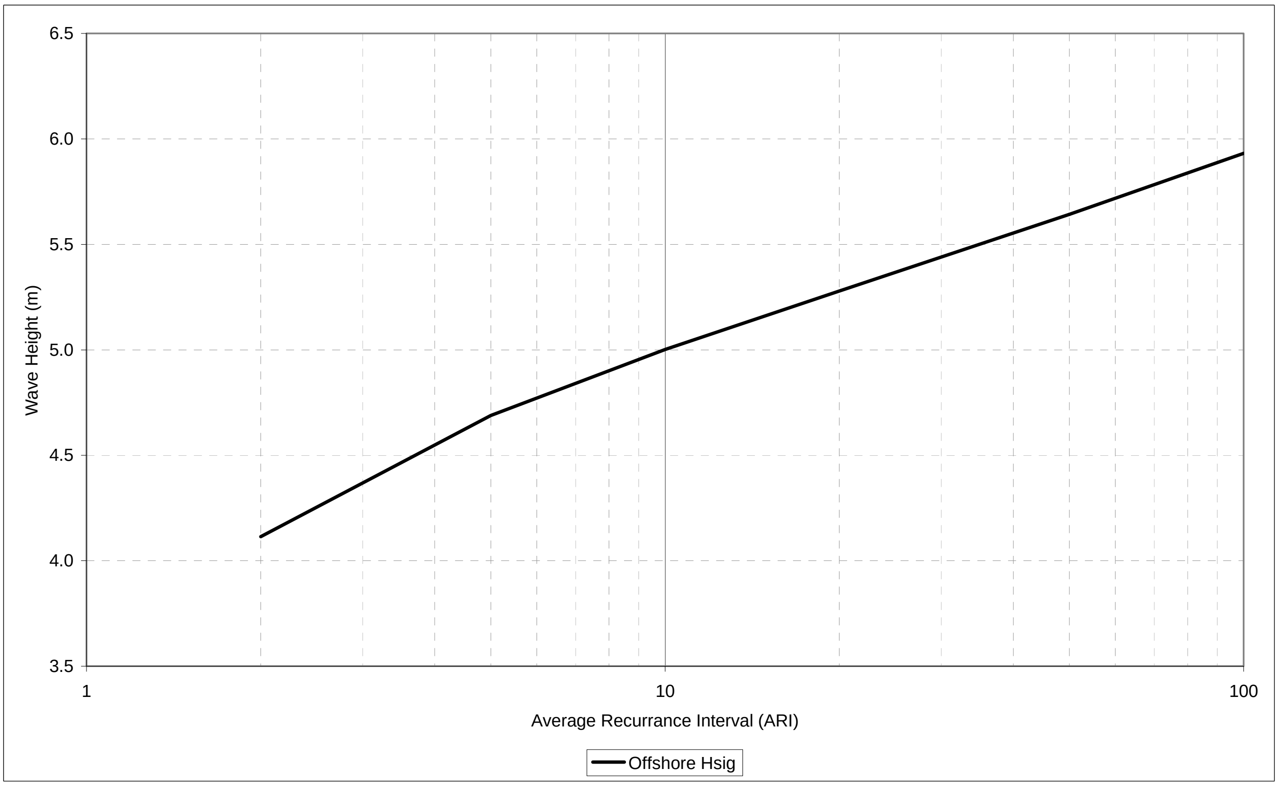
Maroochydore



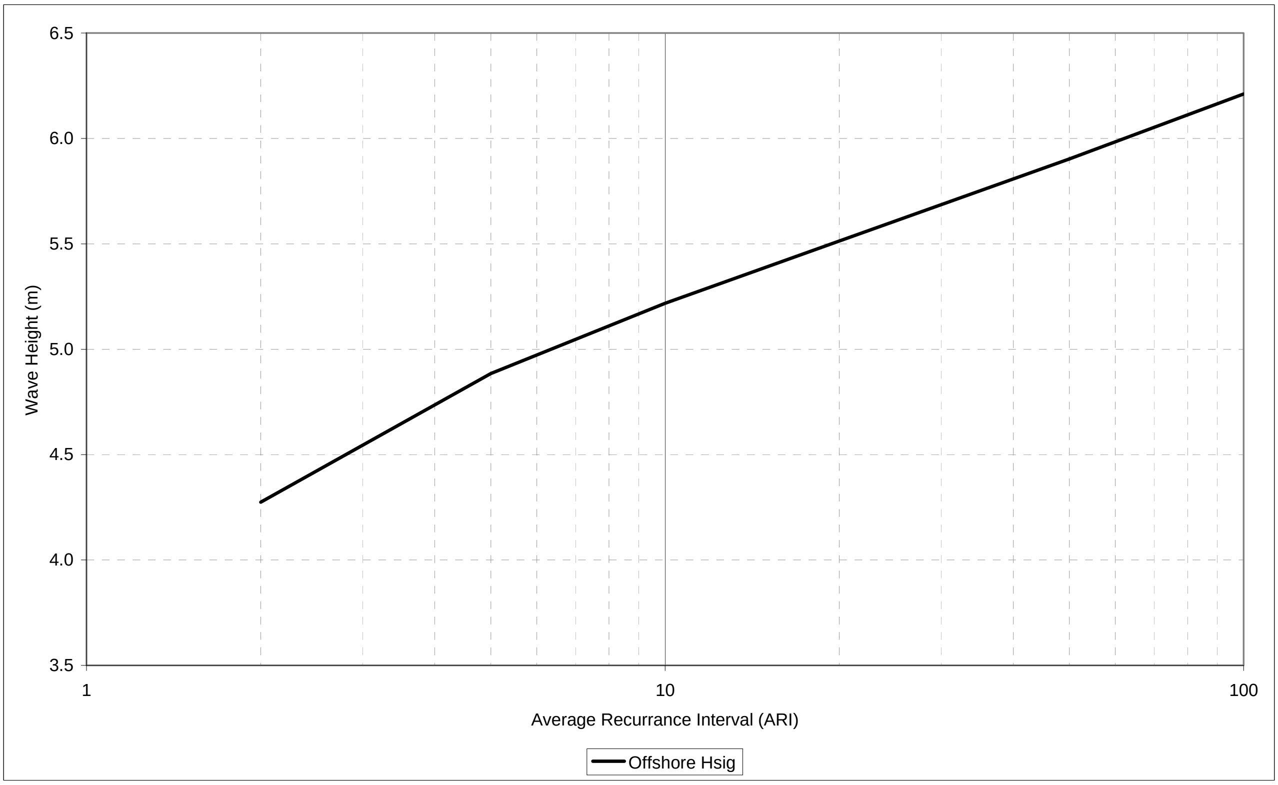
Marcoola



Coolum

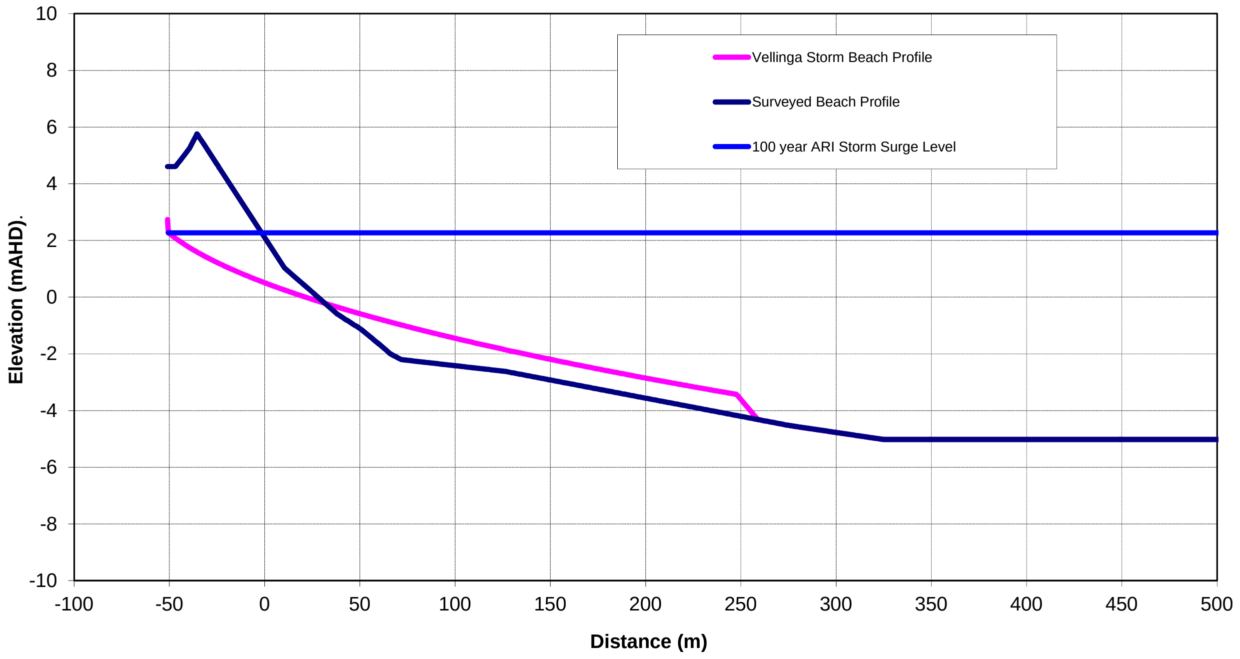


Peregian

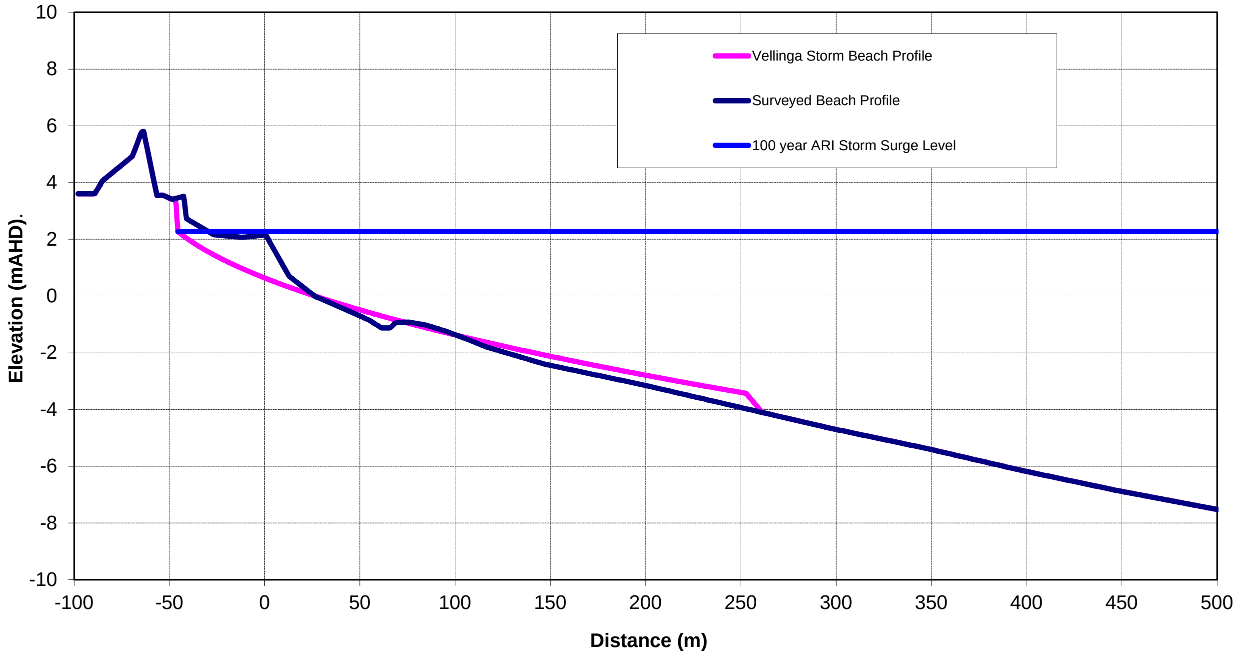

6.5
6.0
5.5
5.0
4.5
4.0
3.5
Wave Height (m)
1
10
100
Average Recurrance Interval (ARI)
Offshore Hsig

Sunshine

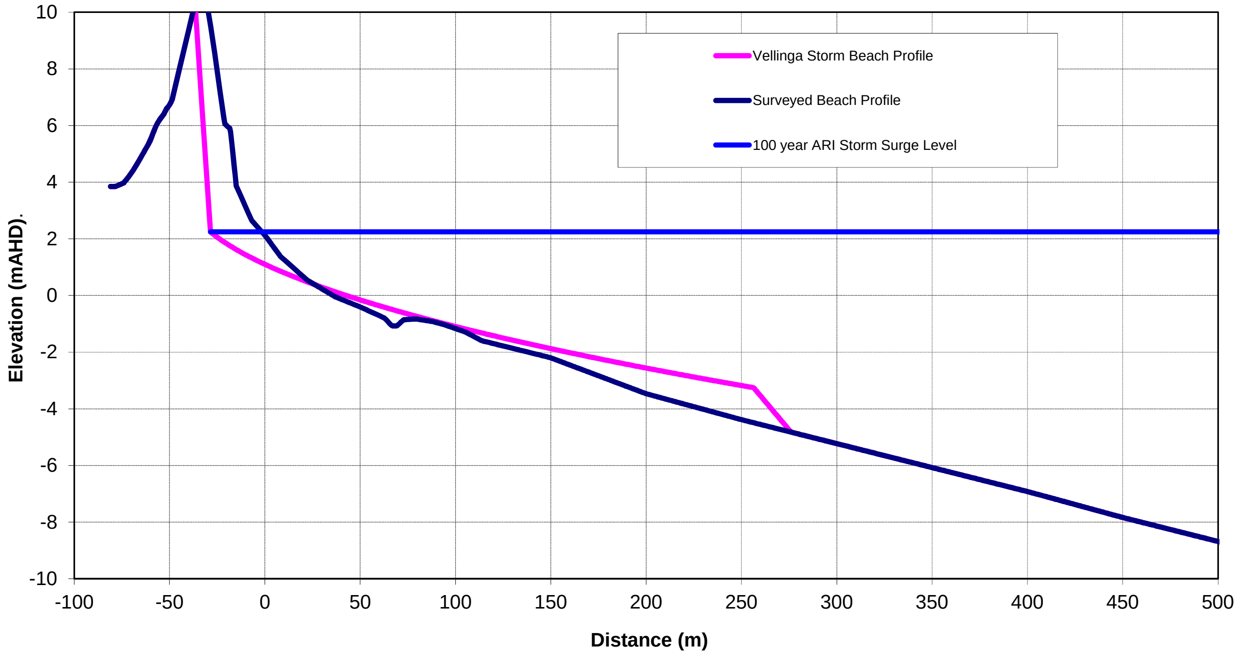
APPENDIX H: VELLINGA STORM PROFILES



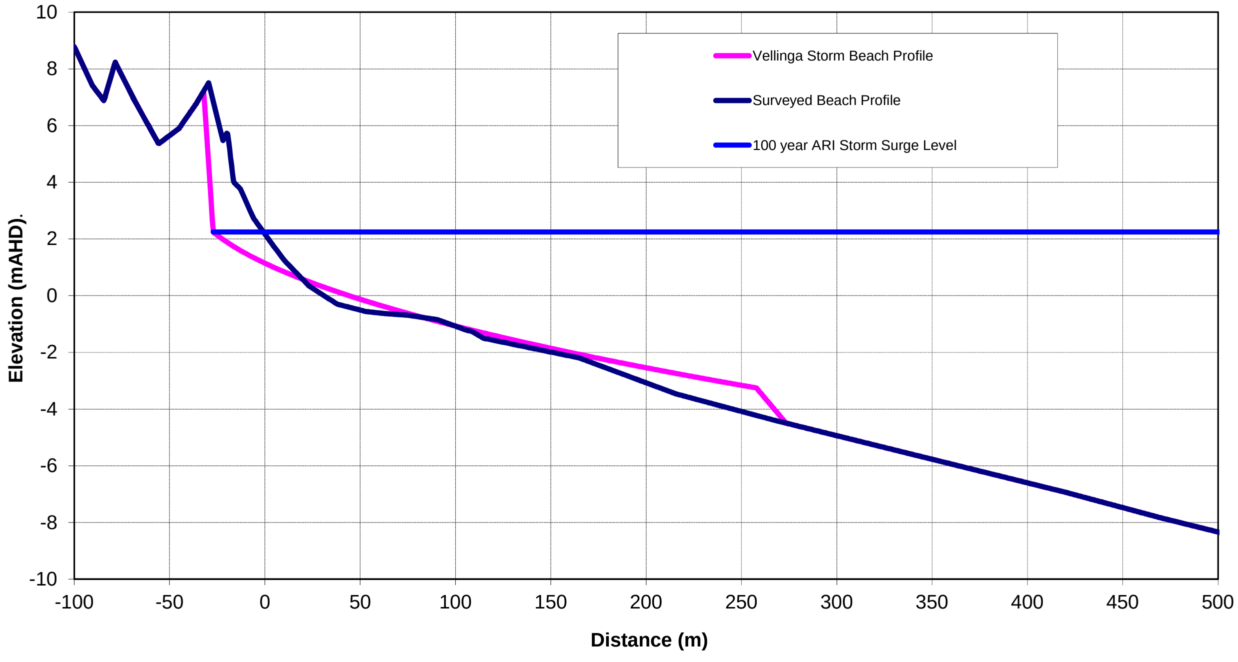
ETA488



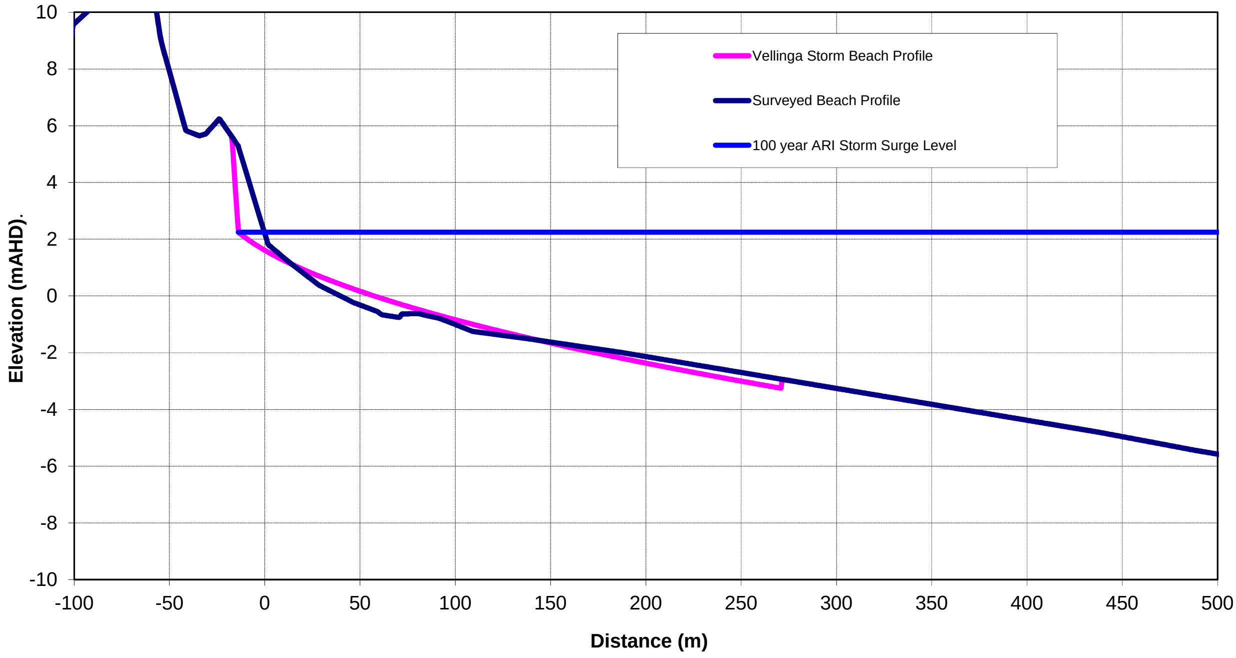
ETA490



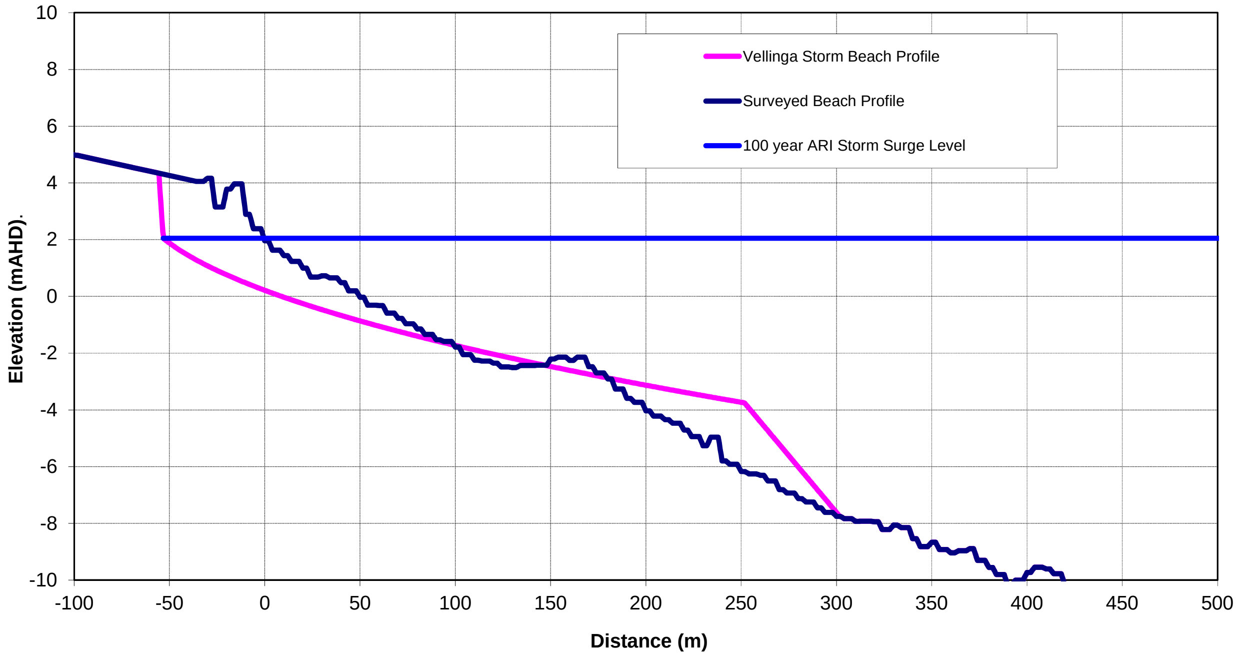
ETA492



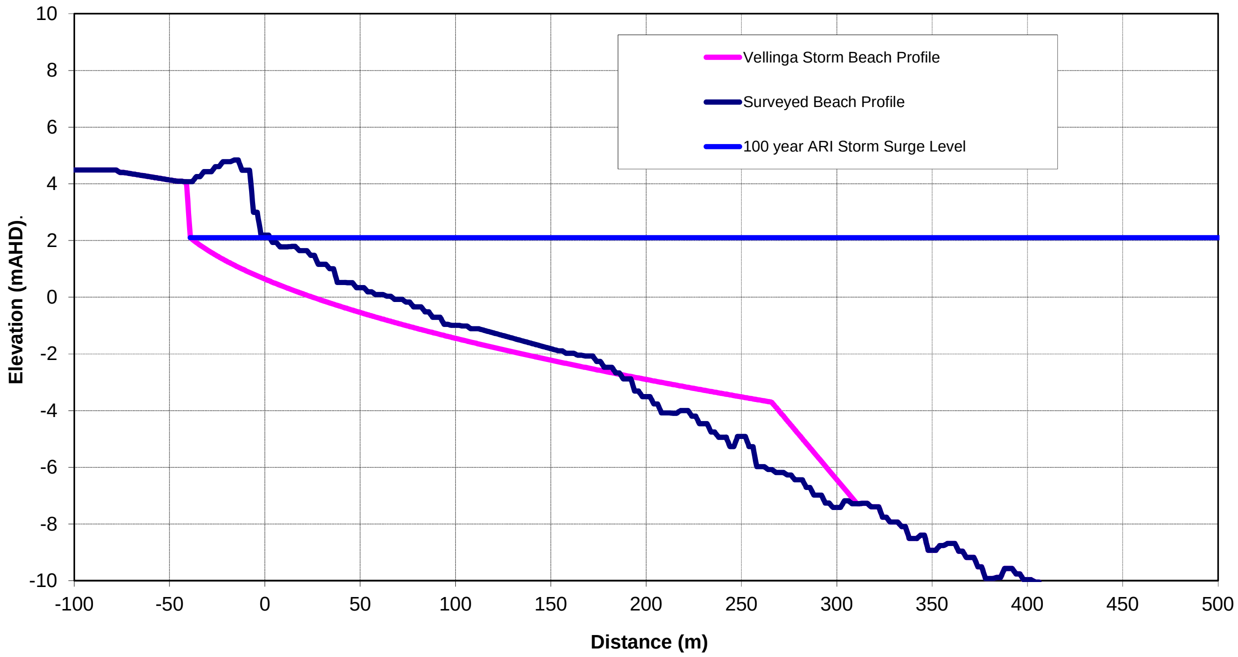
ETA494



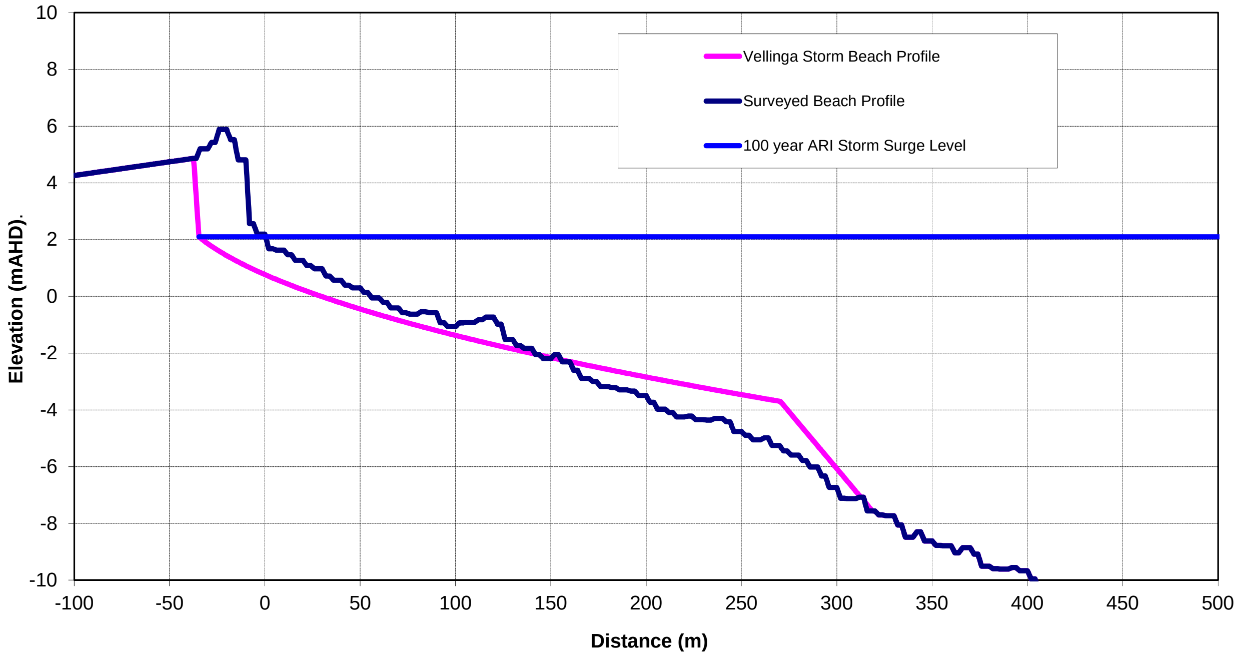
ETA496



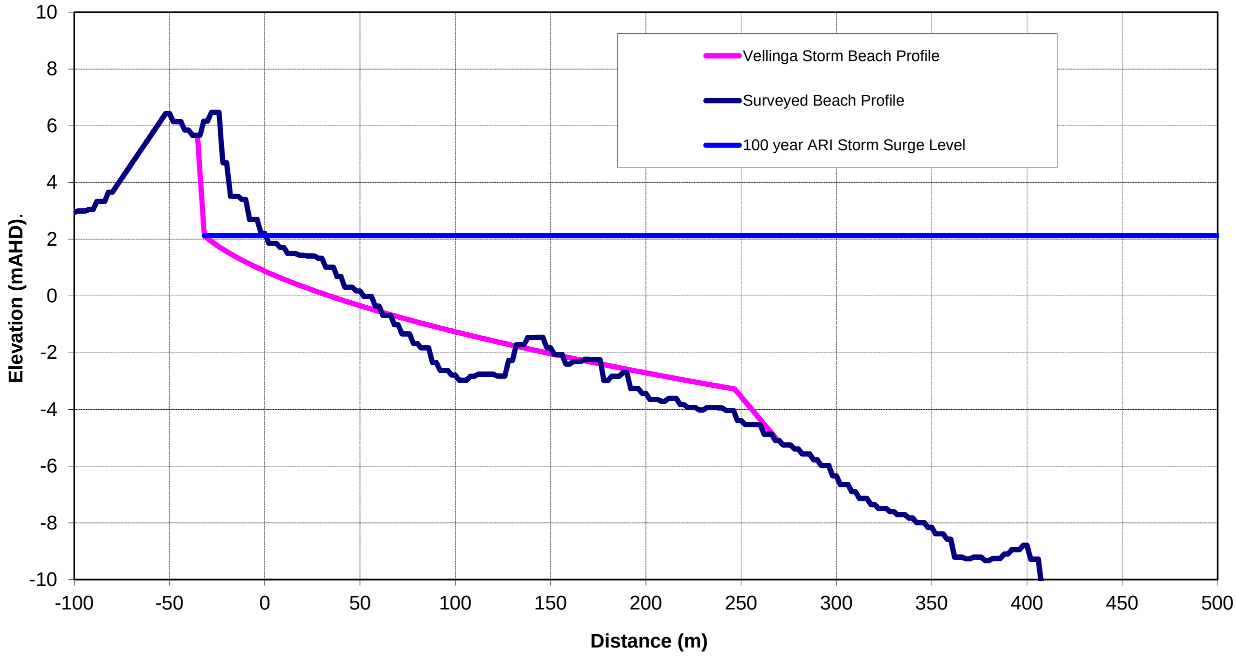
ETA498



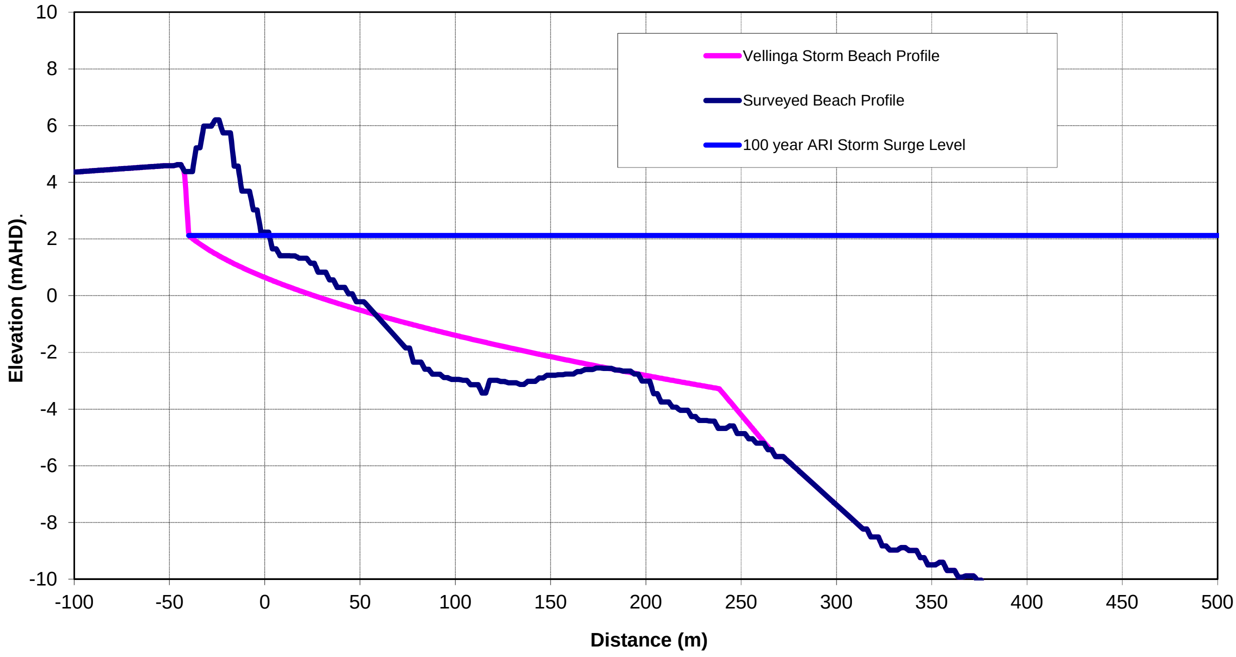
ETA500



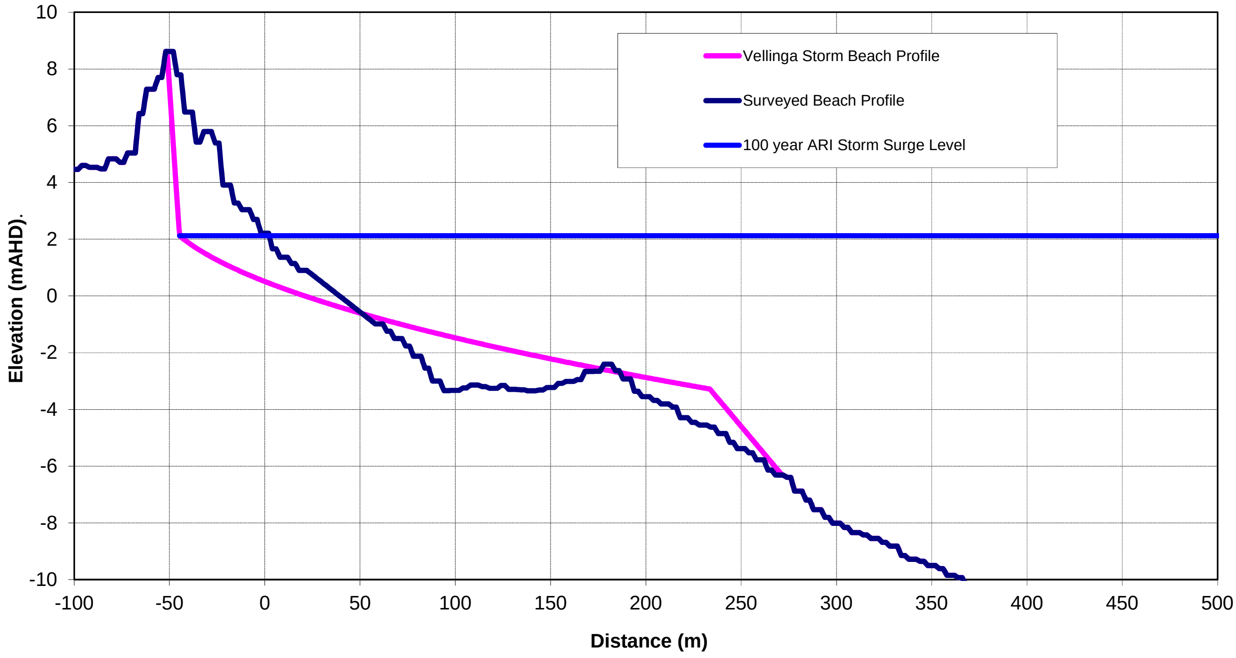
ETA502



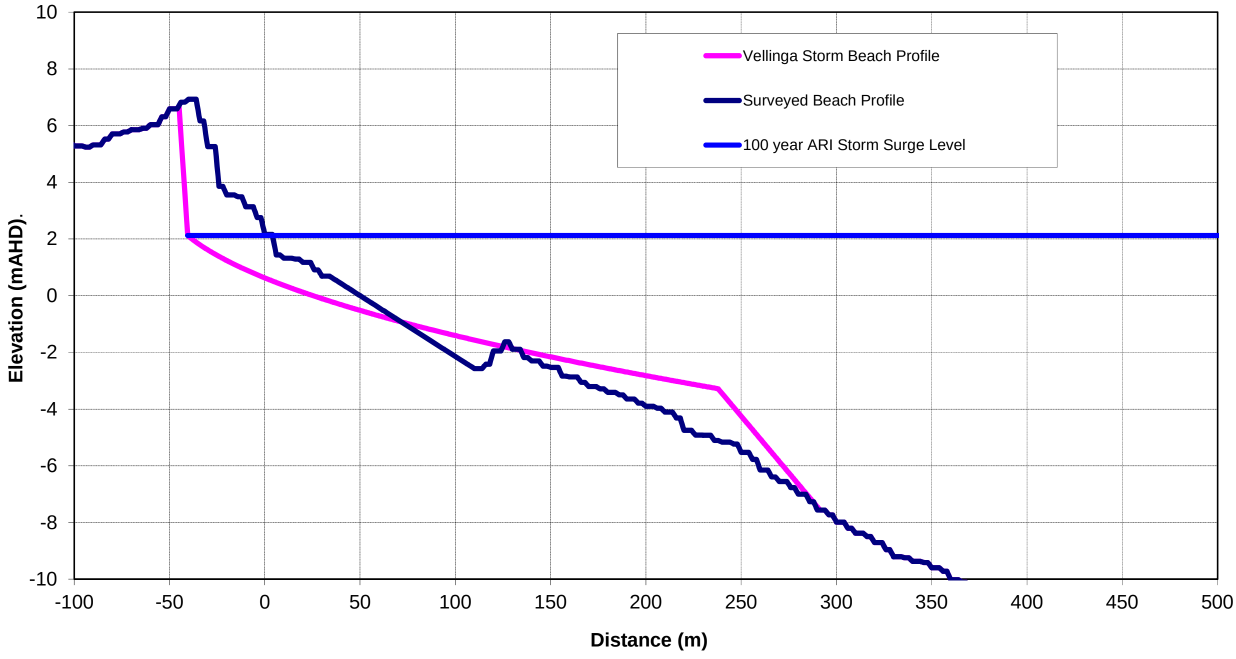
ETA504



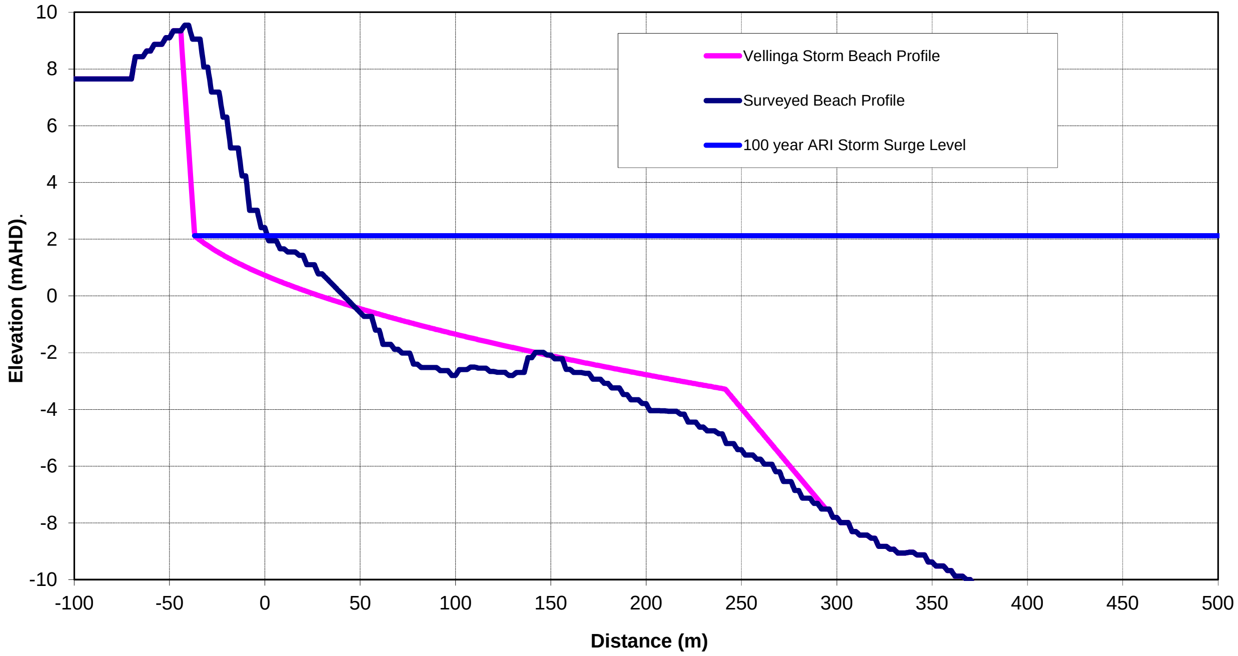
ETA506



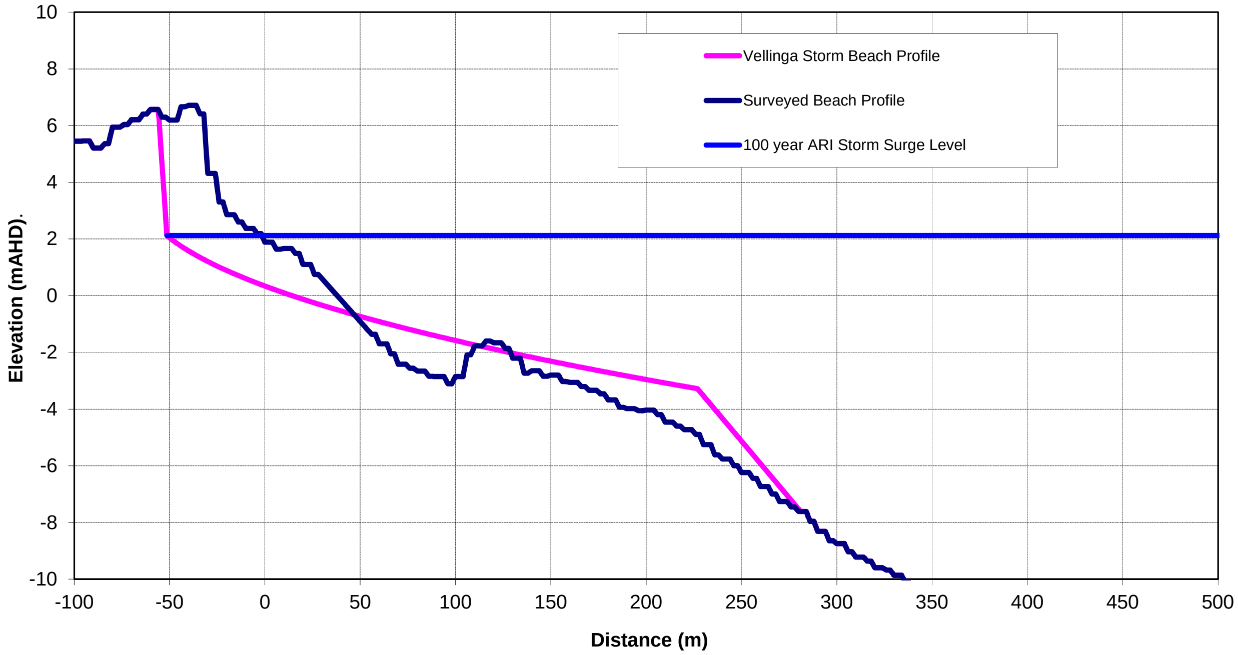
ETA508



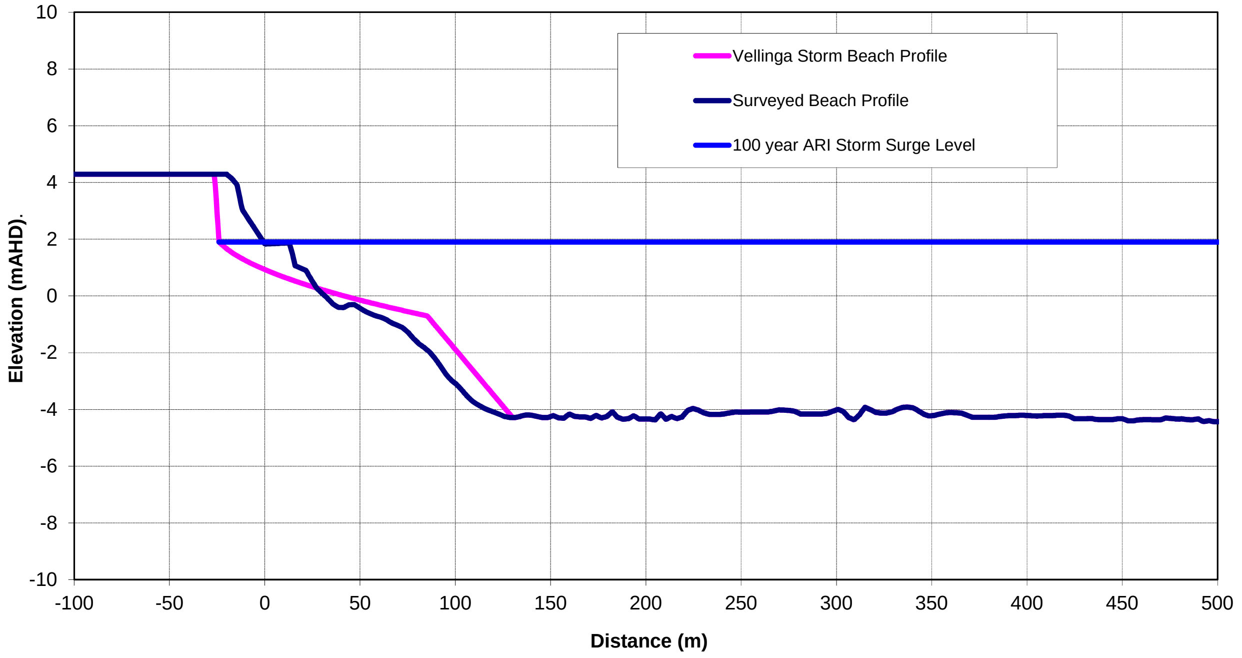
ETA510



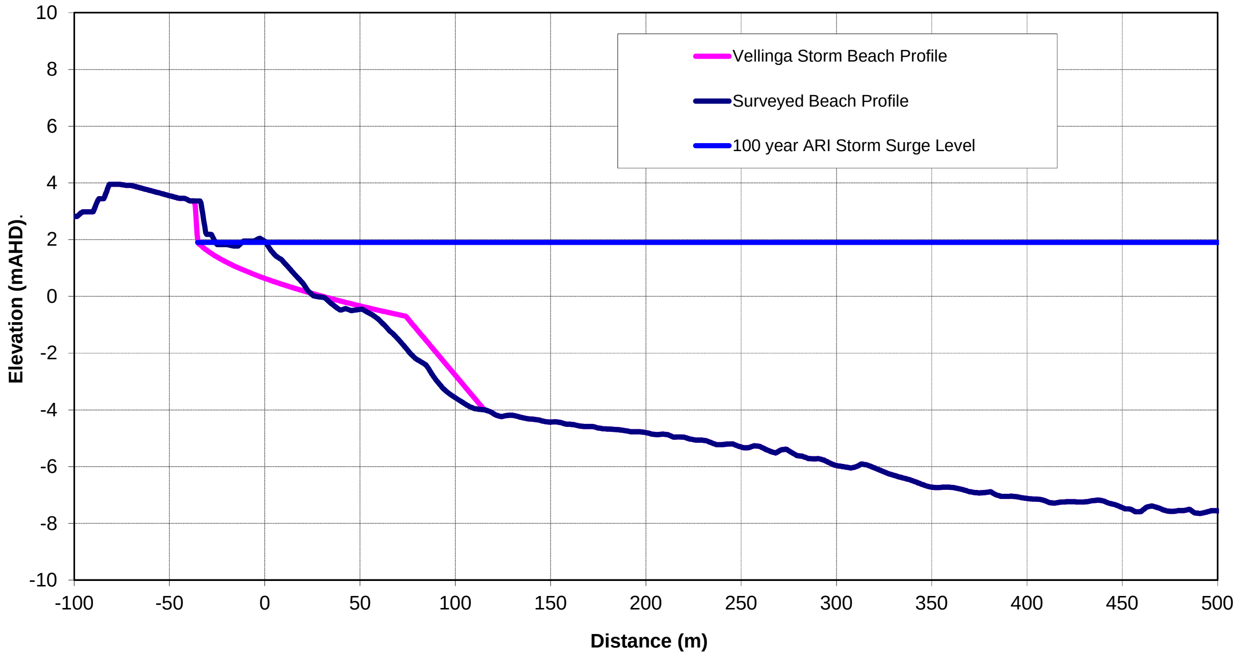
ETA512



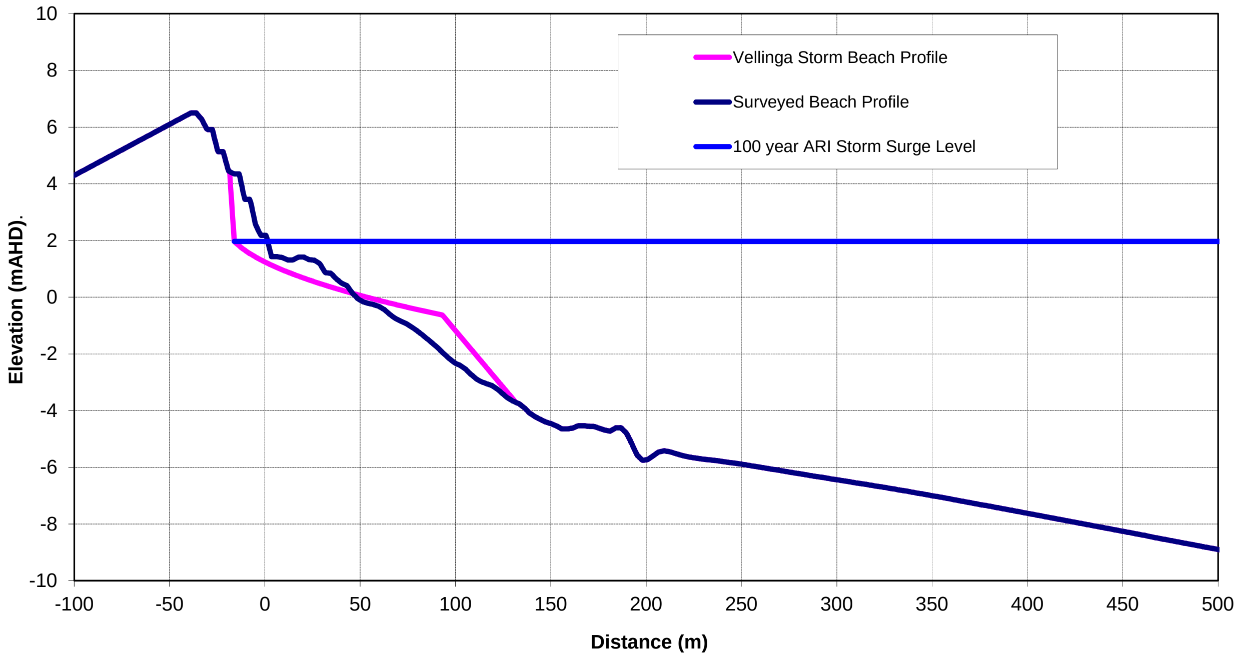
ETA514



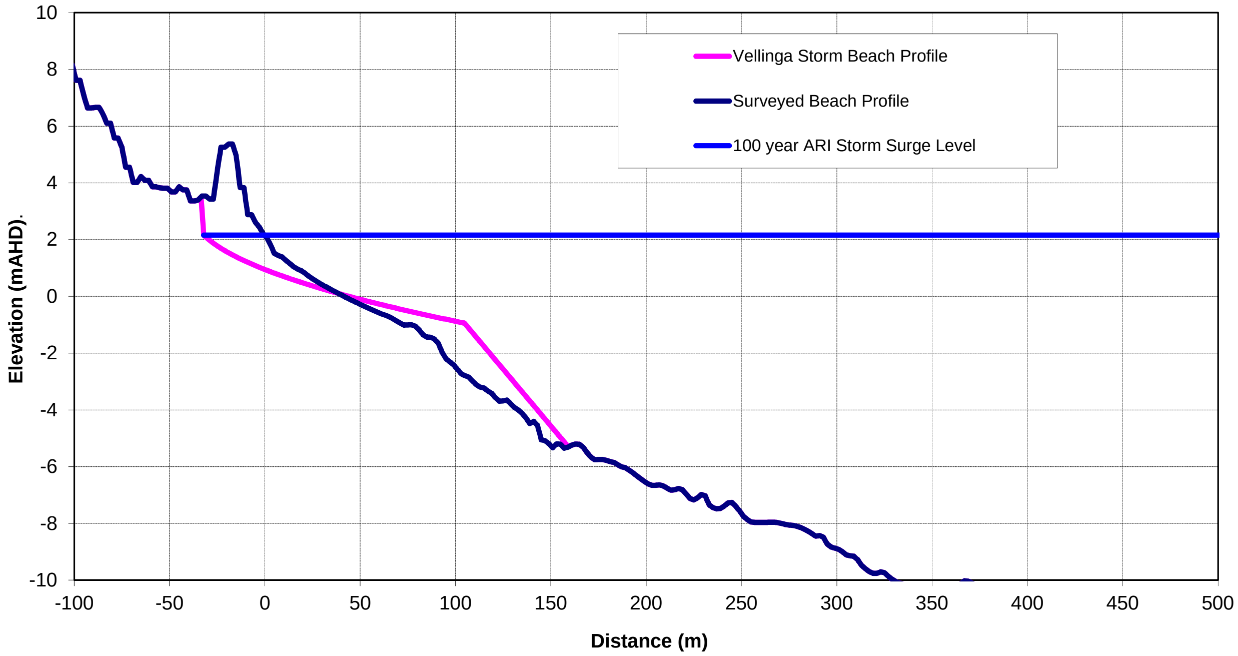
ETA521.5



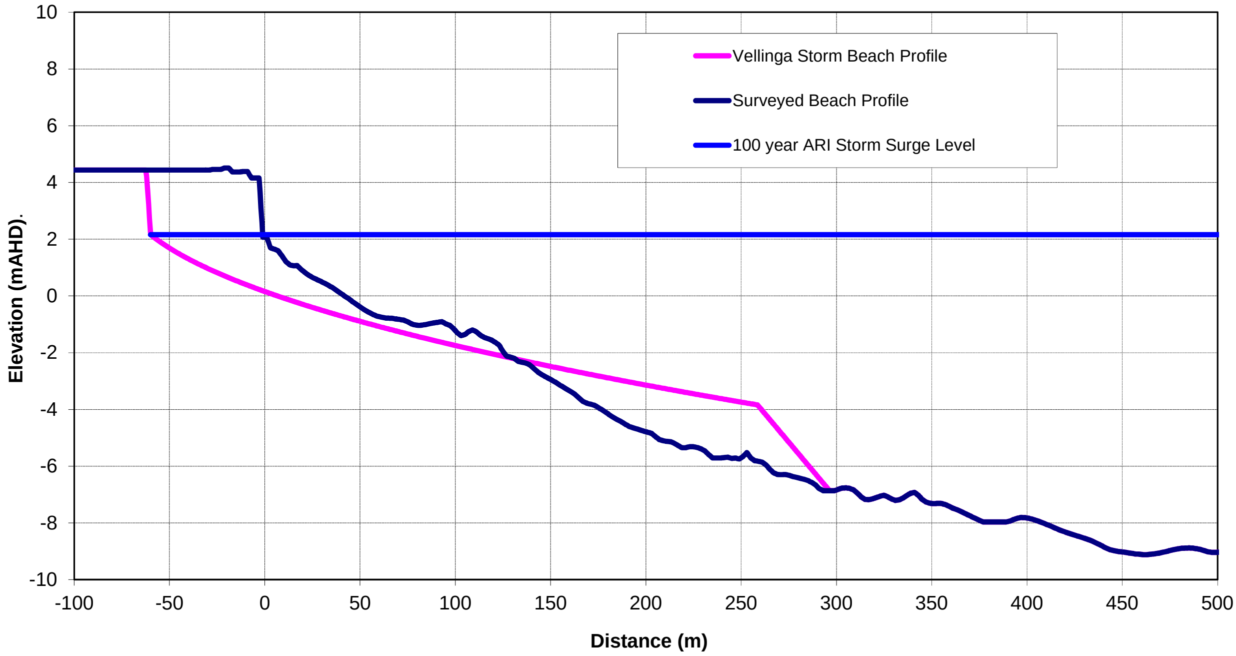
ETA522



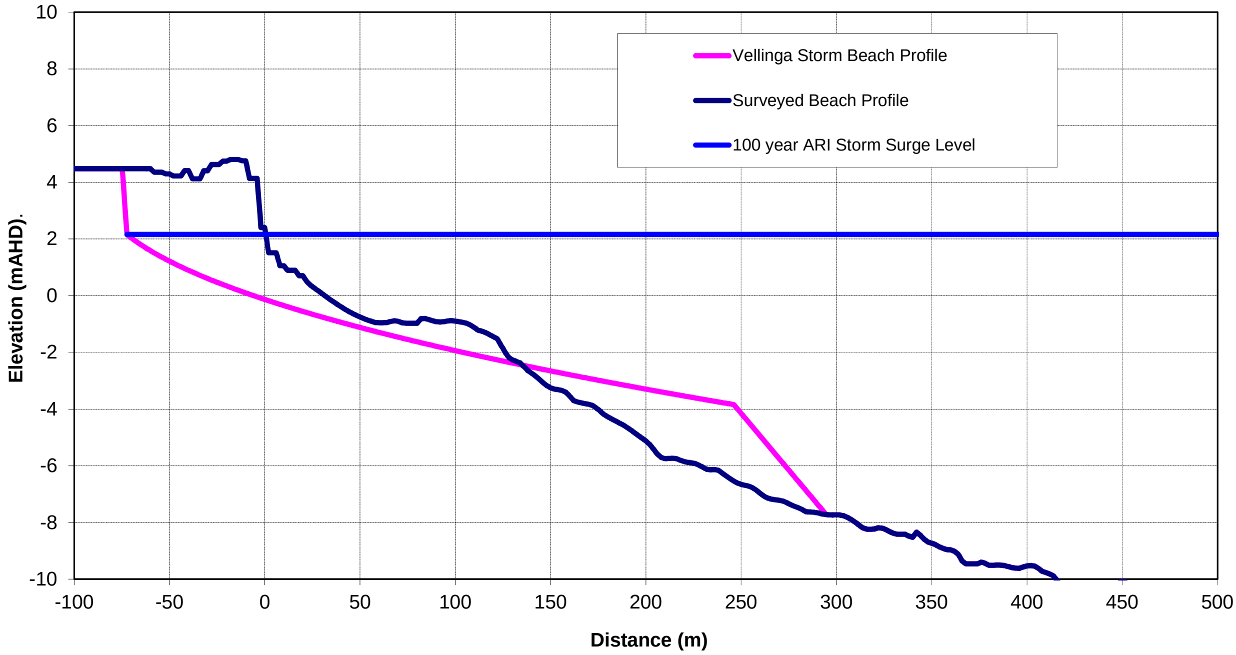
ETA523



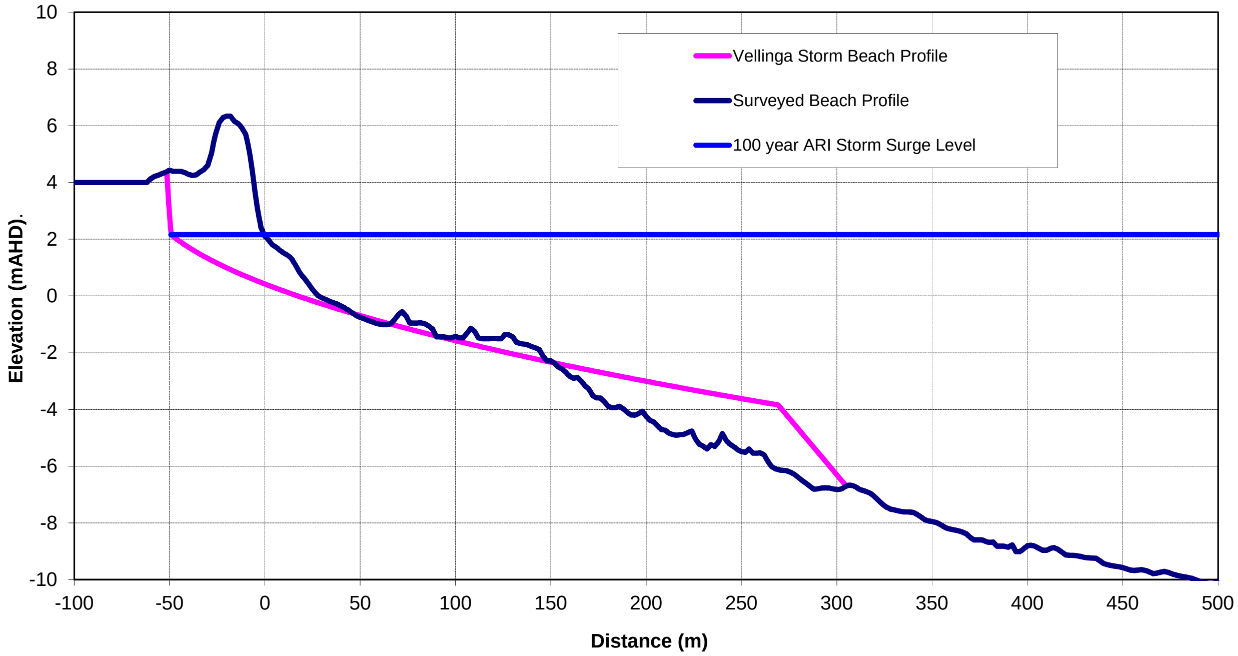
ETA527



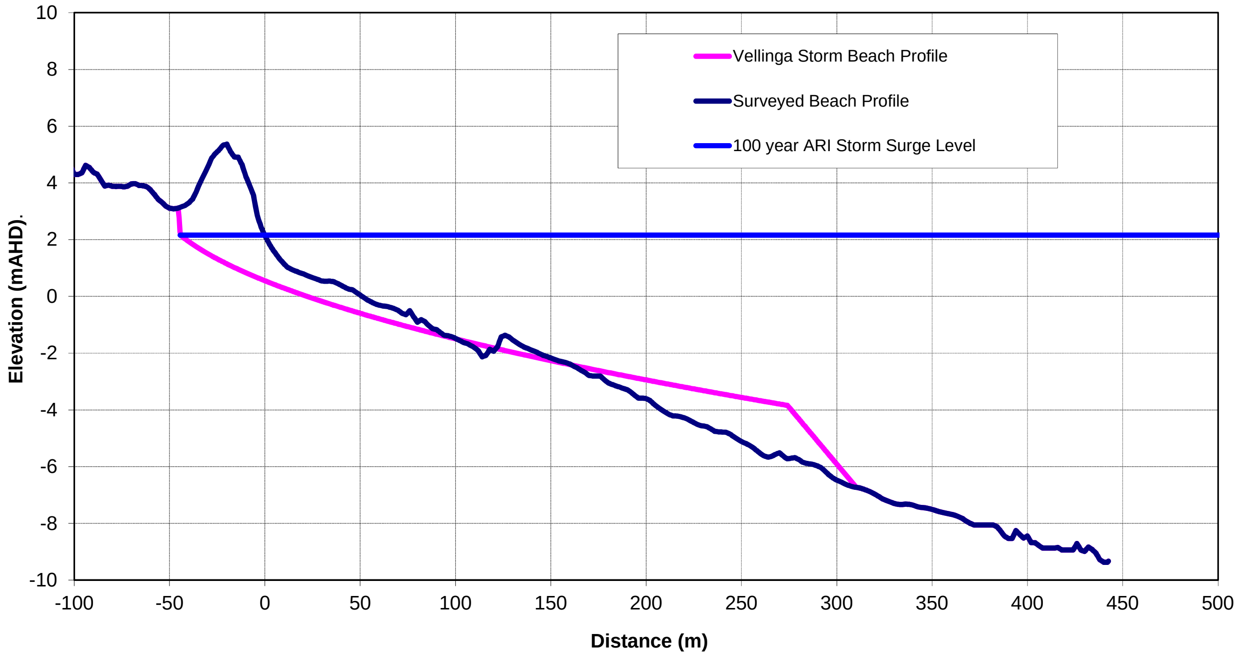
ETA529.8



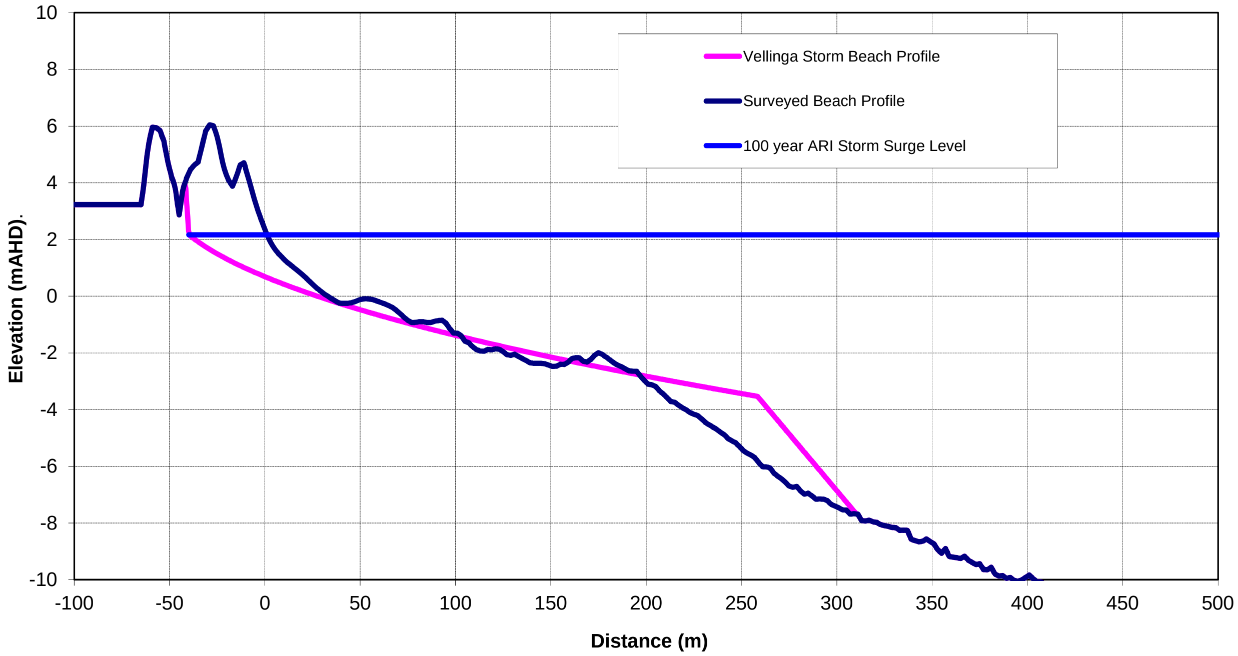
ETA530


Vellinga Storm Beach Profile
Surveyed Beach Profile
100 year ARI Storm Surge Level
Elevation (mAHD).
Distance (m)
10
8
6
4
2
0
-2
-4
-6
-8
-10
-100
-50
0
50
100
150
200
250
300
350
400
450
500

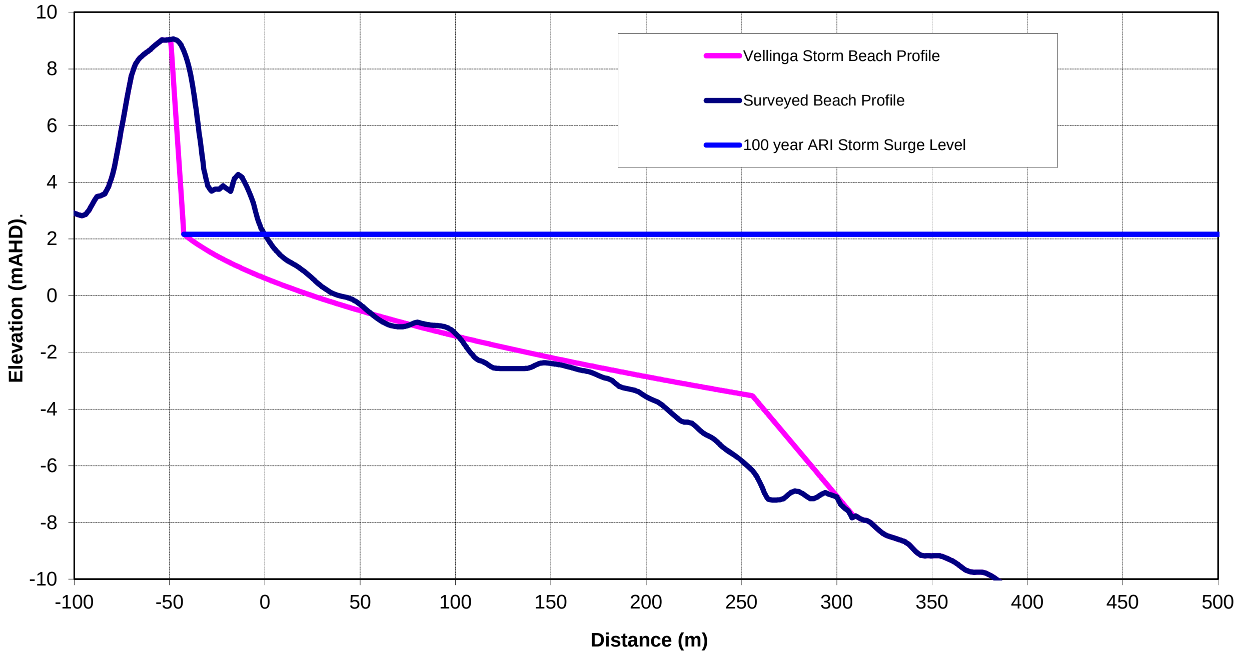
ETA532


Vellinga Storm Beach Profile
Surveyed Beach Profile
100 year ARI Storm Surge Level
Elevation (mAHD).
Distance (m)
10
8
6
4
2
0
-2
-4
-6
-8
-10
-100
-50
0
50
100
150
200
250
300
350
400
450
500

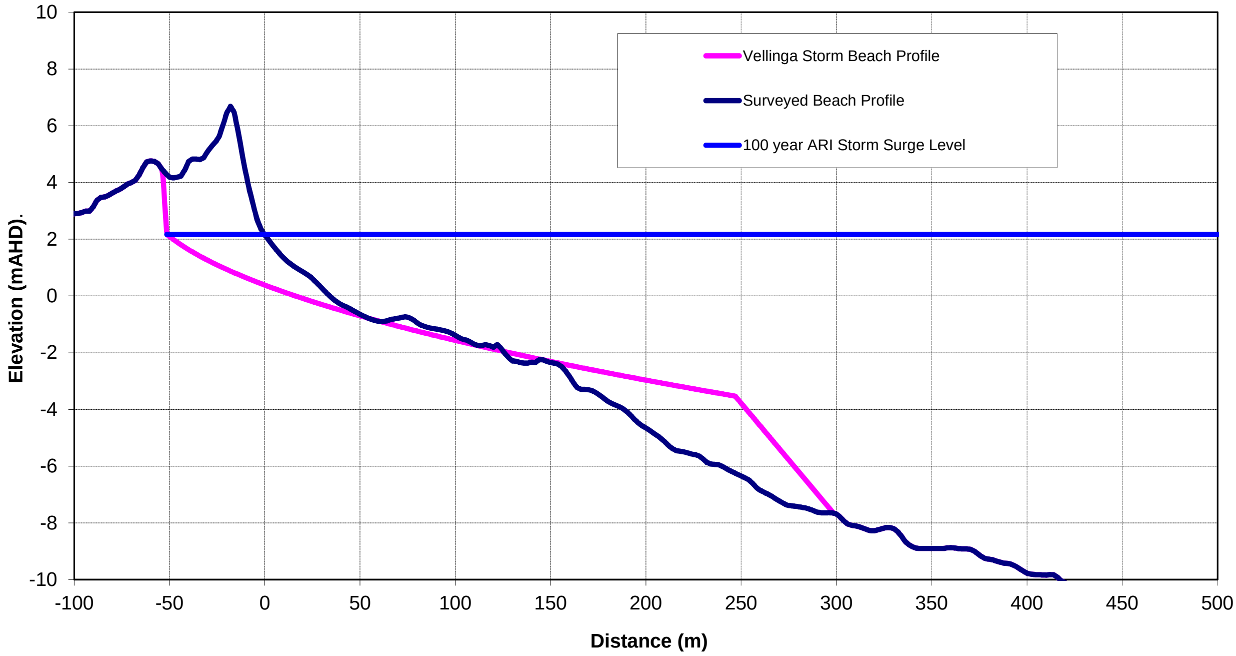
ETA538



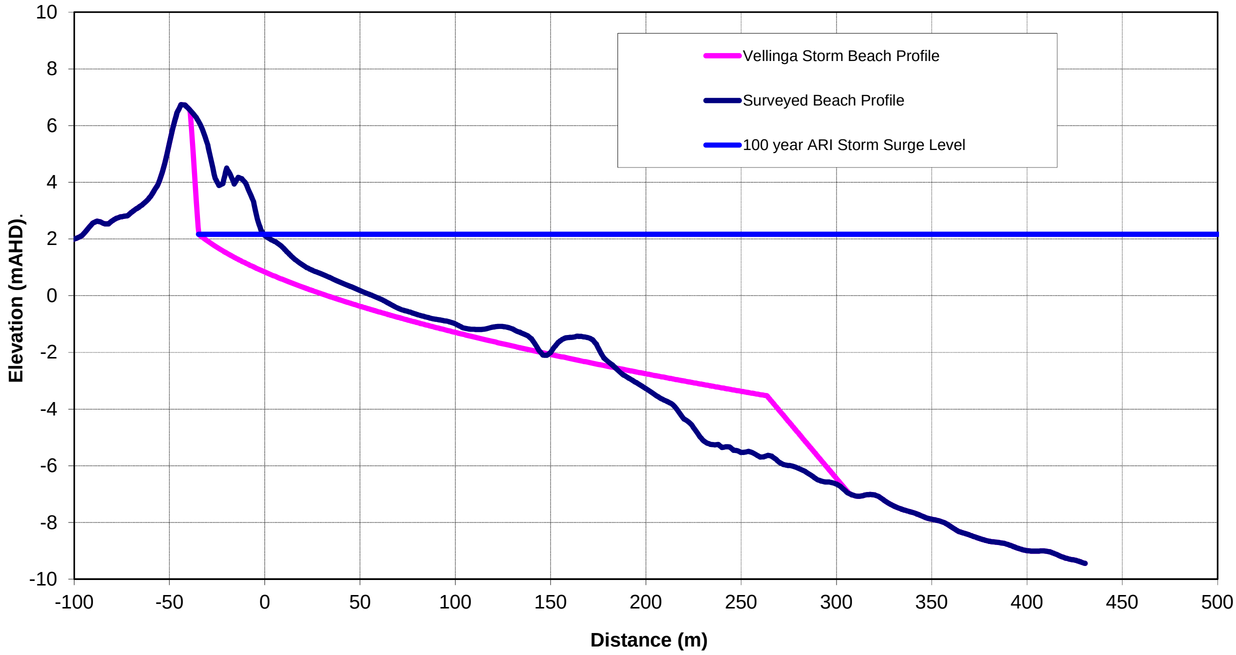
ETA540



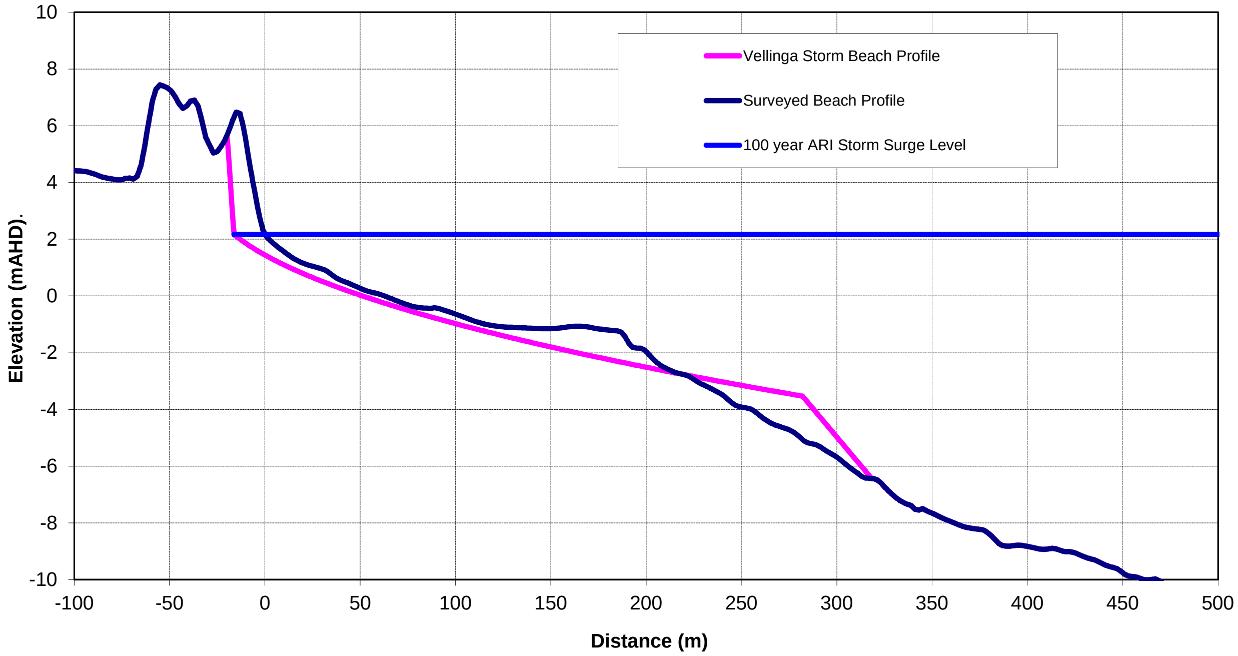
ETA542



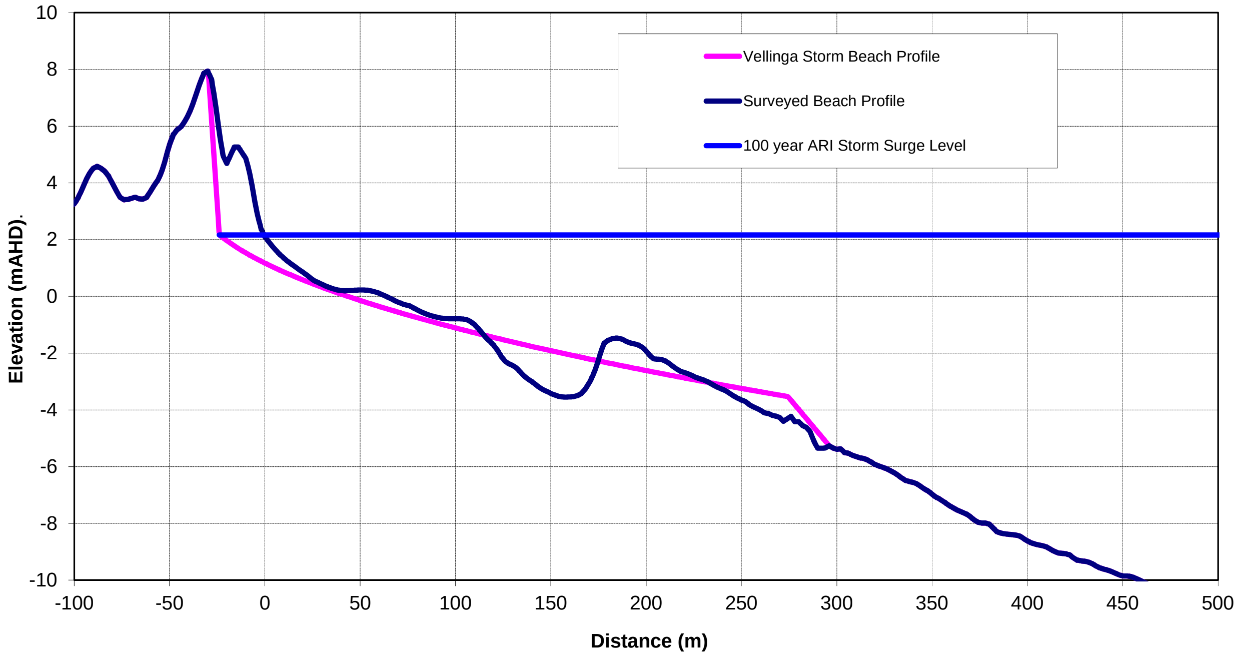
ETA544



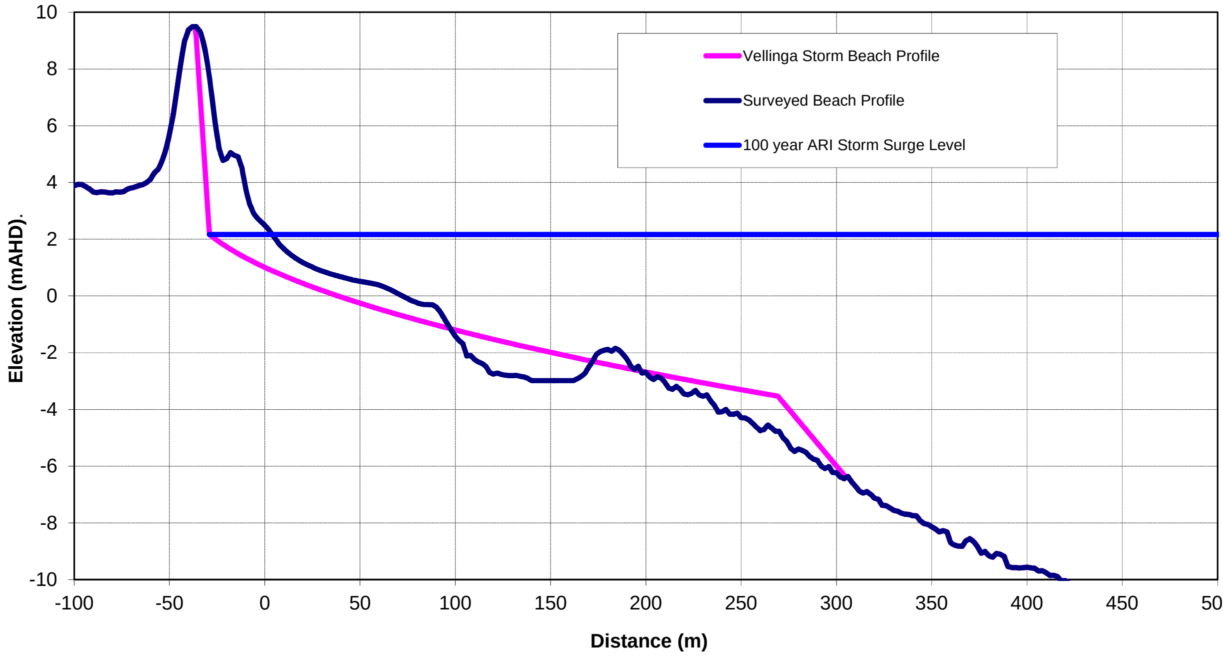
ETA546



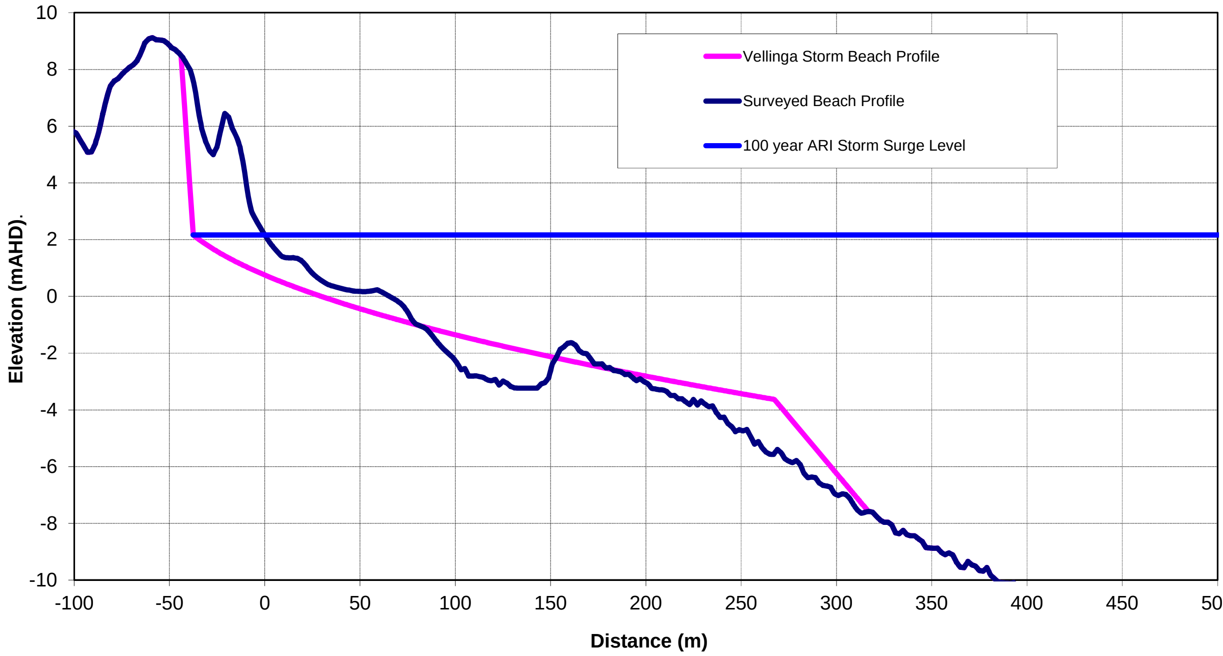
ETA548



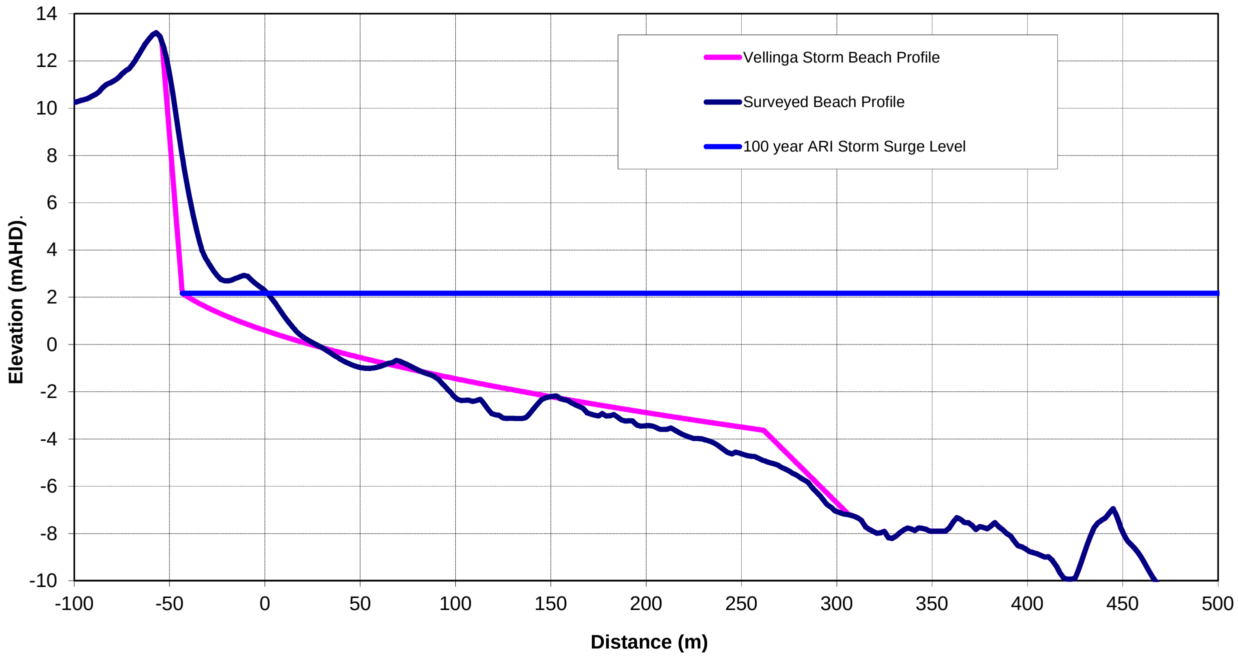
ETA550



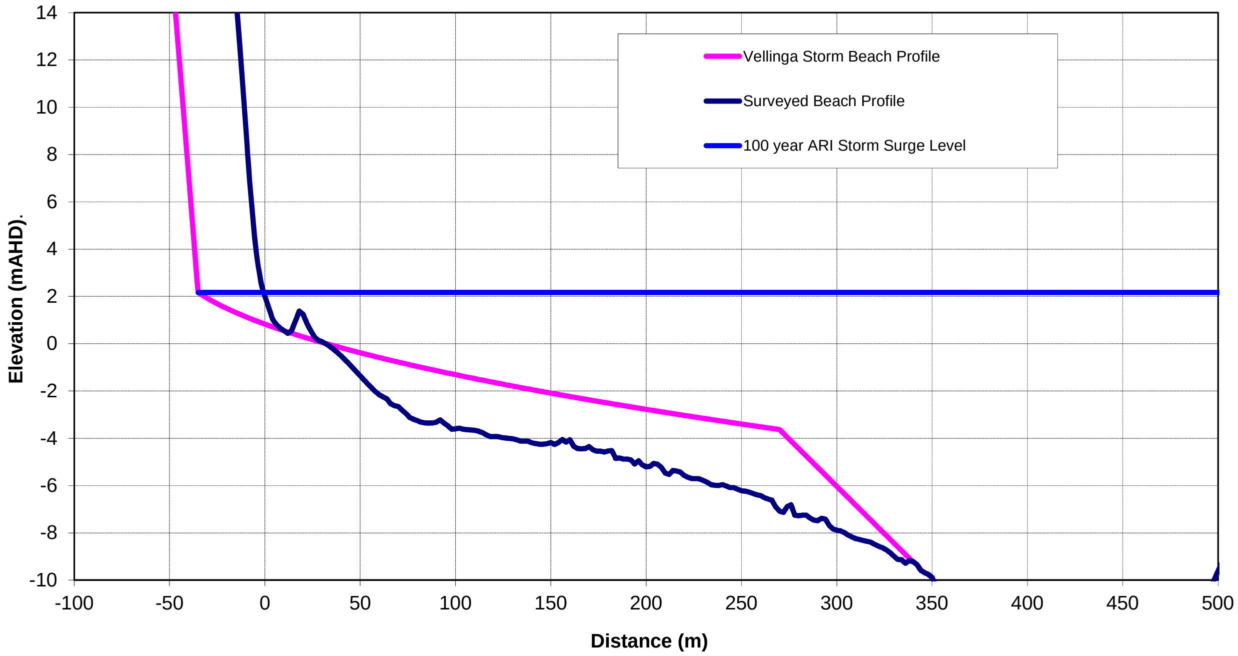
ETA554



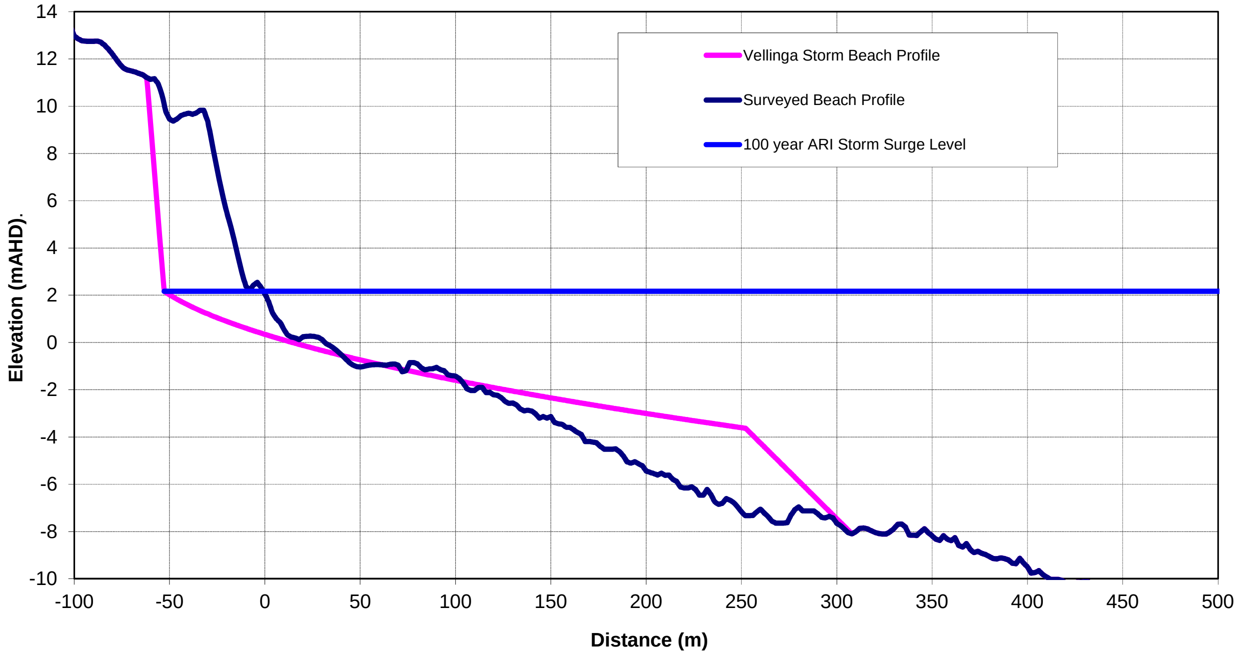
ETA558



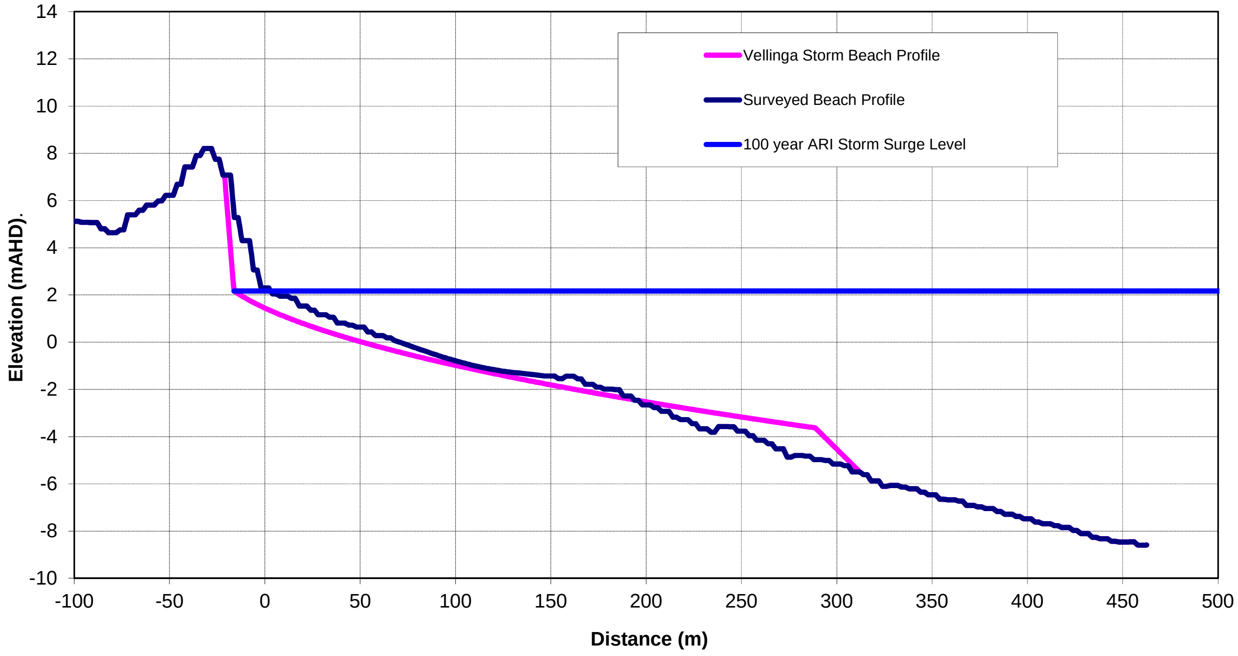
ETA562



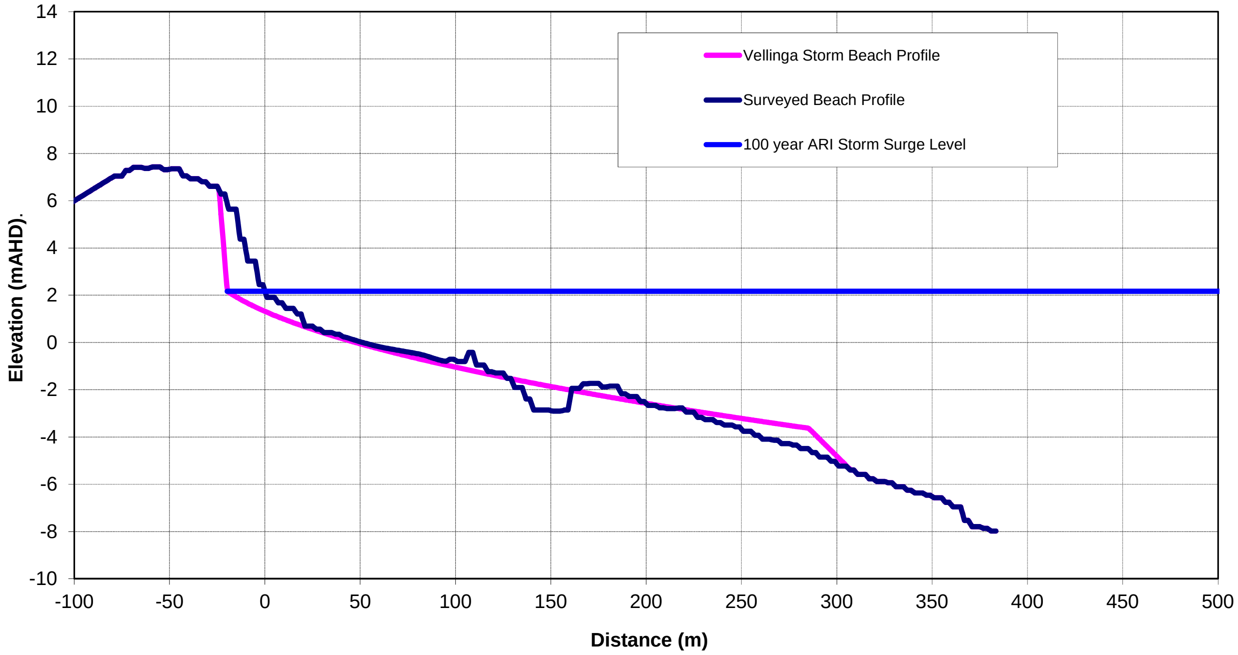
ETA564



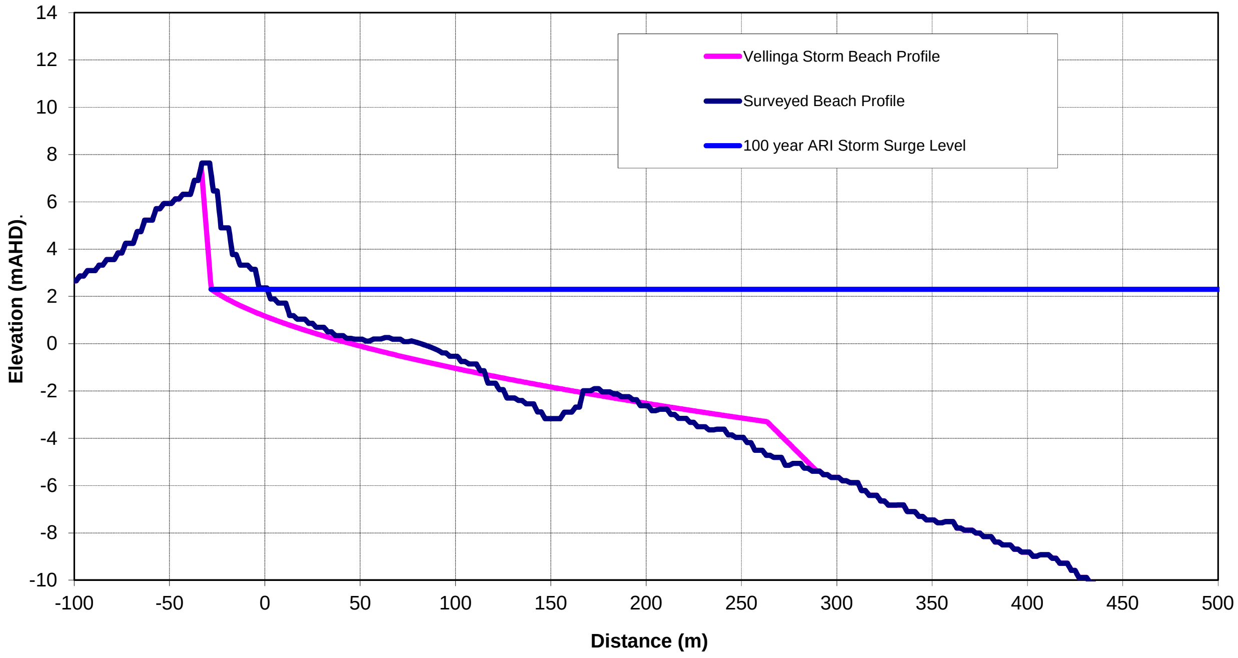
ETA566



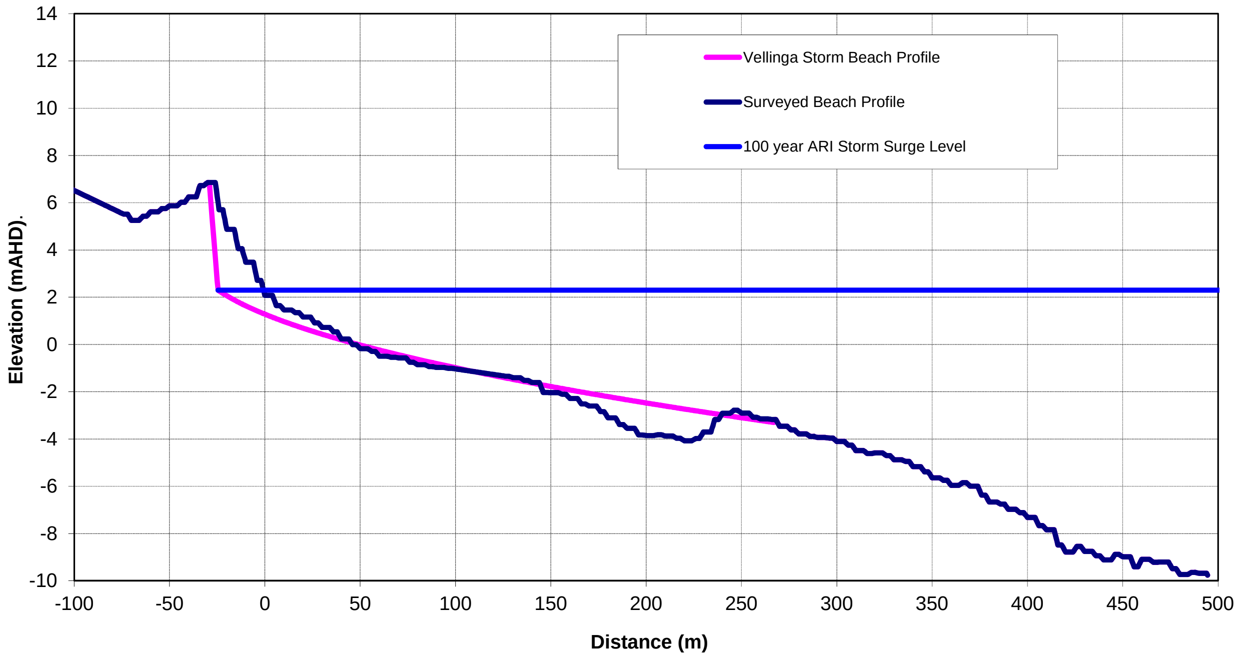
ETA568



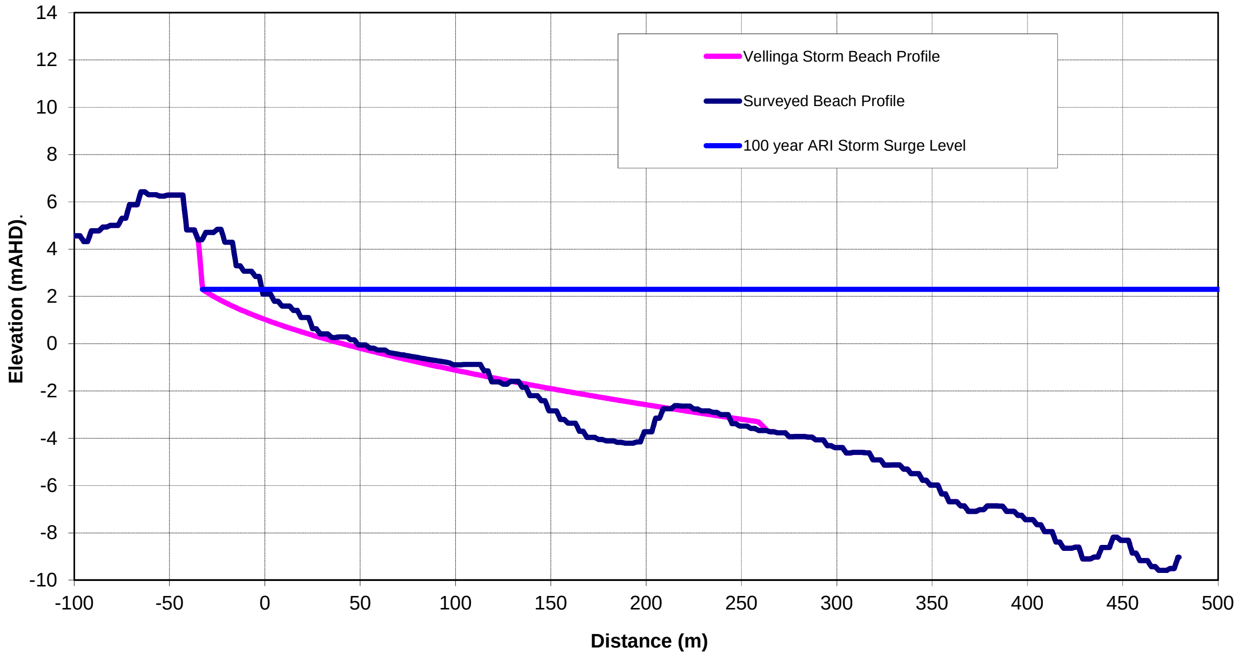
ETA570



ETA574



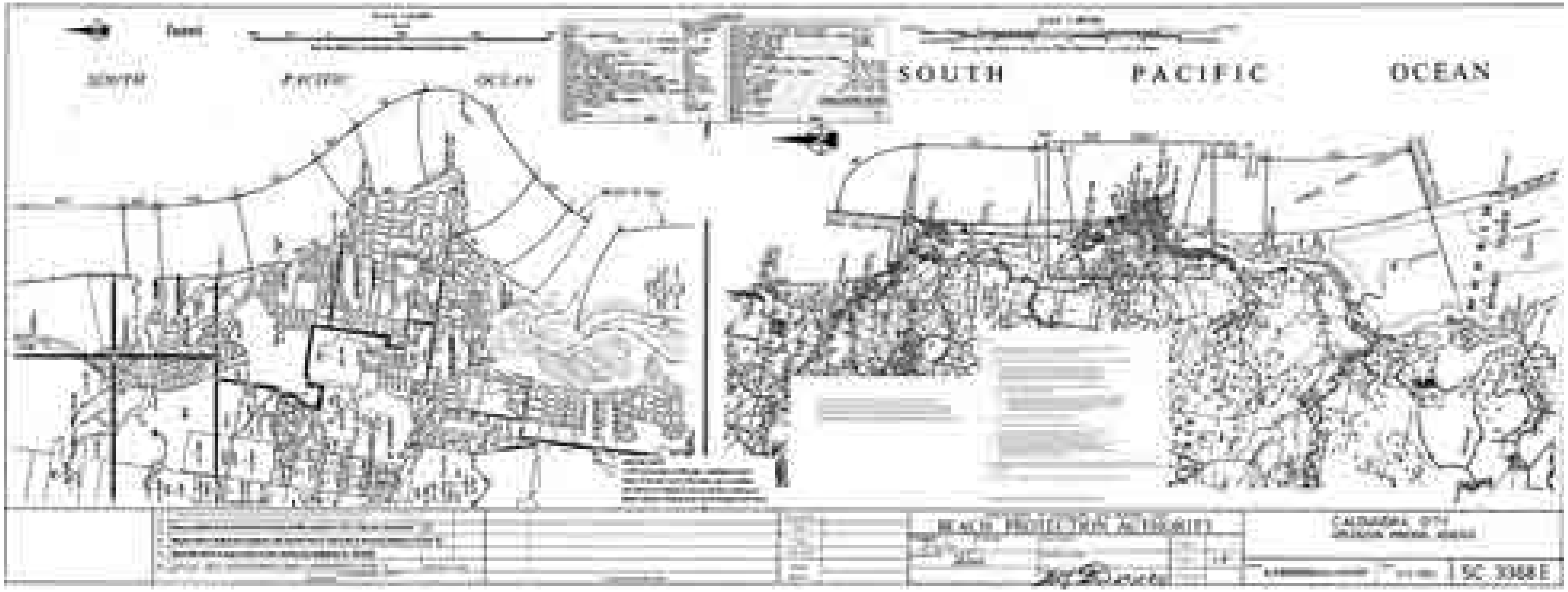
ETA578

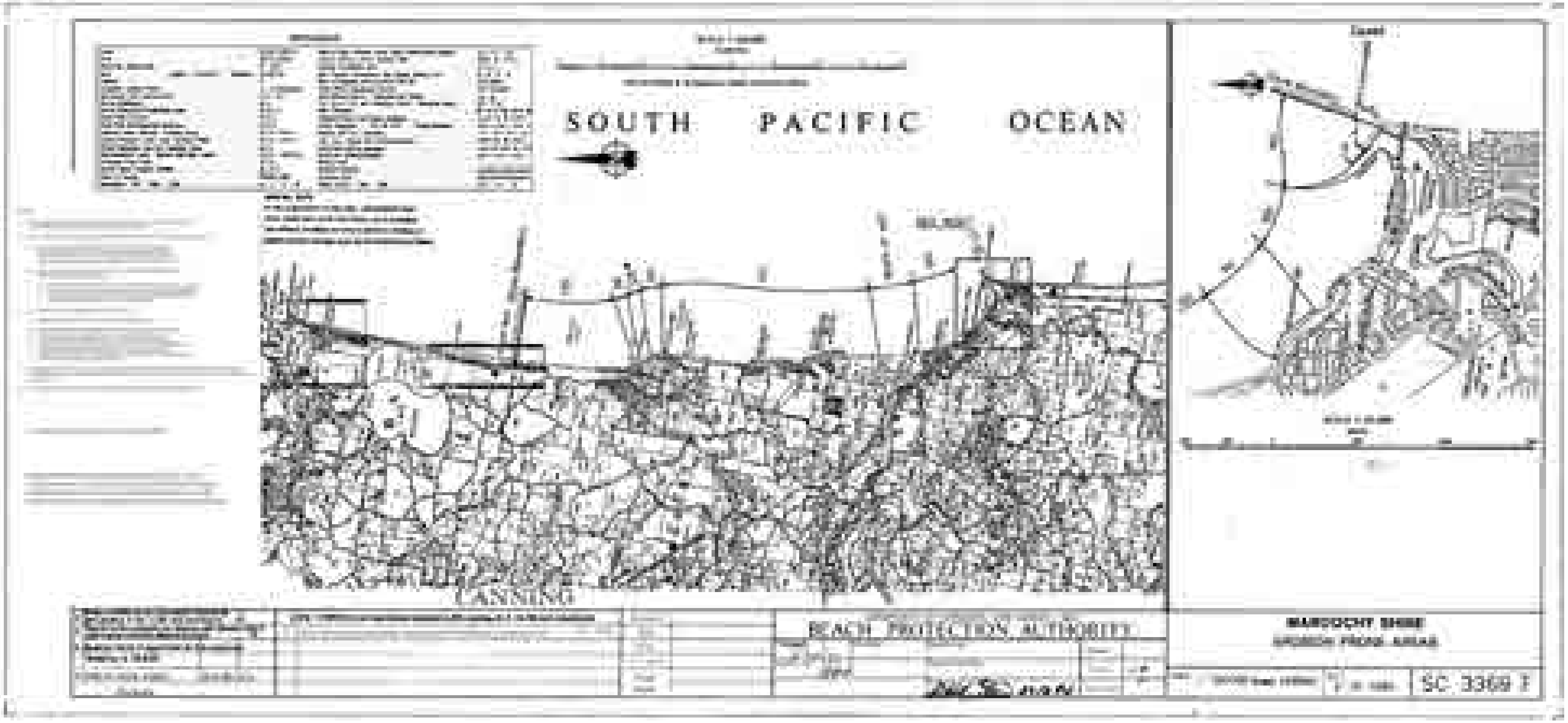


ETA582

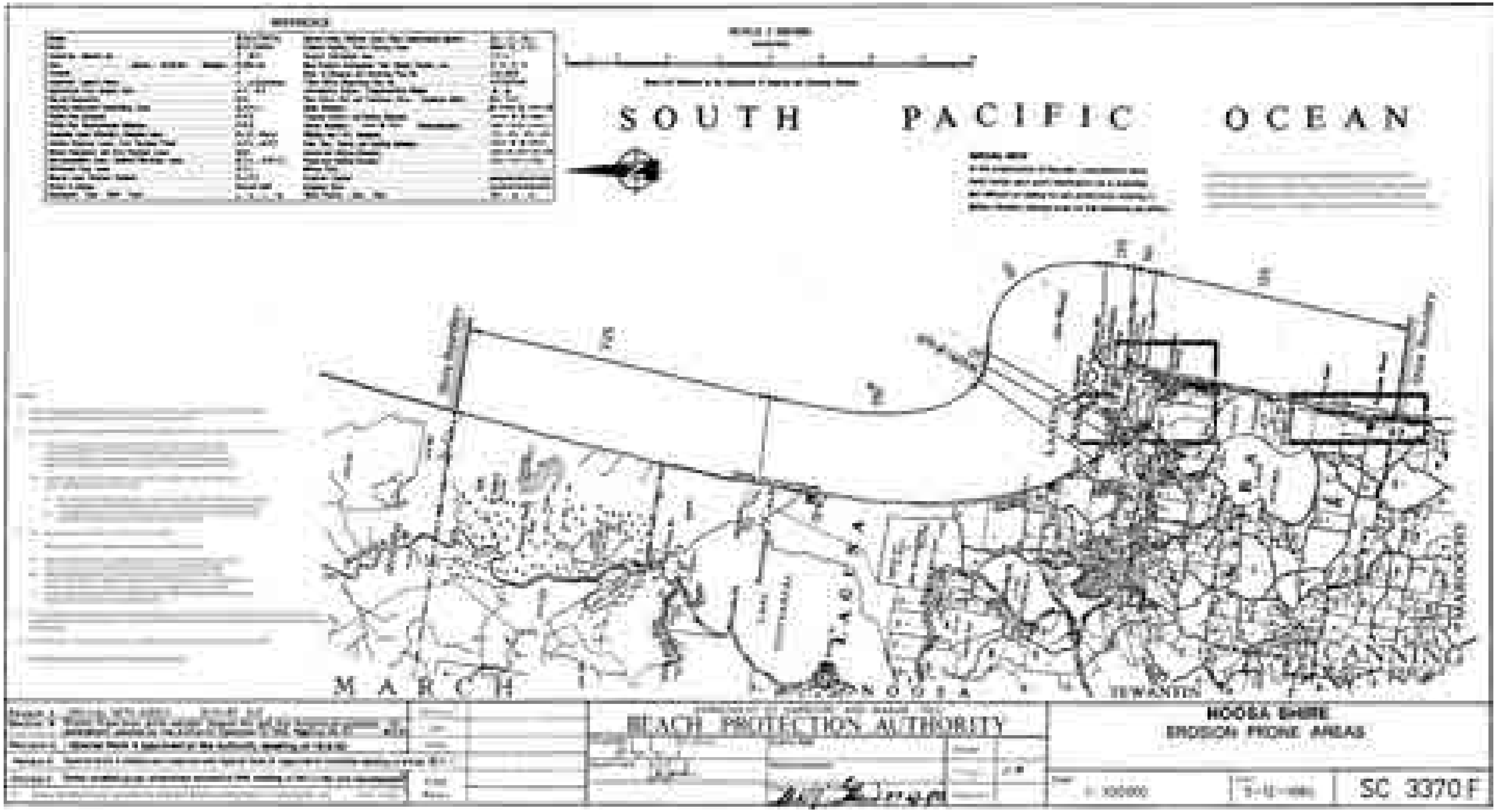
APPENDIX I: EROSION PRONE AREAS (BPA, 1984)

EROSION PRONE AREAS (BPA, 1984)




SOUTH PACIFIC OCEAN
CANNING
BEACH PROTECTION AUTHORITY
MAROOCHY SHIRE
EROSION PRONE AREAS
SC 3369

EROSION PRONE AREAS (BPA, 1984)



BMT WBM

BMT WBM Brisbane
Level 8, 200 Creek Street Brisbane 4000
PO Box 203 Spring Hill QLD 4004
Tel +61 7 3831 6744 Fax +61 7 3832 3627
Email bmtwbm@bmtwbm.com.au
Web www.bmtwbm.com.au

BMT WBM Denver
8200 S. Akron Street, Unit 120
Centennial Denver Colorado 80112 USA
Tel +1 303 792 9814 Fax +1 303 792 9742
Email denver@bmtwbm.com
Web www.bmtwbm.com.au

BMT WBM Mackay
Suite 1, 138 Wood Street Mackay 4740
PO Box 4447 Mackay QLD 4740
Tel +61 7 4953 5144 Fax +61 7 4953 5132
Email mackay@bmtwbm.com.au
Web www.bmtwbm.com.au

BMT WBM Melbourne
Level 5, 99 King Street Melbourne 3000
PO Box 604 Collins Street West VIC 8007
Tel +61 3 8620 6100 Fax +61 3 8620 6105
Email melbourne@bmtwbm.com.au
Web www.bmtwbm.com.au

BMT WBM Newcastle
126 Belford Street Broadmeadow 2292
PO Box 266 Broadmeadow NSW 2292
Tel +61 2 4940 8882 Fax +61 2 4940 8887
Email newcastle@bmtwbm.com.au
Web www.bmtwbm.com.au

BMT WBM Perth
Unit 6, 29 Hood Street, Subiaco 6008
Tel +61 8 9322 1577 Fax +61 8 9226 0832
Email perth@bmtwbm.com.au
Web www.bmtwbm.com.au

BMT WBM Sydney
Level 1, 256-258 Norton Street Leichhardt 2040
PO Box 194 Leichhardt NSW 2040
Tel +61 2 9713 4836 Fax +61 2 9713 4890
Email sydney@bmtwbm.com.au
Web www.bmtwbm.com.au

BMT WBM Vancouver
401 611 Alexander Street Vancouver
British Columbia V6A 1E1 Canada
Tel +1 604 683 5777 Fax +1 604 608 3232
Email vancouver@bmtwbm.com
Web www.bmtwbm.com.au